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ABSTRACTS

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ALBERT, ADJESIWOR*[1], NEVIN LAWRENCE[2], PRASHANT JHA[3], TODD GAINES , ERIC WESTRA and ANDREW KNISS , [1]University of Idaho, [2]University of Nebraska–Lincoln, [3]Iowa State University, Colorado State University, University of Wyoming, [1]Kimberly Research & Extension Center, 3806 N 3600 E, Kimberly, ID 83341, [2]Panhandle Research and Extension Center, 4502 Ave I Scottsbluff, NE 69361, [3]3212 Agronomy Hall, 716 Farm House Lane, Ames, IA 50011, 300 W. Pitkin, Colorado State University, Fort Collins, CO 80523, Dept 3354, 1000 E. University Ave. Laramie, WY 82071 **Economic impacts of managing glyphosate resistant weeds in sugar beet.**

Glyphosate-resistant (GR) sugarbeet (*Beta vulgaris* L.) have been widely adopted by growers primarily due to the economic benefits. However, the value of this trait is beginning to erode, as new weeds continue to evolve resistance to glyphosate. Field studies were conducted in Wyoming, Montana, Nebraska, and Colorado, to evaluate one component of the economic impact of GR kochia (*Kochia scoparia* (L.) Schrad.) and GR Palmer amaranth (*Amaranthus palmeri* S. Wats.) in GR sugarbeet. Five herbicide programs were applied in a randomized complete block design with six replicates at all locations. Treatments included a weed-free control treatment that was sprayed with only glyphosate, and four herbicide treatments where additional herbicides were added to the glyphosate. These four herbicide treatments were chosen based on our expectation that they would provide the best control possible of GR kochia (2 treatments) and GR Palmer amaranth (2 treatments). For each species, one herbicide program was selected that would provide POST control, and a second herbicide program was selected that would rely on the 'layered residual' concept, where residual herbicides are applied multiple times throughout the season. No glyphosate-resistant weeds were present at any of the four field sites, and therefore, all weeds were well-controlled by the herbicide treatments. This allowed us to quantify sugarbeet injury and yield loss based only on the herbicides being applied, and not confounded by weed competition. When harvested at the 10 to 12 true-leaf stage, and at final harvest, layered residual treatments had less impact on sugarbeet yield and biomass production compared to the POST control treatments. Averaged over sites, the POST herbicide treatment targeting Palmer amaranth reduced sucrose yield by 11%, while the POST herbicide treatment targeting kochia reduced sucrose yield 4%. Additional economic impacts have also been analyzed, but vary with price and cost estimates.

BERNHARDSONS, DUANE*[1], ELKE HILSCHER[2] and HEIKO NARTEN[2], [1]KWS Seeds LLC, [2]KWS SAAT SE& co. KG aA, [1]1500 S 40TH ST, Grand Forks ND 58201, [2]Grimsehlstrabe 31, Einbeck Germany 37555
KWS BEETROMETER® in a Commercial Application.

Considerable time and research are invested in developing new products, after much trial and error this investment finally paid off with a useable product. We have reported on the work that has been done in developing the BEETROMETER® which is an innovative approach to providing quality analysis of whole Sugarbeet samples. Current methodology used in analyzing sugarbeet quality is over 40 years old. This is a manual process which requires the production of brei and trained technical staff. We have been able to support a sugar company in updating their process with the BEETROMETER® with the 2019 harvest. The system has been used in research activities for over 10 years collecting several thousand measurements annually and was introduced in 2019 as a commercial offering. This implementation involved converting an existing sugar company's Quality Lab that utilized analysis of fresh brei using a polarimeter, flame photometer and colorimeter for the analysis of polarized sugar, sodium, potassium and amino nitrogen. Using the results from this analysis, the calculate recoverable sugar using the Carruthers Formula. After two successful seasons it has proven to be a reliable replacement to wet chemistry in the sugarbeet Quality Lab with accurate results and the ability to increase throughput and reduce labor requirements. The patented system works well as a retrofit for current labs or as a greenfield project.

DORN, KEVIN*[1], NICK METZ[1], ANN FENWICK[1], AMY NIELSON[1] and BRADLEY SOWDER[1], [1]USDA-ARS, Crops Research Lab, 1701 Centre Ave, Fort Collins, CO 80526 **Accelerating sugar beet germplasm development using genomics-informed breeding strategies.**

USDA-ARS sugar beet research programs have served a central role in germplasm screening and improvement efforts in the United States. The Sugar Beet Genetics Lab in Fort Collins, CO focuses on developing germplasm with improved disease resistance, with a focus on Rhizoctonia root and crown rot (RRCR) resistance trait discovery. Through screening wild germplasm, including crop wild relatives like *Beta vulgaris* spp. *maritima*, for resistance to RRCR and other diseases, we are prioritizing the rapid introgression, mapping and functional validation of potentially novel forms of disease resistance. To this end, we are using whole genome sequencing (WGS) datasets from over 100 USDA-ARS germplasm releases to identify candidate molecular markers for multiple disease resistances, with an initial focus on RRCR resistance. We have coupled these WGS datasets with disease nursery phenotypic screening to begin the process of developing markers that will be used to pre-screen untested germplasm to prioritize those most likely to harbor new forms of resistance. To enable the rapid mapping and functional validation of potentially novel sources of resistance, we are generating *de novo* genome assemblies of plants with demonstrated resistance. Using PacBio HiFi sequencing, we have quickly generated high quality draft assemblies of Fort Collins germplasm with resistance to RRCR and Fusarium yellows, which are being used to map the underlying resistance genes using multiple approaches, including QTL-seq and expression profiling.

EKBLAD, TOBIAS, Hilleshög Seed, Säbyholmsvägen 24, Landskrona, Sweden **Technology advances in sugar beet phenotyping and selection using new image processing methods.**

Drones and other image-generating devices are changing how we do sugar beet phenotyping. Vast amounts of images can now be acquired with minimal effort, and the main challenge has become the conversion of images into useful information. Traditional computer based image processing methods, as well as emerging AI-based technologies, are critical in this context. Over the last few years, there has been great progress in using so-called deep learning, a form of AI, for creating accurate and robust image analysis systems. At Hilleshög we have embraced this technology as a versatile tool for analysis of sugar beet seeds and plants. As an example of this technology we will present a method for classification of seeds based on x-ray images. A deep learning model was trained to recognize different quality classes of sugar beet seed (multigerms, monogerms, twins, etc.) using 350 000 pre-classified x-ray images. The trained model was then used for classification of new sed images. The model could correctly classify seeds with at least 99% accuracy, taking about 20 milliseconds per seed. The deep learning method could therefore be used in place of a time-consuming manual image classification procedure. Similar progress has been made with processing of images of sugar beet plants in the field. As an example, the growth rate and date of leaf canopy closure for different sugar beet varieties was calculated by automatically extracting canopy coverage from all plots in a sequence of drone images and fitting logistic curves to the time series.

FISHKIS, OLGA* and HEINZ-JOSEF KOCH, Institute of Sugar Beet Research, Holtenser Landstraße 77, 37079 Göttingen **Evaluation of potential environmental and economic risks of mechanical weed control in sugar beet.**

Sugar beet field trials were conducted in Southern Lower Saxony to evaluate the potential risks of mechanical, combined mechanical-chemical and chemical weed control. Here we present our first results on the impact of each weed control method on soil erosion, soil structure, earthworm population and crop yield. Most striking results were obtained in regard to soil erosion in 2019. At Site 1 the cumulative soil loss was two times higher for hoeing than for spraying, most probably due to increased soil roughness through hoeing. At Site 2, however, the cumulative soil loss was eight times lower for hoeing than for spraying due to increased infiltration and retarded onset of surface runoff under hoeing. Earthworm population and crop yield were only slightly affected by hoeing operations. The ratio of endogeic to anecic earthworm biomass was significantly reduced by hoeing at Site 2 but not affected by weed control method at Site 1. A slightly higher sugar- and root yield was collected for spraying in comparison to hoeing at Site 1, but no difference in yield was found between weed control methods at Site 2. The slight decrease in yield under hoeing compared to spraying (Site 1) was in line with a bigger mulch loss under hoeing.

FUGATE, KAREN*[1], JOHN EIDE[1], ABBAS LAFTA[2], MOHAMED KHAN[2] and FERNANDO FINGER[3], [1]USDA-ARS, [2]North Dakota State University, [3]Federal University of Vicosa, [1]USDA, Agricultural Research Service, ETSARC, 1616 Albrecht Blvd. N., Fargo, ND 58102, [2]Dept. of Plant Pathology, North Dakota State Univ., Fargo, ND 58108, [3]Dept. de Fitotecnia, Federal Univ. de Viçosa, 365712-000, Viçosa, MG, Brazil
Transcriptional changes during storage identify genes potentially involved in sucrose loss and carbohydrate impurity formation in postharvest sugarbeet roots.

During storage, sugarbeet roots lose sucrose and commonly accumulate carbohydrate impurities such as glucose, fructose and raffinose that interfere with processing. Although these processes are economically important to the industry, amazingly little is known of the genetic changes in stored sugarbeet roots that are responsible for sucrose degradation and conversion to other carbohydrates. Therefore, research was conducted to identify genes contributing to sucrose catabolism in stored sugarbeet roots by analyzing gene expression and metabolite concentration changes in sugarbeet roots stored at 5 and 12°C for up to 120 days. Gene expression and metabolite concentrations were quantified by RNA sequencing and HPLC-MS analysis, respectively, in roots at time of harvest and after 12, 40, and 120 days in storage. Metabolite analysis documented a decline in sucrose and an increase in glucose and fructose during storage at both temperatures, while raffinose concentration increased during storage in roots stored at 5°C but not in those stored at 12°C. Gene expression was minimally altered for the enzymes, sucrose synthase and invertase, which are directly responsible for sugarbeet root sucrose degradation. In contrast, five genes encoding bidirectional sucrose transporters were highly upregulated during storage. Although uncharacterized in sugarbeet, these proteins facilitate sucrose transport across membranes in other plant species and may have a role in remobilizing stored sucrose to allow its reentry into active metabolism in the sugarbeet taproot. Respiratory and fermentative pathway enzymes were also altered during storage, most

notably the glycolytic enzyme, fructose-bisphosphate aldolase and several enzymes involved in ethanol production. Gene expression for galactinol synthase and raffinose synthase, two enzymes of cardinal importance in raffinose biosynthesis, increased in roots stored at 5°C but not at 12°C, with similarities to raffinose accumulation in these roots. Overall, this research identifies genes with potential roles in sucrose loss and carbohydrate impurity formation during storage. Additional research, however, is required to establish their role in postharvest sugarbeet root deterioration.

GALEWSKI, PAUL J* and IMAD EUJAYL, USDA-ARS – Northwest Irrigation and Soils Research Laboratory **A roadmap to durable BCTV resistance using long-read genome assembly of genetic stock KDH13.**

Beet curly top (BCT) is a viral disease which negatively impacts crop productivity for sugar beet growers and the sugar beet industry in the western US and dry regions worldwide. Current varieties exhibit little genetic resistance to the Beet curly top virus (BCTV), suggesting there is a large potential for improvement. KDH13 (PI 663862) is a double haploid line created from a population (C762-17/PI 560130) which segregates for BCT resistance and was identified as genetic stock for the improvement of sugar beet resistance to BCTV. PacBio sequences were generated and assembled to better define the content and organization of variation within the KDH13 genome and to provide resources to identify specific variation underpinning durable genetic resistance. Using /ab-inito/ predicted proteins as anchors, the assembled KDH13 contigs were placed in a more contiguous order using the EL10.1 reference genome, which leveraged Bio-Nano optical maps and Hi-C proximity information for chromosome level scaffolding. In total, 4,681 (75%) of the 6,245 contigs were placed in the order and orientation of the EL10.1 genome. The anchored contigs represented 502,929,268 bp (87.7%) the KDH13 genome assembly. An F1 hybrid, and parental lines KDH13 (resistant) and KDH19-17 (susceptible) were sequenced using Illumina technology in order to characterize the SNP, indel and structural variation between parental lines and allow for a more detailed investigation into causal variation linked to important phenotypes. In total, 11,675,321 variants were detected, 3,377,004 SNP and 602,704 indels contained the ability to discriminate between the two parents. KDH13 contained 1,642,083 SNP and 308,615 indels identified as unique. This information represents a high-density marker dataset distributed across the beet genome and can be used to track genomic segments in populations where KDH13 is used as parental material to improve BCTV resistance.

GROEN, CODY, Southern Minnesota Beet Sugar Coop **Manipulating sugarbeet plant population to compensate for high nitrogen fertility in southern Minnesota.**

As sugar beet production approaches or surpasses factory slice rate and process capacity, increasing the amount of sugar in each sugar beet becomes emphasized. A major obstacle to raising a high sugar, high quality sugar beet is excessive nitrogen fertility. Sugar beet yield increases with nitrogen fertility, but sugar beet quality is detrimentally impacted by nitrogen fertility. The objective of this study was to determine if a producer can increase harvest plant population in high nitrogen situations and mitigate the negative impacts of the excess nitrogen. This study was conducted in two environments during the 2019 growing season in a replicated complete block design with a split plot arrangement of six replications. Four nitrogen rates comprised the whole plot and two plant populations comprised the split plot arrangement and were applied at both locations. Fertilizer was applied by hand to reach a total available soil nitrogen level of 120, 160, 200, and 240 lbs ac^{-1} and incorporated with a field cultivator. Sugar beet was planted at a rate of 120,000 plants ac^{-1} to ensure adequate establishment and stands were thinned after stand establishment to populations of 43,800 and 71,300 plants ac^{-1}. Nitrogen rate significantly affected quality parameters of percent sugar, percent purity, brei nitrate ppm, and extractable sugar per ton, and the highest quality sugar beet crops were produced on soil fertilized to 120 lbs total available soil N ac^{-1}. Plant populations did not significantly impact sugar beet quality, but did significantly impact sugar beet yield and extractable sugar per acre. Extractable sugar per acre was maximized at 120 lbs available soil N ac^{-1} and 71,300 plants ac^{-1}. Extractable sugar per ton was maximized at 120 lbs N per acre.

HERRSTRÖM, JOAKIM*[1], PER SNELL[1], TYLER RING[2] and BRITT-LOUISE LENNEFORS[1], [1]MariboHilleshög Research AB, [2]Hilleshog Seed LLC, [1]Säbyholmsvägen 24, 261 91 Landskrona, Sweden, [2]1020 Sugar Mill Road, Longmont, CO 80501 **Breeding of sustainable Cercospora resistant varieties for the US market.**

Cercospora is globally one of the most devastating sugar beet diseases and sustainable resistance in sugarbeet varieties are required. Hilleshög has developed for many years Cercospora resistant varieties with good root quality parameters. In the Michigan Sugar growing area Hilleshög offers some of the industry leading fully approved varieties and has always been a leader in that area of disease resistance. The resistance is built on a number of gene sources to make the resistance sustainable. Different screening platforms are used to be able to select for the best lines. It includes observation trials, yield trials, greenhouse tests and marker analyses. Recently, several mapping populations based on novel resistance sources have been developed and genotyped using a high-density SNP array. Using genome-wide association studies, several novel QTLs were detected. Identified QTLs were then verified using a cross-validation approach, revealing several robust QTLs with both dominant and additive effects. Additionally, these analyses reveal the presence of both strong single Cercospora resistance QTLs as well as regions carrying several weaker QTLs, potentially indicating late gene duplication events. Varieties built on the novel resistance sources are on the way to market. It is important to maintain strong disease package and maximing the sugar content while combating leaf disease complex of Cercospora and Alternaria to meet the needs of the market.

KAFFKA, STEPHEN*[1], MICHAEL RETHWISCH[2], AND BRYAN VAN DER MEY[1], [1]Department of Plant Sciences, Univ of California, Davis; [2]UCCE Riverside County, One Shields Avenue, Davis, CA 95616
Alternatives to chlorpyrifos for sugarbeet production in the Imperial Valley of California.

This research focusses on identifying less toxic substitutes for chlorpyrifos (Lorsban®) in sugarbeet production in the Imperial Valley. Chlorpyrifos is a known neurotoxin and affects both humans and other animal and fish species. It is hazardous to applicators and workers, has been shown to accumulate in the Salton Sea and has been restricted in California. The primary insects affecting stand establishment are diverse flea beetle species, primarily pale stripped flea beetle (*Systena blanda*) and armyworm species (*Spodoptera sp.*). In spring with rising temperatures, army worms and diverse leaf hoppers (*Empoasca sp.*) can reach pest level. Low risk strategies for stand establishment emphasize IPM practices including pre-irrigation of fields, dates of planting, and seed treatments. Low risk strategies for late season insect control include the avoidance of treatment for early season harvest, improved scouting and sampling techniques and the use of biologicals and natural controls. Two complementary field experiments are being carried out at UC Desert Research and Extension Center (DREC), integrated with complementary trials in 3 growers' fields. Poncho Beta® (clothianidan + cyfluthrin-PB) seed treatments are a reduced toxicity standard common to all station and field experiments. Data collected include seedling emergence and loss, seedling dry weight at establishment, season-long estimates of insect pest abundance and damage, yield and root quality, and comparative costs of differing treatments. At the UC DREC, pesticide treatments are compared to untreated controls within pre-irrigated or dry-planted treatments, at two different planting dates (mid-September and mid-October). Additional soil treatments at planting are compared and include granular, soil-applied chlorpyrifos, Coragen® (chlorantaniliprole), PB seed treatments and PB plus Coragen®. These plots are split and half include additional post emergence control with Asana® (esfenvalerate), commonly used in growers' fields. A randomized block design is used in growers' fields with three treatment comparisons. Strips (plots) 50 to 60 feet wide the length of the field are compared. The common practice used by each grower is the control in each field, and PB seed treatment is a second treatment in all locations. The third treatment varied and depended on the choices of each grower and their PCA. Observations from the fall 2020 stand establishment period (September to November) are reported. The efficacy of different approaches to pest management research, inference, and approaches to pest management by PCAs in the Imperial Valley are discussed.

KAFFKA, STEPHEN*[1], PETER ROBINSON[2], NICK CLARK[3], AND GENE AKSLAND[4], [1]Depar. of Plant Sciences, [2]UC Davis; Department of Animal Sciences, UC Davis; [3]UCCE-Tulare County, and [4]Agronomic Services, Visalia, California, Davis, California, 95616 **Growing and feeding sugarbeets to dairy cows in the San Joaquin Valley of California.**

Sugarbeets were widely grown throughout California during the 20th century, but the last sugar factory in the northern California closed in 2008. In the absence of a sugar industry, interest in the use of sugarbeets as a silage feedstock for dairy cows has grown, especially in the San Joaquin Valley (SJV). Increasing regulatory restrictions on the availability of water for irrigation and stricter controls on nutrient management support the use of alternative crops by dairy producers that are both water use efficient and capable of recovering both water and nutrients at depth in the soil profile. Sugarbeets can be planted in fall in the SJV, and harvested in late spring/early summer. When grown through the winter, water use is approximately half that of a summer crop (2 to 2.5 ac ft compared to 4 ac ft). And beets have been documented recovering water and nutrients at 3 m in depth in previous studies in the region, deeper than alternative winter annual forages. Most, if not all pests and pathogens common to summer crops are avoided during winter. While of no interest to the sugar industry, if winter beet production proves viable on dairies in the San Joaquin Valley, a large market for hybrid seed would develop, potentially dwarfing previous uses for sugar alone in the region. Two trials on dairy farms growing and feeding sugarbeets for silage have been carried out during the 2018 to 2020 period. Beets were planted using strip tillage methods following corn silage in fall (late October and early November) in heavily manured fields and harvested in early June to late June. Root yields varied from 58 t/ac (+/- 11 t/ac) in year one to 43 t/ac (=/- 6 t/ac) in year two. Tops were not harvested due to concerns about nitrate content and technical limitations around harvesting and feeding. No pest or disease issues were observed in either year. In both years, beets were co-ensiled in ag-bags with almond hulls to absorb seepage and adjust silage dry matter to approximately 38%. Beet silage combined with almond hulls was similar to corn silage in quality and readily consumed by dairy cattle

as part of total mixed rations. Silage quality was similar in both years despite varying skill in producing the crop between the two dairy farms. A third year's trial is currently underway. Beets show considerable promise as a new winter forage feed for the San Joaquin Valley. Barriers to adoption include the need for beet harvesters and forage transport adapted to beets otherwise absent on dairy farms, the need for greater care in crop production compared to corn and small grain silages, especially during stand establishment, and more precise information on feeding values associated needed by dairy nutritionists.

KNISS, ANDREW R., University of Wyoming, Plant Sciences, Dept. 3354, 1000 E. University Ave, Laramie, WY 82071 **Helping glufosinate work in the West.**

Glufosinate provides variable weed control in the Western US, in part, due to low relative humidity near the time of application. Field studies were conducted under irrigated and dryland locations near Lingle, Wyoming in 2019 and 2020 to evaluate adjuvants and glufosinate rates to improve weed control. Glufosinate was applied once at rates of 0.45, 0.59, 0.74, and 0.84 kg ha^{-1}. Glufosinate was applied sequentially at rates of 0.45 followed by (fb) 0.45 kg ha^{-1}, 0.59 fb 0.45 kg ha^{-1}, and 0.59 fb 0.59 kg ha^{-1}. Adjuvant treatments included a humectant, an acidifying agent, a high-surfactant oil concentrate, and a non-ionic surfactant. All treatments included ammonium sulfate. Glyphosate treatments (applied at 0.75 or 1.12 kg ha^{-1}) were included as comparison treatments. Two sequential glufosinate applications 7 days apart provided better kochia and common lambsuqarters control than any single application of glufosinate.

LAMB, JOHN*[1], RYAN KOWTA[2], ISRAEL SANTIAGO[2] and MARK BLOOMQUIST[3],
[1]Univ. of Minnesota, 2182 Woodbridge Way, Woodbury, MN 55125, [2]Spreckels Sugar Company, 95 West Keystone Rd. Brawley, CA 92227, and [3]Southern Minnesota Beet Sugar Cooperative, 83550 County Road 21, Renville, MN 56284. **At What Plant Stand is Replanting Needed.**

Establishing an optimum sugar beet plant stand is important to maximizing extractable sucrose yield in the Imperial Valley of California. If conditions are right at planting, then an optimum stand is the result. If there are problems such as seed quality, hot weather, or crusting soil, the stand will be reduced. Currently, the growers in the Imperial Valley aim for a plant stand of 30 sugar beet plants per ten feet of row for optimum production. At what plant stand should a grower decide to replant when the emergence is sub-optimal? The objective of this study was to determine the threshold plant stand that requires replanting in early and late harvest sugar beet production in the

Imperial Valley of California. A study was conducted with five site years, two early harvest trials and three late harvest trials. The treatments were sugar beet stands of 10, 14, 18, 22, 26, 30, and 34 plants per 10 feet of row. While the treatments with 22, 26, 30, and 34 beet plant stands were thinned to a uniform stand, the 10, 14, and 18 plant plots were thinned unequally simulating an uneven stand that occurs with poor emergence (gappy). The plots were four 30 inch rows and a length of 20 ft. Each site had a randomize complete block design with four replications. This study would indicate that decision of replanting is not influenced by harvest date. The optimum plant stand in recent studies is around 24 plants per 10 feet of row. Good yields of extractable sucrose per acre can be obtained most of the time with a stand as low as 14 plants per 10 feet of row. The results from this study would not recommend replanting a of stand greater than 14 plants per 10 feet or row. A population of less than 14 on late harvest sugar beet can cause harvest issues because of variable size roots.

PETERS, THOMAS J.*[1], ALEXA L. LYSTAD[1] and DAVID C. METTLER[2], [1]North Dakota State University / University of Minnesota, [2]Southern Minnesota Beet Sugar Cooperative, [1]Dept. 7670, PO Box 6050, Fargo, ND 58108-6050, [2]83550 County Road 21, Renville, MN 56284
Hooded sprayer for application of nonselective herbicides in sugarbeet.

Sugarbeet producers recognized waterhemp as their most troublesome weed control challenge on 373,064 acres or 59% of the production acreage in Minnesota and eastern North Dakota in 2020. Waterhemp is controlled using soil residual herbicides applied preemergence, early postemergence, and postemergence in sugarbeet. Control is dependent on timely rainfall following application to move herbicides into the weed zone or 2-cm from the soil surface for optimal control. Desmedipham plus phenmedipham or triflusulfuron-methyl postemergence and inter-row cultivation have been used for waterhemp control when there are performance challenges. However, remnant supplies of desmedipham plus phenmedipham have been exhausted, triflusulfuron-methyl resistant waterhemp populations plague the production area, and inter-row cultivation for weed control is not a common production practice. Glyphosate applied through the hooded sprayer in cotton improved weed control while not affecting cotton tolerance. Use of nonselective postemergence sugarbeet herbicides through the hooded sprayer are being evaluated as a control method for herbicide-resistance species and a preemptive solution for Palmer amaranth in sugarbeet. Experiments conducted in 2020 evaluated sugarbeet tolerance and weed control from glyphosate, glufosinate, and paraquat applied through the hooded sprayer at multiple locations in Minnesota and North Dakota. Glyphosate, glufosinate, and paraquat

were applied between sugarbeet rows to 4-, 8-, and 12-leaf sugarbeet and on weed species 10- to 23-cm in height. Paraquat applied at the 4-leaf sugarbeet stage reduced sugarbeet stature early in the growing season, however, stature reduction became negligible as the sugarbeet developed. Yield components were not affected across all treatments and timings. Paraquat at 0.55 kg a.i. ha^{-1} plus non-ionic surfactant (NIS) and glufosinate at 0.88 kg a.i. ha^{-1} plus ammonium sulfate (AMS) improved 10-cm and 15-cm waterhemp control as compared to repeat glyphosate applications at 1.10 / 1.10 kg a.i. ha^{-1} plus NIS and AMS. Repeat glyphosate applications controlled common lambsquarters greater than glufosinate at either rate or application timing. Paraquat at 0.55 kg ha^{-1} controlled 13-cm common lambsquarters similarly to glyphosate but controlled 23-cm common lambsquarters less than glyphosate.

SCHLINKER, GERO, Betaseed GmbH, Friedrich Ebert-Anlage 36, 60325 Frankfurt, Germany. **Mechanical weed control in sugarbeet – European experiences and outlook.**

Sugarbeet cultivation is only successful with efficient weed control, otherwise the different weed species would compete for nutrients, water and radiation from sugarbeet. Weed control in the EU is done by a combination of herbicide applications of two to six times regarding weed pressure and the recommendations in the different countries. In these systems no mechanical weeding is integrated. Due to an increasing demand for a lower input of agrochemicals and the ban of important active ingredients the interest and activities in mechanical weeding in sugarbeet is growing. In most cases a combination of hoeing and application of herbicides is used. This can be achieved by band spraying of the sugarbeet and inter-row hoeing or displacing one broadcast application by one pass with a mechanical hoe. Nevertheless, weeding strategies with intra-row weed control are necessary to fulfil the demands of organic sugarbeet production. Trials (IfZ/KA 2014, 2015) with different combinations of herbicide application and mechanical hoeing showed comparable results in respect of efficacy. Hoeing combined with band spraying reduced herbicide costs by 60 %. Still lower acreage capacity plus weather and soil conditions are more crucial for mechanical weeding. Different developments are on the way to be effective in respect to: – efficacy of mechanical weeding, – accuracy of hoeing, – labour cost. These requirements can be achieved by combining: – Time tested implements of inter-row hoeing installed to frames which cover 18 rows respectively 9 m at least. – Camera and/or GPS-RTK guided hoes which improve the steering. New implements like finger weeders or torsion weeders which do intra-row hoeing show promise. In the future automated systems with the identification of sugarbeet plants will allow hoeing in the row. The use of robots is also progressing and could be the way of the future.

SELS JAN*[1], OLIVIER AMAND[1], MAARTEN VANDERSTUKKEN[1], IBRAHEEM ADETUNJI[1], GLENDA WILLEMS[1], DAN BJUR[2], MARK ANFINRUD[2] and HENDRIK TSCHOEP[1], [1]SESVANDERHAVE, [2]SESVANDERHAVE USA, [1]Industriepark 15, BE- 3300 Tienen, [2]5908 52ND AVE S, Fargo, ND 58104 **A trait stacking breeding approach for increased stability in variety performance – an Idaho case study.**

In this paper we describe the approach for multiple trait stacking in sugar beet variety development. As a case study, the focus will be on variety development for Idaho market. Traits required for the variety approvals in Idaho, such as curly top tolerance requirements, strong rhizomania tolerance, but as well traits as nematode tolerance, powdery mildew resistance and specific adaptation to Idaho environment and abiotic factors will be discussed. The target is on combining these traits, and at the same time ensuring high yields and high sugar contents to meet the future market requirements. An outline will be given on the breeding tools used in this approach, such as disease nurseries, bio-assays and field trials, and the combination with in-house developed genetic marker tools. The stability of variety performance, as a result of this trait stacking, is monitored over multiple years across the proprietary Idaho field trials and results will be shown.

STRAUSBAUGH, CARL A.*[1] and ERIK J. WENNINGER[2], [1]USDA-ARS, [2]University of Idaho, [1]USDA-ARS NWISRL, 3793 North 3600 East, Kimberly, ID 83341, [2]Kimberly Res. & Ext. Center, 3806 North 3600 East, Kimberly, ID 83341 **Beet leafhopper populations and Beet curly top virus strains in southern Idaho.**

Curly top caused by *Beet curly top virus* (BCTV) is a widespread disease problem vectored by the beet leafhopper (BLH; *Circulifer tenellus* Baker) in semiarid sugar beet production areas. Host resistance is the primary defense against curly top, but resistance in commercial cultivars is only low to intermediate perhaps in part because strain-specific host resistance may not match strain prevalence in the field. Thus, an investigation was initiated into the distribution and abundance of BLH over time and the BCTV strain types present in the insects. Using yellow sticky cards (4 x 5 inch), BLH numbers were assessed in 8 counties in southern Idaho twice a month from May through September in 2019. Subsamples of BLH (samples contained from 1-5 BLH) were collected and investigated for biotype (sequencing cytochrome oxidase gene; COI), BCTV strains, and phytoplasmas. The BLH populations at desert and sugar beet sites in all counties peaked in late July and early August in 2019. Cards at dry bean sites tended to peak when the crop was cut and dried for harvest in August and September. BCTV was found in 51% of the BLH samples with the following strain mix: 11% of samples had CA/Logan, 6% Severe, and 70% Wor-like (either Worland and/or Colorado strains). The Wor-like samples were evenly distributed since 37, 33, and 30% of the samples came from dry bean, sugar beet, and desert sites, respectively. These BCTV strain results mirror what was found in sugar beet plants in recent years. Based on COI sequencing, the BLH population was dominated by two haplotypes. No phytoplasmas were detected. The BLH survey will be conducted again in 2020 and 2021 while doubling sampling frequency and reducing the number of sites to four.

TARKALSON, DAVID*[1], DAVID BJORNEBERG[1], and DAVEY OLSEN[2]; [1]USDA-ARS Kimberly Idaho, [2]Amalgamated Sugar Company **Static Range Nitrogen Management in Northwest U.S. Sugarbeet Production.**

Nitrogen (N) management is important in sugarbeet production. This paper presents data to support a shift from a yield-based N management approach to a static range N management approach in the Northwest U.S. Production data and research show that yield-based N management can result in over application of N. Past research has been critical to improving and understanding sugarbeet N nutrition. However continued research is needed so cumulative data can be evaluated to improve management practices. From 2005 to 2019, studies from 20 locations (20 site-years) were conducted by agronomists from The Amalgamated Sugar Company (TASCO) and scientists at the USDA-ARS Northwest Irrigation and Soils Research Laboratory to evaluate the effect of N supply (fertilizer N + spring soil residual N (Nitrate N + Ammonium N) on sugarbeet production in the Pacific Northwest. Eleven of the site-years had a significant relationship between N supply and ERS yield. Nine of the site-years did not have a significant relationship between N supply and ERS yield. The amount of N supply needed to maximize yields in the 11 responsive sites research studies was within N supply range of 129 to 258 kg/ha (115 to 230 lbs N/acre). Using the past yield-based N management approach (3.5 kg N/metric ton beet [7 lbs N/ton beet]), recommended N supplies would have ranged from 213 to 325 kg/ha (190 to 290 lbs N/acre) from 2005 to 2019. Data shows that needed N supplies to maximize yields have not increased as yields have increased over time. Variation in the needed N supplies are likely due to spatial and temporal variability, and producer knowledge of the fields will help them dial in the needed N supply, preventing over supply of N.

TARKALSON, DAVID*[1], ROB DUNGAN[1], DAVE BJORNEBERG[1], USDA-ARS, 3793 NORTH 3600 EAST Kimberly, ID 83341-5076 **Dairy Manure and Fertilizer Effects on Microbial Activity of an Idaho Soil Growing Sugar Beet.**

Dairy manure applications that have occurred in the past can have long-term lingering effects on crop production. Understanding the cause is important for current and future management practices. This study was

conducted to assess selected microbial activity among past manure application rates. In a past study (2014-2016) in Kimberly Idaho, historic manure applications have been shown to have significant positive and negative effects on sugar beet production. The manure treatment history (2004 to 2009) was manure applied at a total cumulative amount of 0, 135, 238 dry Mg/ha. The 0 Mg/ha treatment received commercial fertilizer based on University of Idaho recommendations from 2004 to 2009. Starting in 2019, these main plots were divided in to thirds and three N rate treatments were applied annually. In spring 2020, soil samples were collected from the 0-15 and 15-30 cm depth from the highest N rate treatment of each past manure treatment. The soil samples were analyzed for -glucosidase, -glucosaminidase, phosphomonoesterase, arylsulfatase enzymes and autoclaved citrate extractable (ACE) soil protein assay. -glucosidase, -glucosaminidase, phosphomonoesterase, arylsulfatase enzymes, and ACE were higher for the 135 and 238 dry Mg/ha manure treatments than the 0 dry Mg/ha manure treatment (fertilizer only). Manure last applied 11 years ago, still has a significant effect on the soil microbial activity.

TARKALSON, DAVID, USDA-ARS NWISRL, 3793 North 3600 East, Kimberly, ID 83341 **Sugar Beet Lime Effects on High pH Soils and Crops in the Northwest U.S.**

A viable solution to dispose of sugar beet precipitation calcium carbonate (PCC) is needed due to the unsustainable issues associated with storage. Sugar beet PCC is a lime material produced as a waste product from extracting sugar from sugar beet. The three main sugar beet processing factories in the Amalgamated Sugar Company growing area in Idaho and Oregon have stockpiled approximately 11.3 million Mg of PCC. Each year these three factories produce a total of 350,000 Mg annually. A 6-year study was conducted to evaluate the effects of lime application on soil properties and yields of sugar beet, dry bean, and barley. Treatments were: 1) lime applied at a rate of 6.7 Mg/ha annually for 3 years, 2) lime applied at a rate of 22.4 Mg/ha annually for 3 years, and 3) A one-time lime application of 89.7 Mg/ha. The treatments were replicated 4 times in a randomized block design. The lime was first applied in fall of 2014 with the cropping rotation of sugar beet-dry bean-barley starting in 2015. The life of the study allowed two full rotations. In the fall of 2014 before lime applications and every subsequent spring, soil samples (0-30.5 cm) were taken in each plot. Soil samples were analyzed for pH, electrical conductivity, bicarbonate extractable P, and for selected metals. Preliminary results show that lime applications do not affect crop yield or quality. Effects on soil properties will be presented. Initial data suggests that PCC can be applied to high pH soils, with similar properties in this study, in the Amalgamated Sugar Company growing area and not have negative effects on crop production.

Agronomy
Poster Presentations

ANDERSON, JAY F.* and PETER J. REGITNIG, Lantic Inc., 5405 – 64 Street, Taber, AB T1G 2C4 **How does nitrogen fertilizer rate affect sugar beet quality and root yield in low, medium and high plant populations?**

Sugar beet plant population tests were conducted in Alberta from 2016 to 2019 to determine if plant population recommendations were still accurate under the current Roundup Ready cropping system. Although not statistically significant, this recent work found that under optimal soil fertility conditions, 150-175 plants/100ft row produced the highest recoverable sugar per acre (RSA) in all four test years. This recent plant population work did not consider scenarios where soil nitrogen levels were not optimal. Producers in Alberta may encounter situations where soil nitrogen levels are not ideal, perhaps where soil nitrogen is excessive. In 2020, a test was conducted to evaluate three different sugar beet plant populations with three nitrogen fertilizer regimens using a current commercially approved sugar beet variety. This type of work has not been explored previously in Alberta. Root yield and quality was measured to determine treatment effects.

BERNHARDSONS, DUANE*[1], ELKE HILSCHER[2] and HEIKO NARTEN[2], [1]KWS Seeds LLC, [2]KWS SAAT SE&Co. KG aA, [1]1500 S 40th St, Grand Forks ND 58201, [2]Grimsehlstrabe 31, Einbeck Germany 37555 **KWS BEETROMETER® – Advancing Beet Quality Analysis.**

The BEETROMETER® is a patented system which provides advanced automated technology for the analysis of whole sugarbeet samples using a dioad array – NIRS spectrometer. Samples are chopped into small uniform pieces on to the conveyor belt in a homogenized stream. The spectrometer records a single spectrum every 40ms, leading to a total of at least 400 spectra measurements per 40 kg sample. This leads to the entire heterogeneity of a beet sample is captured with accurate results delivered in 20 seconds. An advancement in this technology is that all the sample data collected is stored electronically. As new calibrations are developed, past data can be re-evaluated, unlike current methodology, in that once the sample is analyzed, it is gone. Having over 10 years of Research and Development together with KWS' breeding operations and industry partners has resulted in highly accurate measurements for quality parameters such as sugar content, dry matter and recoverable sugar. Development work has been ongoing for analyzing sugarbeets beyond sugar. Examples of new developments which will provide upgrades to the current system with additional calibrations and software upgrades will be presented.

GRUNWALD, DENNIS*, PHILIPP GÖTZE and HEINZ-JOSEF KOCH, Institute of Sugar Beet Research, Holtenser Landstraße 77, 37079 Göttingen, Germany **Effects of contrasting sugar beet rotations and residue management on soil organic carbon stocks.**

Crop rotation and residue management affect soil organic carbon (SOC) pools through variations in tillage intensity among the used crops and the variable input of organic matter. In a long-term crop rotation trial near Göttingen, Germany, sugar beet yield differed depending on the preceding crop; further, yield of second winter wheat after sugar beet differed due to the removal or addition of sugar beet leaves and tops. Such findings might be related to differences in SOC stocks among the crop rotations and the amounts of sugar beet residues remaining on the field. In order to clarify the effects of crop rotation and residue management on SOC stocks under sugar beet, soil samples to determine SOC concentrations and soil bulk density were taken in sugar beet plots of the above-mentioned crop rotation trial in spring of 2018 and 2019 in 0-10, 10-20 and 20-30 cm soil depth. The following crop rotations were sampled: (i) SB (sugar beet) – WW (winter wheat) – WW, (ii) SB – WW – SM (silage maize) and (iii) SB – WW – WOR (winter oilseed rape) – WW – WW – GP (grain pea). As catch crops, mustard was grown before SB and SM, and phacelia before GP. In addition, the first rotation (SB – WW – WW) was replicated in the trial to include a further variant in which all sugar beet residues (leaves and tops) were moved from one half of the plot to the other, resulting in the double amount or lack of residues when compared to the regular variant of this rotation. Preliminary results suggest higher SOC stocks with an increasing share of winter wheat in the crop rotation or a larger amount of beet residues as well as lowest SOC stocks in the crop rotation with maize.

LAWRENCE, NEVIN*[1], ANDREW KNISS[2], JOEL FELIX[3] and CLARKE ALDER , [1]University of Nebraska, [2]University of Wyoming, [3]Oregon State University, Amalgamated Sugar, [1]4502 Ave I, Scottsbluff, NE 69361, [2]1000 E University Ave, Laramie, WY 82071, [3]595 Onion Ave, Ontario, OR 97914, The Amalgamated Sugar Co., Nampa, ID 83687 **Efficacy of Metamitron Applied PRE in the High Plains and Intermountain West Sugar Beet Production Region.**

There are currently no effective herbicides for managing glyphosate and ALS-resistant kochia (*Bassia scoparia*) and Palmer amaranth (*Amaranthus palmeri*) in sugar beet. In 2019 and 2020, the herbicide metamitron was evaluated for crop safety and herbicide efficacy on various weeds. The study was established in 2019 at Lingle, WY with common lambsquarters (*Chenopodium album*) and redroot pigweed (*Amaranthus retroflexus*) being the dominant weeds; Scottsbluff, NE in 2019 and 2020 where Palmer amaranth and common lambsquarters were dominant weeds; in 2020 in Ontario, OR in a field with redroot pigweed, common lambsquarters, and kochia (*Bassia scoparia*) being dominant weeds, and in 2020 in Nyssa, OR with redroot pigweed, common lambsquarters, and kochia being dominant. Cycloate (3.36 kg a.i. ha^{-1}), ethofumesate (1.47 kg a.i. ha^{-1}), metamitron (2.8, 5.6, and 7 kg a.i. ha^{-1}) standalone, and metamitron (5.6 kg a.i. ha^{-1}) + ethofumesate (1.47 kg a.i. ha^{-1}) were applied PRE. Additionally, Metamitron (5.6 kg a.i. ha^{-1}) + ethofumesate (1.47 kg a.i. ha^{-1}) was applied PRE followed by (fb) either ethofumesate (2.21 kg a.i. ha^{-1}) at the sugar beet two true leaf (2TL) stage, acetochlor (1.26 kg a.i. ha^{-1}) at 2TL, ethofumesate (2.21 kg a.i. ha^{-1}) at 2TL stage fb acetochlor (1.26 kg a.i. ha^{-1}) at 8TL, or acetochlor (1.26 kg a.i. ha^{-1}) at 2TL and 8TL. A non-treated check and weed-free check were included. No sugar beet injury was recorded across all study locations and years. At the Lingle and Scottsbluff locations metamitron followed by ethofumesate or acetochlor provided control similar to the weed-free control. At Scottsbluff and Lingle metamitron alone provided control past 4 TL (2.8 kg a.i. ha^{-1}) and 6TL (5.6 kg a.i. ha^{-1}) while metamitron PRE fb acetochlor POST provided season-long weed control without the use of glyphosate POST. At the Nyssa and Ontario locations control of redroot pigweed and common lambsquarters was comparable to what was observed at Scottsbluff and Lingle locations. Kochia control, however, was poor at both Nyssa and Ontario. Metamitron provides excellent PRE control of common lambsquarters and pigweed species at the rates used across locations, but kochia control was poor compared to the weed-free check.

SPRAGUE, CHRISTY L., Michigan State University, 1066 Bogue Street, East Lansing, MI 48824 **Experiences with sugarbeet tolerance to acifluorfen in Michigan.**

The lack of postemergence herbicide options to control glyphosate-resistant waterhemp is a concern for sugarbeet growers. In the past, sugarbeet has shown some tolerance to the Group 14 herbicide, acifluorfen (*Ultra Blazer*). In soybean, acifluorfen's strengths include control of *Amaranthus sp.* (including waterhemp), eastern black nightshade, and common ragweed. If sugarbeet tolerance is high, perhaps special labeling could be pursued for acifluorfen use in sugarbeet. In 2018, 2019, and 2020 field research trials were conducted in Michigan to examine sugarbeet tolerance to acifluorfen. Acifluorfen in combination with glyphosate (0.84 kg ae ha^{-1}) was applied at rates ranging from 0.14 to 0.43 kg ai ha^{-1} to sugarbeet at the 2-, 4-6, and 12-leaf stages. This combination was also applied with the common tank-mix partners of clopyralid, ethofumesate, s-metolachlor, or acetochlor at 6-leaf sugarbeet. Multiple applications of acifluorfen or acifluorfen applied to 2-leaf sugarbeet resulted in unacceptable sugarbeet injury (>40%) and caused substantial yield loss compared with glyphosate alone applied three times. Acifluorfen applications to 6- or

12-leaf sugarbeet caused significant injury, but in many cases outgrew this injury relatively quickly and did not result in significant yield loss. Sugarbeet yield loss was also observed when acifluorfen was applied in combination with ethofumesate. While sugarbeet injury is a concern with acifluorfen, applications to sugarbeet at the 6-leaf stage or greater could be an option for postemergence glyphosate-resistant waterhemp control and special labeling should be pursued with caution.

SPRAGUE, CHRISTY L., Michigan State University, 1066 Bogue Street, East Lansing, MI 48824 **Overlapping residuals for control of glyphosate-resistant waterhemp in sugarbeet.**

Glyphosate- and multiple-resistant waterhemp is quickly becoming one of the most difficult weeds to control in sugarbeet. Waterhemp's extended emergence, rapid growth rates, and the lack of postemergence herbicide options necessitates the use of creative options to manage waterhemp. Residual herbicides, including ethofumesate and several Group 15 herbicides, will likely need to be apart of these programs. In 2018, 2019, and 2020 field research trials were conducted in Michigan to examine: sugarbeet tolerance and the effectiveness of overlapping residual herbicides applied postemergence alone, and following a preemergence application of ethofumesate (1.12 kg ha^{-1}) or a reduced rate s-metolachlor (0.53 kg ha^{-1}) on waterhemp. Overlapping residual herbicide treatments include: 1) s-metolachlor at 1.06 kg ha^{-1}, 2) acetochlor at 1.26 kg ha^{-1}, 3) dimethenamid-P at 0.56 kg ha^{-1}, and 4) ethofumesate at 1.12 kg ha^{-1} + HSOC tank-mixed with glyphosate + AMS applied twice at 2- and at 6-8 leaf sugarbeet. Over the three years, the most consistent waterhemp control included the use of a preemergence herbicide either ethofumesate or s-metolachlor followed by one of the overlapping herbicide programs. In most cases, these programs also did not significantly influence sugarbeet yield. It is important to remember that the residual herbicide will not control emerged waterhemp. This is where understanding the time of waterhemp emergence in relation to sugarbeet planting is important. Most of Michigan's waterhemp populations start to emerge the 3rd or 4th week of May. The first application of a residual herbicide would need to be applied prior to waterhemp emergence. If sugarbeets are planted later, the use of a preemergence herbicide would be needed.

STILES II, BRIAN. Michigan State University, 7955 S Durand Rd. Durand, MI 48429 **Cereal rye suppresses glyphosate-resistant horseweed in sugarbeet.**

Glyphosate-resistant horseweed proves to be a challenge for many Michigan sugarbeet growers. Integrating multiple management strategies, including a cereal cover crop, may improve horseweed control.

In 2019 and 2020 field studies were conducted in East Lansing, Michigan to evaluate the effects of fall-planted cereal rye termination time and method in combination with different postemergence (POST) herbicide treatments for horseweed control. Cereal rye was drilled at 67 kg ha^{-1} in the fall of 2019 and 2020. The studies were conducted as a split-plot design with cereal rye termination method and time as the main plot factors and herbicide treatments as the sub-plot factor. Cereal rye treatments included: early burndown (EBD) 14 d prior to sugarbeet planting, burndown at planting (PBD), PBD + roller, and PBD + roller crimper, a delayed burndown (DBD) 14 d after planting, and a no cover control, the addition of no-cover strip-till and delayed burndown strip-till were treatments added to the 2020 study. The burndown treatment consisted of glyphosate applied at 1.27 kg ae ha^{-1} + ammonium sulfate. The three herbicide treatments consisted of two POST applications at the 2- and 6-8 leaf sugarbeet stage. The treatments included: 1) glyphosate twice (control), 2) glyphosate (0.84 kg ae ha^{-1}) followed by glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.11 kg ha^{-1}), and 3) glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.06 kg ha^{-1}) followed by glyphosate (0.84 kg ae ha^{-1}) + clopyralid (0.11 kg ha^{-1}). In 2019, cereal rye biomass at the time of termination was 640 and 740 kg ha^{-1} for the EBD and PBD terminations, respectively. Cereal rye biomass at the time of the 'Planting Green' termination was 5-times higher (4,200 kg ha^{-1}). Horseweed biomass 14 d after planting (DAP) was 11 times lower where a cover crop was planted compared with the no cover control, regardless of termination time or method. 'Planting Green' with an application of clopyralid applied either once or twice reduced horseweed biomass up to 99%. At harvest, the main effect of the cereal rye cover crop reduced horseweed biomass up to 75%. The main effect herbicide treatments showed a greater reduction in horseweed biomass with two applications of clopyralid followed by clopyralid one application, followed by the control. Even though horseweed biomass was lowest in the DBD treatment, sugarbeet yield was reduced and was not different compared with the no cover control, due to reduced sugarbeet growth in the DBD. Sugarbeet yield for the EBD, roller crimper, and roller were all similar and the PBD showed the highest overall sugarbeet yield and was not different than the roller treatment. Regardless of clopyralid treatment, sugarbeet yields were the same. Data for the 2020 season is currently being analyzed. However, it appears that integrating cereal rye into a sugarbeet system could be an important tool for horseweed management. This research will be repeated in 2021.

Physiology, Genetics and Plant Pests
Oral Presentations

ANFINRUD, MARK*[1], JAN SELS[2], JUAN VEGAS[3] and HENDRIK TSCHOEP[3], DR. LINDA HANSON[4], [1]SESVANDERHAVE USA, [2]SESVANDERHAVE , [3]SESVANDERHAVE, [1]5908 52ND AVE S, Fargo, ND 58104, [2]Industriepark 15, BE- 3300 Tienen, [2]Industriepark 15, BE-3300 Tienen, [4]1066 BOGUE STREET, #384, [4]MICHIGAN STATE UNIVERSITY, East Lansing, MI 48824 **Breeding For Durable Cercospora Resistance Embeded In A Broader Leaf Disease Package.**

Cercospora leafspot causes significant financial losses in many sugar beet cooperatives in the USA. Breeding efforts for Cercospora tolerance have demonstrated major progress in developing varieties that combine significant resistance levels with competitive yields. Unfortunately, these achievements hold risks as well. By introgressing these traits, we risk bringing in increased susceptibility to other diseases like Alternaria, Stemphylium and Sclerotinia which have been reported in the growing regions like Michigan, Southern Minnesota and the RRV. Multigenic resistance approaches have a higher likelihood to withstand resistance breakdown by rapidly evolving pathogens. To safeguard the breeding achievements on Cercospora tolerance, it is necessary to consciously tackle these risks. In this presentation, we outline the breeding achievements in CLS breeding. In addition, we elaborate on our efforts to build a durable multi-genetic CLS tolerance barrier and our efforts to achieve CLS tolerance in combination with a base tolerance to other emerging and established leaf diseases.

BHUIYAN, M. Z. RAHMAN*[1], SHYAM SOLANKE[2], GAZALA AMEEN[2], ROBERT S. BRUEGGEMAN[2], PAWEL BOROWICZ[1] and MOHAMED F. R. KHAN[3], [1]North Dakota State University, [2]Washington State University, [3]North Dakota State University & University of Minnesota, [1]Fargo, ND 58108, [2]Pullman, WA 99163, [1]Fargo, ND 58108 **Proliferation success of Cercospora beticola on sugar beet is associated with an early penetration and nutrient acquisition.**

Cercospora leaf spot caused by necrotrophic fungal pathogen *Cercospora beticola* Sacc. is one of the most destructive and yield-limiting foliar diseases in sugar beet. *C. beticola* produces toxins and enzymes to alter the host membrane permeability, triggering the hypersensitive response (HR), beneficial for pathogens necrotrophic lifestyle. A twelve-hour interval time-course experiment up to 120 hours was conducted to determine the progression of *C. beticola* growth on a sugar beet susceptible and resistant variety. Leaf samples were stained with 3,3 -diaminobenzidine (DAB) solution to detect the production of HR-related

H_2O_2. Samples were also stained with WGA-Alexa-Fluor-488 dye for *in-planta* fungal growth visualization on confocal laser scanning microscope. In DAB staining, the susceptible variety exhibited an HR response starting from 48 hours post-inoculation (hpi), whereas in the resistant variety HR was not detected until 60 hpi. At later time-points, the amount and spread of HR in the susceptible variety was significantly higher than in the resistant variety indicating the nutritional success of the pathogen. In fluorescently stained samples, we observed pathogen penetration followed by conidia germination was either direct or by producing appressorium on stomata starting at 48-hpi in the susceptible variety while at 60-hpi in the resistant variety, later followed by secondary hyphae produced appressorium onto stomatal guard cells. Thus, pathogen entry and HR were correlated indicating importance of early establishment in the pathogens' infection success. We hypothesized that a spatio-temporally controlled host cell-death machinery is in constant struggle with evolving *C. beticola* pathogen effectors. RNAseq analysis is underway to decipher this molecular mechanism operating in sugar beet – *C. beticola* host-pathogen system.

BLOOMQUIST, MARK*, DAVID METTLER and CODY GROEN, Southern Minnesota Beet Sugar Cooperative, 83550 County Road 21, Renville, MN 56284 **Methods to reduce Cercospora beticola inoculum in field.**

Cercospora leaf spot can be a devastating disease for sugar beet production in southern Minnesota. Since 2016, Cercospora leaf spot levels have been high across the Southern Minnesota Beet Sugar Cooperative growing area. Six to seven fungicide applications are being applied to manage disease levels in fields which is placing a significant amount of selection pressure on these fungicides. As fungicide resistance trends upward, additional tools are necessary to manage this disease. In 2019 and 2020, SMBSC conducted a trial to look at potential methods to decrease the levels of *Cercospora beticola* inoculum that survive from one season to another in the soil and plant debris. Trials were established on areas that were planted to sugar beet the previous year and had high levels of Cercospora present. There were five treatments in the trial each season. The treatments were tillage, heat/burning, copper fungicide application, hydrogen peroxide/peroxyacetic acid application, and an untreated check. The treatments were applied in the spring prior to planting. Sugar beets were no-till planted across the trial area following the treatment application. The sugar beets were allowed to develop through the growing season, and when disease began developing across the trial, foliar ratings were taken using the KWS 1-9 scale. The foliar ratings were conducted 2-3 times per week for a three week period. The tillage treatment and heat/burn treatment slowed disease development when compared to the untreated check in the 2019 trial season. In 2020, the tillage treatment and heat/burn treatment again both slowed disease development in comparison to the untreated check. This trial will be repeated for a third year during the 2021 growing season.

BOLTON, MELVIN*[1], REBECCA SPANNER[1], JONATHAN NEUBAUER[1], THIES M. HEICK[2], OLIVIA HAMILTON[1], VIVIANA RIVERA-VARAS[3], RONNIE DE JONGE[4]; SARAH PETHYBRIDGE[5]; KIMBERLEY M. WEBB[1] and GARY A. SECOR[3], [1]U.S. Dept. Agriculture, [2]Aarhus University, [3]North Dakota State University, [4]Utrecht University, [5]Cornell University, [1]Northern Crop Science Laboratory, 1616 Albrecht Blvd. N, Fargo, ND 58102-2765, [2]Institute for Agroecology, Aarhus University, Slagelse, Denmark, [3]Department of Plant Pathology, North Dakota State University, Fargo, ND, United States, [4]Plant-Microbe Interactions, Department of Biology, Science4Life, Utrecht University, Utrecht, the Netherlands, [5]Cornell AgriTech, Cornell University, Geneva, NY, United States **Seed-borne Cercospora beticola can initiate disease in sugar beet.**

Cercospora leaf spot (CLS) is a globally important foliar disease of sugar beet (*Beta vulgaris* ssp. *vulgaris*) caused by the fungus *Cercospora beticola*. Management of CLS has been challenging due to the polycyclic nature of the disease and the rapid development of resistance to many effective fungicide groups. Long distance movement of *C. beticola* has been indirectly evidenced in multiple recent population genetic studies. In this study, we provide direct evidence for seed-borne *C. beticola* to initiate disease in sugar beet. We confirmed the presence of viable *C. beticola* for ten out of 37 sugar beet seed lots in plate growth assays. All isolates contained the G143A mutation in cytochrome b conferring QoI fungicide resistance and 32 of 38 isolates showed low DMI fungicide sensitivity (EC_{50} > 1µg/mL). Direct planting of pelleted seed demonstrated the ability of seed-borne inoculum to initiate CLS disease in sugar beet. Additionally, this was the first study to investigate the fungal microbiome within sugar beet seed. Long read internal transcribed spacer amplicon sequencing using the MinION platform demonstrated the presence of potentially viable fungi from 20 different fungal genera. The three genera *Fusarium*, *Alternaria* and *Cercospora* were dominant taxa and comprised an average of 92.7% relative abundance over 12 seed lots. The presence of seed-borne inoculum should be considered when implementing integrated pest management for CLS disease of sugar beet in the future. Further investigation is required to develop reliable diagnostic tools for seed health inspection and to study the epidemiology and control of this primary inoculum source.

BOTKIN, JACOB*[1], ASHOK CHANDA[1], FRANK MARTIN[2] and CORY HIRSCH[1], [1]University of Minnesota, CFANS, Dept. of Plant Pathology, 1991 Upper Buford Circle 495 Borlaug Hall St. Paul, MN 55108, [2]USDA-ARS, 1636 East Alisal St Salinas, CA 93905 **DNA-based detection of Aphanomyces cochlioides infested soil and plant samples.**

Aphanomyces cochlioides, the causal agent of Aphanomyces seedling damping-off and root rot of sugar beet, causes yield losses in major sugar beet growing regions. Currently, a 4-week growth chamber bioassay is used to evaluate the root rot index (RRI) of soils infested with *A. cochlioides,* and a 2-day culture-based diagnostic assay is used to confirm if a sugar beet is infected with *A. cochlioides.* Sugar beet growers would benefit from a sensitive, specific, and rapid assay that can detect and quantify *A. cochlioides* infestation levels in field soil and detection in plant samples. A specific TaqMan (qPCR) assay targeting mitochondrial DNA was developed to detect and quantify *A. cochlioides* DNA in infested field soils and infected sugar beet samples. The qPCR assay was tested against *A. euteiches* and sugar beet DNA to confirm the specificity. A standard curve was made with 10-fold dilutions of *A. cochlioides* genomic DNA from 1 ng to 0.1 pg and the mean Cq (quantification cycle) value for 0.1 pg was 26.86. The qPCR assay was validated using eight naturally infested field soil samples. For these samples, the RRI ranged from 88-100 (mean RRI = 95.2), while the qPCR assay had Cq values ranging from 25.7 – 35.4. The assay was also validated using diseased mature sugar beet roots (60) that were sent to the sugar beet pathology lab at the University of Minnesota for diagnosis, and infected sugar beet seedlings. Out of the 60 samples, the qPCR assay detected *A. cochlioides* DNA on 63% of the diseased sugar beets, and culture-based diagnostics identified *A. cochlioides* in 15% of samples. Also, the qPCR assay detected *A. cochlioides* DNA in sugar beet seedlings 9 days after planting (mean Cq = 28) in naturally infested field soil, and 5 days after planting (mean Cq = 30) in naturally infested field soil that was used for bioassay of *A. cochlioides* for 4-weeks. We will discuss the challenges involved in developing a reliable soil DNA isolation method from soils naturally infested with *A. cochlioides*. This qPCR assay can be used to determine the *A. cochlioides* infestation of field soils, so that sugar beet growers can make informed disease management decisions prior to planting.

EINI O.*[1], N., SCHUMANN[2], M., NIESSEN[2], M., VARRELMANN[1], [1]Institut für Zuckerrübenforschung, Abteilung Phytomedizin, Holtenser Landstr. 77, 37079 Göttingen, Germany, [2]KWS SAAT SE & Co. KGaA, Grimsehlstr. 31, 37574 Einbeck, Germany **Generation of targeted mutagenesis in sugar beet using geminiviral replicons for delivering CRISPR/Cas systems**

Genome editing (GE) tools like the type II clustered regularly interspaced short palindromic repeat (CRISPR)/Cas system possess the potential to accelerate crop improvement by providing the means to modify genomes (gene disruption, correction or insertion) rapidly in a precise and predictable manner. The efficacy of the entire process, however, is critical and depends on efficient delivery of the editing components, which are the sequence-specific nucleases (SSN) and the single guide RNA (sgRNA). Geminiviruses (Family *Geminiviridae*) are plant viruses with circular single stranded DNA genomes that rely on host DNA replication machinery for their genome amplification. Therefore, they need to change the host cell cycle into S phase, in which DNA replication and homology-directed DNA recombination (HDR) occur. This study aims to establish targeted gene mutation in sugar beet by means of Geminivirus based plant virus vectors for the efficient delivery of SSN and sgRNA for mutagenesis in Acetlactate synthetase 1(ALS1) gene. We have prepared two geminiviral replicons (GVRs) from *Beet curly top virus* (BCTV-Svr) and *Beet curly top Iran virus* (BCTIV) by removing the virion sense genes. Their replication efficacy was compared with wild type virus. The BCTIV replicon accumulates at a lower level as compared with wild type BCTIV. However, the replicon from BCTV-Svr accumulates more efficiently in plants tissues as compared to the wild type virus. Both replicons provide a large cargo capacity up to 7 Kb which enable more efficient delivery of CRISPR/Cas components. The efficacy for targeted mutagenesis in *ALS1* gene using both replicons was comparable to the conventional T-DNA system. This demonstrates application of geminiviral replicons for efficient delivery of CRISPR/Cas components into sugar beet and provides a framework for future studies in sugar beet and other plants.

FLOBINUS, ALYSSA*[1], JOHN J. WEILAND[2] and MELVIN D. BOLTON[2], [1]North Dakota State University, [2]USDA-ARS, [1]1402 Albrecht Blvd N, Dept of plant pathology, Walster Hall, Fargo ND 54105-5713, [2]1307 18th St. N, Fargo, ND 58102-2765 **Development of U.S. BNYVV infectious clones to study Rz1 and Rz2 resistance breaking.**

Beet necrotic yellow vein virus (BNYVV) is a *Benyvirus* consisting of four positive-sense single-stranded RNAs. BNYVV is the main agent responsible for the most devastating sugar beet viral disease worldwide, Rhizomania. Rhizomania leads to a major reduction in sugarbeet yield and sugar content, resulting in significant financial losses to the industry. To manage BNYVV, three sugar beet genotypes possessing Rz1 (the mostly widely used resistance gene), Rz2, or more recently the combined Rz1+Rz2, have been deployed. Over the last 16 years, resistance-breaking (RB) strains of the virus have been reported for Rz1, a phenomenon associated with modifications in the gene p25 encoded on RNA3. More recently, RB strains have been identified that appear to overcome Rz2- and Rz1+Rz2-mediated resistance, but the mechanism of RB remains elusive. In order to investigate the role of RNA-3 and potentially other genome regions in the RB phenomena, BNYVV infectious clones have been created for the first-time using U.S. strains of the virus. BNYVV RNA-1 and -2 clone design and construction was based on RNA sequencing data obtained from BNYVV-infected plants grown in infested soil possessing RB isolates of virus. RNA-3 and -4 clones were directly isolated from these plants *via* RT-PCR. Our results shown that these clones, when transcribed to produce capped RNAs, are infectious on *Chenopodium quinoa* and *Beta macrocarpa* hosts. Protein p25 modifications associated with RB in U.S. will be introduced in the p25 gene and tested in sugarbeet genotypes encoding the different resistance gene complements. Through use of these clones, a better understanding of BNYVV virulence in general and the RB phenomenon specifically will be obtained. Additionally, the clones will allow us to study other viral functions, some of them may determine virus transmission and aggressiveness, leading to strategies for the inhibition of BNYVV infection in plants. **Keywords:** Resistance, BNYVV, Infection, Gene.

KHAN, MOHAMED*[1] and HAKK PETER[2], [1]North Dakota State University & University of Minnesota, [2]North Dakota State University, [1]Fargo, ND, 58105, [2]Fargo, ND 58108 **Under heavy rainfall conditions, fungicides do not provide season long control of Cercospora beticola on more susceptible sugar beet varieties.**

Cercospora beticola causes Cercospora leaf spot (CLS), the most economically damaging foliar disease of sugar beet produced in warm and humid regions worldwide. Growers incorporate tolerant varieties, crop rotation, incorporation of infected residue by tillage, and fungicides holistically to manage CLS. After more than two decades of producers using single site mode of action fungicides in mixtures or individually in a rotation program to control *C. beticola*, the pathogen has developed resistance and /or reduced sensitivity to several fungicide chemistries in Europe and the United States (US). Field studies conducted at Andrea, MN, US, indicated that mixtures of multi-site fungicides or multi-site with site-specific fungicides applied 4 to 6 times in a rotation program at 10 to 14 day intervals provided effective control of *C. beticola,* even on more susceptible varieties, when fungicide applications were followed by several days of dry conditions. However, when fungicide treatments applied to more susceptible varieties were followed 24 to 72 hours by heavy and regular rainfall, disease control became less effective, as measured by area under the disease progress curve, by late August. It was observed that more CLS tolerant varieties treated with fungicides, and some new improved, but not yet approved, CLS resistant varieties with and without fungicide treatments, resulted in effective control of the pathogen. Over the past five years, there was a pattern of increased frequency and/or amounts of rainfall and warm temperature during the

CLS season (July through September), especially in central and southern Minnesota. The use of more tolerant CLS varieties that can provide acceptable economic returns, even in the absence of fungicides, will reduce the risk of losing 40 to 50% of potential yield that typically results in catastrophically low beet payment, when fungicides are rendered ineffective because of adverse weather conditions.

LIEN, AUSTIN* and ASHOK KUMAR CHANDA, Department of Plant Pathology, University of Minnesota, 495 Borlaug Hall 1991 Upper Buford Circle, St. Paul, MN 55108 **Finding the perfect match: Triazole fungicide and tank-mix partner combinations for managing Cercospora leaf spot of sugarbeet.**

Sterol demethylation inhibitor (DMI) fungicides are currently the most important group of fungicides used to manage Cercospora leaf spot (CLS) in sugarbeets. However, *Cercospora beticola* isolates with reduced sensitivity to DMIs have been reported in recent years. Systemic fungicides (such as DMIs) that target a specific site in the fungus are commonly mixed with a protectant fungicide having broad-spectrum activity (tank-mix partner). The expected outcome of tank-mixing fungicides is to improve the efficacy of CLS disease management, subsequently improving harvestable root yield and sucrose quality, and to reduce buildup of fungicide resistance. Nevertheless, fungicide mixtures can result in unanticipated and antagonistic effects, depending on the chemistry and type of formulation. Therefore, it is necessary to identify interactions between DMI fungicides and tank-mix partners to develop fungicide recommendation strategies to manage CLS effectively. We evaluated DMI fungicide and tank-mix partner interactions that impact CLS disease control, harvestable root yield, and sucrose quality. A randomized, five-by-seven split-plot trial with four replicates was conducted at the University of Minnesota Northwest Research and Outreach Center in 2020. Plants were thinned to achieve a uniform plant density and the trial was inoculated with a mixture of fine talc (1 part) and dried, ground sugarbeet leaves infected with *C. beticola* (2 parts) collected at the end of the season in 2019. Fungicide treatments were applied five times during the growing season. DMI fungicide treatments, assigned as main plots, included Proline 480 SC, Minerva, Inspire XT, Provysol, and a 'No-DMI' treatment. Tank-mix partner treatments, assigned as sub-plots, included Manzate Pro-Stick, Badge SC, Ele-Max Phosphite (macro-nutrient analysis 0-0-26), Microthiol Disperss, Pure Baking Soda and non-ionic surfactant (NIS), Serenade START (*Bacillus subtilis* QST 713 FS), and a 'No-partner' treatment. Each DMI alone and in combination with a tank-mix partner were evaluated for control of CLS. CLS disease severity was assessed weekly by calculating the percent of CLS affected area using an image processing software. Data was also collected for root yield and quality parameters. Significant differences were apparent within the DMI fungicides and tank-mix partners regarding harvestable root yield and recoverable sucrose per acre; moreover, interactions were present regarding overall CLS disease progress and severity as well as sucrose quality.

MAHLEIN, ANNE-KATRIN, Inst. f. Zuckerrübenforschung, Holtenser Landstr. 77, 37075 Göttingen, Germany **Digital technologies in growing sugar beets: the benefit of sensors and robots.**

Agricultural practice and scientific research is confronted with new challenges. Environmentally friendly and sustainable solutions are increasingly demanded. Precision agriculture and phenotyping technologies are increasingly developed and implemented in processes during vegetation period from sowing to harvest. These technologies can provide information on growth dynamics, plant development and plant vitality or to the presence of pest and diseases or weeds in sugar beet fields. The information may help to make a decision on a subsequent management practice. The current presentation focuses on the potential of digital technologies for monitoring the crop cultivation of the above mentioned parameters. A specific focus will be on current work at the IfZ on the use of optical sensors for an accurate and objective detection of pests and plant diseases. An approach for monitoring disease incidence and disease severity of foliar diseases like Cercospora leaf spot will be presented. Furthermore information on accurate plant monitoring via unmanned aerial vehicles will be shown. However, the application of optical sensors in a practical context in the field is still challenging. Sophisticated data analysis methods have to be developed and results need to be compared to human expert results. In general, the entire system pipeline, consisting of the type of sensor, the platform carrying the sensor, and the decision making process by data analysis has to be tailored to the specific problem and evaluated application-oriented. For this purpose, an experimental field site for testing digital technologies in sugar beet cultivation is currently being established in Göttingen, Germany, called FarmerSpace.

MARTIN, FRANK*, VIVIANA CAMELO-GARCIA and WILLIAM M. WINTERMANTEL, USDA-ARS, 1636 East Alisal St., Salinas, CA 93905 **Development of molecular genomic resources for Polymyxa betae.**

Polymyxa betae functions as a vector for several different soilborne viruses of sugar beet. Since it is an obligate pathogen, there are challenges for developing genomic resources to support further investigations with this fungus. The use of high throughput Illumina sequencing is one approach that can address these challenges. A single cystosorus culture collection was established for a range of isolates recovered from soil samples collected from sugar beet growing areas across the U.S.A. Heavily infected roots were recovered from four geographically diverse isolates and the extracted DNA submitted for Illumina sequencing. The resulting reads were mapped against a reference library of the sugar beet genome to filter out host sequences and the remaining reads *de novo* assembled and mapped to *P. betae* reference sequence (isolate A26-41 from Belgium; GenBank RZBT01). Comparative genomics was used to identify polymorphic regions among the five genomes. Eighteen genotypic markers were tested on ten *P. betae* isolates; amplification reactions were performed using identical conditions and annealing temperature for all of them. Most of the primers tested performed well and the amplicons obtained were sequenced. Multiple sequence alignments identified polymorphisms in the sequences obtained with a set of twelve primer pairs. A total of 132 DNA sequences were concatenated, including the reference sequence, for each locus. The Neighbor-Joining method was used for phylogenetic reconstruction as implemented in Geneious 2020.2.3, and network analysis was performed using the neighborNet method from the SplitsTree5 software. Both analyzes showed different clades independent of the geographic origin, revealing genetic variability between the *P. betae* isolates. Currently, we are testing field samples from different sugar beet production areas to validate the marker set and subsequently will use them for population studies in commercial production fields.

MAXIMILIAN M MUELLENDER*[1]; ANNE-KATRIN MAHLEIN[1]; GERD STAMMLER[2]; MARK VARRELMANN[1,] [1]Institute of Sugar Beet Research, Holtenser Landstraße 77, 37079 Göttingen, Germany; [2]BASF SE, Speyerer Strasse 2, 67117 Limburgerhof, Germany. **Evidence for the association of target-site resistance in cyp51 with reduced DMI sensitivity in European *Cercospora beticola* field isolates**

Cercospora leaf spot caused by *Cercospora beticola* is the most relevant leaf spot disease in sugar beet in Germany. In the last decade a decreasing sensitivity of *C. beticola* towards demethylation inhibitors (DMIs) occurred, but so far none of the known resistance mechanisms were found to be responsible for the loss of efficacy. An analysis of the cytochrome P450-dependent sterol 14 demethylase gene sequence (cyp51) of European *C. betico*la isolates with reduced DMI sensitivity revealed the amino acid alterations Y464S, L144F and I309T combined with L144F. Furthermore, mutations I387M, M145W and M145W with E460Q were found, uniquely. Together with the EC_{50} values of the isolates, these mutations are probably responsible for the DMI resistance. Additionally, constitutive and fungicide triggered expression of *cyp51* was previously described as possible resistance mechanism. A very strong induction of cyp51 mRNA expression in sensitive isolates was determined by RT-qPCR. This suggests that the fungal cells upregulate expression to maintain ergosterol biosynthesis in DMI presence. The less intensive *cyp51* induction in isolates with higher EC_{50} values underlines the possible correlation of the found target-site mutations with reduced sensitivity. This study provides new results about the loss of efficacy of *C. beticola* towards DMIs and hypothesized alterations in the target gene cyp51 as main reason for the so called "Azole-shifting".

METTLER, DAVID C.* and MARK W. BLOOMQUIST, Southern Minnesota Beet Sugar Cooperative, 83550 County Road 21, Renville, MN 56284. **Cercospora leaf spot management with varying levels of varietal disease tolerance.**

Cercospora leaf spot is a serious disease in sugar beet that has had a major impact on sugar beet production in the Midwest. One hurdle in managing this disease is the development of resistance due to the polycyclic nature of Cercospora and the limited number of effective fungicide modes of action. However, new advancements in genetic tolerance to Cercospora may give farmers more options for controlling this disease. The objective of this study was to determine the efficacy of new advancements in genetic tolerance to Cercopsora using different fungicide spray programs. These trials were planted using three sugar beet varieties with KWS ratings of 4.0, 3.0, and 1.8. These trials were inoculated to achieve an even disease pressure across the site. Six fungicide programs were applied each of the three varieties. Foliar ratings and pictures were taken throughout the summer once applications of the fungicides began. These trials were also harvested to gather yield and quality data.

RAMACHANDRAN, VANITHARANI*, JOHN, WEILAND and MELVIN, BOLTON, Sugar beet and Potato Research Unit, 1616 Albrecht Blvd. N, Fargo, ND 58102 **CRISPR-based diagnostic method development for detecting viruses in Sugar beet.**

Sugar beet is highly prone to viral diseases affecting its sustained productivity. Among these viral diseases, rhizomania caused by the soilborne *Beet necrotic yellow vein virus* and transmitted by *Polymyxa betae* significantly affects sugar beet yield and consequently the grower's economy. Management of rhizomania and other plant diseases relies on the accurate detection of pathogens early in the infection process so control strategies can be implemented when they are most efficacious. For detecting rhizomania, ELISA has been the most commonly used method but has its own limitations on both sensitivity and specificity. Advanced molecular methods, such as qPCRs and HTS are highly specific but expensive because they require sophisticated instrumentation. Hitherto, it has been a challenge to develop an ideal assay that would be sensitive, specific, rapid, and easy-to-do while still being cost-effective. Recently invented CRISPR technology has opened the door to develop such an assay with high sensitivity and specificity that is suitable for high throughput diagnostics and field applications. We are developing CRISPR-based assays for rapid and accurate detection of viral pathogens associated with rhizomania in sugar beet. The development of these assays and their field implications on rhizomania diagnostics along with other management strategies will be useful for disease control measures in sugar beet.

RANGEL, LORENA I.*[1], OLIVIA HAMILTON[2], J.J. SANCHEZ GIL[3], RONNIE DE JONGE [3] and MELVIN D. BOLTON [1], [1]USDA ARS, [2]NDSU, [3]Utrecht University, [1]Northern Crop Science Laboratory, U.S. Dept. Agriculture, Fargo, North Dakota, USA, [2]Department of Plant Pathology, North Dakota State University, Fargo, North Dakota, USA, [3]Department of Plant-Microbe Interactions, Utrecht University, Utrecht, The Netherlands **The effect of cercosporin production by Cercospora beticola on bacterial diversity in the sugar beet phyllosphere.**

Cercospora leaf spot (CLS), caused by the fungal pathogen *Cercospora beticola*, is a devastating foliar disease of sugar beet worldwide. This pathogen is well-known for its capability to produce a multitude of secondary metabolites. One secondary metabolite, cercosporin, is considered to be a non-host specific community modifier, *i.e.,* likely have broad functions that affect a wider range of species than on the host wherein it was produced. This compound has historically been deemed a virulence factors for plant invasion, however, it was soon after discovered to be toxic towards other organisms. Although the non-host specific toxicity of cercosporin has been informally described, no reports have explicitly investigated the range of impacted organisms, plant-associated or otherwise. Here, we found that CLS disease onset was earlier and disease severity was higher when *C. beticola* that lack the ability to produce cercosporin were inoculated onto greenhouse-grown sugar beets compared to sugar beets that were inoculated with wild-type *C. beticola*. Additionally, we have found that extracts of cercosporin act as selective antibiotics against only a limited subset of bacteria isolated from sugar beet, suggesting that this compound may also be produced for the purpose of outcompeting specific microbes during infection. To test this hypothesis *in planta*, we first sampled a natural phyllosphere community from field-grown sugar beet leaves and filtered to only capture the bacterial community. The natural bacterial community was both taxonomically characterized by 16S sequencing and used as inoculum to spray greenhouse-grown sugar beets. The bacterial community was allowed to establish on the leaves for seven days and was subsequently inoculated with *C. beticola* or cercosporin-deficient mutants. CLS disease progress was assessed for 21 days post *C. beticola*-inoculation via transcriptomic approaches. At this final time point the bacterial community was assessed on leaves inoculated with wild-type or cercosporin-deficient mutants to

determine any shifts in bacterial community profiles. Our findings will offer a greater understanding of the impacts of cercosporin on plant microbial structure and dynamics during CLS disease progress.

RIVERA-VARAS, VIVIANA*[1] and GARY SECOR[2], [1]North Dakota Staate University, [2]North Dakota State University, [1]Dept 7660 Box 6050, Fargo, ND 58108, [1]Dept 7660 Box 6050, Fargo, ND 58108 **The effect of temperature, moisture and fungicide resistance on germination of Cercospora beticola conidia.**

The purpose of this study is to determine conditions for germination of conidia of *Cercospora beticola,* and the effect of fungicide resistance characteristics on conidial germination. For this study, we evaluated germination of conidia collected from isolates either sensitive or resistant to seven fungicides at various temperature and moisture conditions. The process of spore germination begins in two hours at 10°C and requires free moisture. Differences in percent germination between fungicide sensitive and resistant isolates were found. Conidia from resistant isolates have a lower germination incidence (72%) compared with conidia from sensitive isolates (95%) after 24 hours at temperatures between 10 to 16°C. Conidia from sensitive isolates have significantly higher germination at lower temperatures (10 and 14°C) compared to conidia from resistant isolates, and this difference disappears at higher temperatures (18 and 20°C). Conidia produced by fungicide resistant isolates are larger and produced faster compared to conidia from fungicide sensitive isolates at higher temperatures . It appears there may be a fitness penalty for germination of conidia from resistant isolates at colder temperatures, and fitness advantage of resistant isolates for conidia production at warmer temperatures. This study may complement spore production and daily severity values used for CLS forecasting, and may facilitate adjustment of current models to include spore germination conditions that may alter fungicide application timing.

ROSSI, VALENTINA*[1], LOUISE HOLMQUIST[1], ERIK ALEXANDERSSON[2] and LAURA GRENVILLE-BRIGGS[2], [1]Hilleshög Seed, [2]Swedish University of Agricultural Sciences, [1]Säbyholmsvägen 24, Landskrona, Sweden, [2]Box 102, Alnarp, Sweden **Novel breeding tools and effective management of Aphanomyces cochlioides in sugar beet.**

The soil-borne pathogen *Aphanomyces cochlioides* is the principal agent of the black rot, one of the most serious diseases in sugar beet. It is a pathogen of major importance in the United States where it is responsible for considerable losses on sugar beet. When severe, Aphanomyces root rot disease can lead to the destruction of entire fields and to a drastic reduction of sugar yield. *A. cochlioides* is one of the most problematic pathogens due to its persistence in the soil and the lack of effective control measures. Sources of resistance are limited, thus the identification and characterization of resistance genes represents a major task in sugar beet breeding. In this study a screening of resistance sources tested with four different isolates coming from major sugar beet producing areas (Sweden, USA and Japan) was performed to gain insight into the pathogenicity of the isolates and their interaction with partially resistant genotypes. Breeding lines and commercial varieties have been tested for resistance through a reproducible Aphanomyces infection test in the greenhouse. Furthermore an *in planta* infection system was established to enable host-pathogen molecular studies in laboratory. A quantitative PCR was performed to detect and measure *A. cochlioides* DNA in roots at 3 days post-inoculation and a reliable protocol for RNA extraction from roots was assessed in order to perform RNA sequencing. The study seeks to conduct transcriptome analysis with the aim to identify genes involved in the resistance to *A. cochlioides* by comparing the defense responses in resistant and susceptible breeding lines. A QTL mapping is performed with the aim to identify QTLs associated to Aphanomyces resistance. The identification of QTL will be used to improve future breeding but also for the interpretation of the RNA-seq results.

SEBASTIAN LIEBE[1], EDGAR MAISS[2], MARK VARRELMANN[1], [1]Institute of Sugar Beet Research, Department Phytopathology, Holtenser Landstr. 77, D-37077 Göttingen, [2]Leibniz University Hannover, Institute of Horticultural Production Systems, Dept. Phytomedicine, Herrenhäuser Str.2, 30419 Hannover **Investigations on Rz1 resistance breaking populations of Beet necrotic yellow vein virus**

Beet necrotic yellow vein virus (BNYVV) is a member of the genus *Benyvirus* in the family *Benyviridae*. BNYVV causes Rhizomania disease in sugar beet, which is characterized by the abnormal proliferation of lateral roots leading to a significant decrease in sugar content and massive yield losses. Therefore, all sugar beet cultivars carry the *Rz1* resistance gene preventing infection with BNYVV. However, there are several reports describing the occurrence of *Rz1* resistance breaking strains. The high selection pressure has lead to several mutations in the pathogenicity factor P25 at amino acid positions 67-70 (tetrade). Furthermore, an additional RNA component from the P-type (RNA5) has been associated with *Rz1* resistance breaking. However, experimental studies investigating the structure of such *Rz1* resistance breaking populations are rare. Therefore, soil samples infested with putative *Rz1* breaking populations of BNYVV were collected from in different sugar beet growing regions in Europe. *Rz1* resistance breaking was confirmed in bait plant tests conducted in the greenhouse. For each collected population, the virus type, tetrade sequence of P25 and the presence of RNA5 was determined by PCR. A reverse genetic system for sugar beet using a cDNA clone of BNYVV A-type was applied to confirm the resistance breaking ability of certain tetrade variants and RNA5. Finally, selected virus populations isolated from susceptible and *Rz1* resistant genotypes were subjected to high-throughput sequencing. The present results revealed that viral populations from A, B and P type posses *Rz1* resistance breaking abilities as demonstrated by bait plant tests. Depending on the population, the tetrade in P25 showed strong variability in the susceptible genotype. In contrast, populations isolated from the *Rz1* resistant genotype displayed less variability in the tetrade. Furthermore, the presence of RNA5 originating from P and J type was confirmed in certain populations. Moreover, high-throughput sequencing revealed a high heterogeneity within BNYVV populations comprising RNA components belonging to different virus types. Furthermore, the tetrade of P25 seems to be genetically fixed in populations with long history of *Rz1* cultivation like in the Pithiviers region in France. Finally, the resistance breaking ability of certain tetrade variants and RNA5 could be confirmed independent of the virus population by using the reverse genetic system in sugar beet. To sum up, our study provides a deep insight into BNYVV populations and their *Rz1* resistance breaking abilities.

SHRESTHA, SUBIDHYA*[1], ROSHAN SHARMA POUDEL[1], RONNIE DE JONGE[2], KIMBERLY WEBB[3] and MELVIN D. BOLTON , [1]North Dakota State University, [2]Utrecht University, [3]USDA-ARS, Soil Management and Sugar Beet Research Unit, U.S. Dept. AgricUSDA-ARS, Northern Crop Science Laboratory, [1]Department of Plant Pathology, North Dakota State University, Walster Hall-306 Fargo, ND 58102, [2]Utrecht, NL, [3]Fort Collins, CO 80523, Fargo, ND 58102
Molecular profiling of the sugar beet pathogen, Fusarium secorum.

Fusarium yellowing decline caused by the fungal pathogen *Fusarium secorum* has become an emerging problem in the sugar beet industry. Since *F. secorum* is not closely related to other *Fusarium* pathogens of sugar beet, little is known of the virulence mechanisms of this pathogen. To that end, we utilized whole-genome sequencing of the pathogen, xylem sap mass spectrometry, and transcriptome analysis of *F. secorum* infected-sugar beet plants to understand the molecular basis of virulence of this pathogen. *Fusarium secorum* showed an increased genome size due to an increased number of introns and repetitive elements. Additionally, we successfully developed a CRISPR-Cas9 ribonucleoprotein mediated gene-editing technique to disrupt target genes encoding candidate effector proteins in the pathogen. There were five gene targets, and among them, one gene target (*Fsec2*) was identified as a virulence factor of *F. secorum*. This study provides valuable genomic resources and a better understanding of the virulence strategies of an important pathogen of sugar beet.

Physiology, Genetics and Plant Pests
Poster Presentations

BUBLITZ, DANIEL M.*[1], J. MITCH MCGRATH[1] and LINDA E. HANSON[2], [1]Michigan State University, [2]USDA-ARS, [1]9923 Krueger Rd, Frankenmuth, MI 48734, [2]612 Wilson Road, 37 Plant Biology, East Lansing, MI 48824 **Early-Season Production and Dispersal of Cercospora beticola Spores in the Great Lakes Region of North America.**

Cercospora leaf spot (CLS), caused by the fungal pathogen *Cercospora beticola*, is a major foliar disease of sugar beet (*Beta vulgaris*). In the Great Lakes region of North America as well as several other parts of the world, this disease can have a major impact on yield, with losses of up to 40% reported. Management of CLS involves an integrated approach which includes the application of fungicides. To guide fungicide application timings, disease prediction models are widely used by sugar beet growers in North America. While these models have generally worked well, they have not included information about pathogen presence. It is hypothesized that incorporating information about spore production and dispersal into the models could make them more effective. To increase our understanding of the factors involved in spore release and dispersal, the current study used sentinel beets to assess the presence of the *C. beticola* spores in the environment prior to the main epidemic in the 2017 and 2018 growing seasons. Weather variables including air temperature, relative humidity, rainfall, leaf wetness, wind speed, and solar radiation were collected. These data were used to identify environmental variables that correlated with spore levels during a time when CLS is not generally observed in commercial fields. *C. beticola* spores were detected during mid-April both years, which is much earlier than previously reported. A correlation was found between spore data and all the weather variables examined during at least one of the two years, except for air temperature. In both years, spore presence was significantly correlated with rainfall ($p<0.0001$) as well as relative humidity ($p<0.0090$). Rainfall was particularly intriguing, with an adjusted R^2 of 0.3135 in 2017 and 0.1652 in 2018. Efforts are ongoing to investigate information on spore presence to improve prediction models and CLS management.

CHU, CHENGGEN*, RACHAEL CLAIRE POORE, MELVIN BOLTON and KAREN FUGATE, USDA-ARS, USDA-ARS, Sugarbeet and Potato Research Unit, Edward T. Schafer Agricultural Research Center, Fargo, ND 58102 **Gene Expression During Seed Germination Induced by Hydrogen Peroxide.**

Seed germination is the most important stage in plant development, but it is often affected by factors including seed dormancy and growing condition. Hydrogen peroxide (H_2O_2) is known to promote seed germination. However, the mechanism by which H_2O_2 promotes seed germination remains unknown. In this study, we treated sugarbeet seeds with H_2O_2 at room temperature for seven days, which increased seed germination rate in selected sugarbeet lines from below 10% to over 80%. In order to understand the molecular basis of H_2O_2-mediated germination, sugarbeet seeds were treated using H_2O_2 and water-treated controls and RNA-seq was used to compare gene expression levels during germination under the two treatments. A total of 91 genes exhibited a significantly higher level of expression in H_2O_2-treated seeds with majority of them related to cell growth and proliferation. In addition, expression level in another set of 57 genes were significantly decreased during germination under both treatments but dropped much faster in H_2O_2-treated seeds, which is likely the indication of degrading mRNAs stored in seeds before germination since most of them were involved in response to cold or osmotic stresses and agreed with seeds having been dried and stored in cold for a long period. This research indicates that H_2O_2 improves seed germination not only by enhancing expression of genes related to cell growth but also by accelerating degradation of stored mRNAs to quickly transition seeds from dormancy into germination.

FUGATE, KAREN*[1], JOHN EIDE[1], PETER HAKK[2], ABBAS LAFTA[2], and MOHAMED KHAN[2], [1]USDA-ARS, [2]North Dakota State University, [1]USDA, Agricultural Research Service, ETSARC, 1616 Albrecht Blvd. N., Fargo, ND 58102, [2]Dept. of Plant Pathology, North Dakota State Univ., Fargo, ND 58108 **Effect of Cercospora leaf spot on sugarbeet root storage properties.**

Cercospora leaf spot (CLS), caused by *Cercospora beticola* Sacc., is one of the most damaging foliar diseases of sugarbeet worldwide. CLS has traditionally been controlled by fungicides, although increasing tolerance of the pathogen to many of the chemistries utilized for control has caused not only the prevalence and severity of CLS to increase, but also the likelihood that roots from CLS-diseased plants are incorporated into storage piles. Effective management of storage piles requires knowledge of the effect of CLS on root storage properties. These effects, however, are largely unknown. Therefore, research was conducted to determine the impact of varying levels of CLS disease severity on sugarbeet root storage properties including respiration rate, sucrose concentration, invert sugar accumulation, sugar loss to molasses, and recoverable sugar per ton after different durations in storage. Roots were obtained from field plots that were inoculated with *C. beticola*-infected leaves and treated with varying number and type of fungicide applications to achieve a range of disease levels. Roots were then stored at 5°C and 95% relative humidity and storage properties were evaluated after 30, 90, and 120 days in storage. From data collected in the first two years of a three-year study, moderate to severe levels of CLS negatively affected root yield, sucrose content, recoverable sugar per ton, and recoverable sugar per acre at harvest. CLS, at any severity level, however, had no effect on root respiration rate, sucrose concentration, invert sugar accumulation, sugar loss to molasses, or loss in recoverable sugar per ton after short- or long-term storage. These results indicate that CLS, at any level of disease severity, has no detectable impact on sugarbeet root storage properties. Results, however, should be considered preliminary until all years of the research study are complete.

GALEIN, YANN*[1], MAARTEN VANDERSTUKKEN[1], JAN SELS[1], MARK ANFINRUD[2] and OLIVIER AMAND[1], [1]SESVANDERHAVE, [2]SESVANDERHAVE USA, [1]Industriepark 15, BE- 3300 Tienen, [2]5908 52ND AVE S, Fargo, ND 58104 **Rhizomania symptoms in strong Rhizomania tolerant varieties in southern Minnesota – Is there a Rz2 breaking virus strain emerging?**

In recent years several reports of rhizomania symptoms have been made in varieties from different breeding companies that carry both the Rz1 and Rz2 sources of resistance (ex. SESVanderHave Tandem Technology). This has raised the question whether a new Rz2-breaking virus strain is emerging. To study this phenomenon, we took plant samples and soil samples from different infected patches. These samples were subjected to rhizomania bioassays to characterize the infectious potential of the virus against different reference genotypes. In addition, diagnostic sequencing was performed to identify the virus strain. Our results indicate that the Rz2 resistance was not broken by the virus strains present in the symptomatic soil patches. Moreover, sequencing diagnostics revealed that the virus was a well-known BNYVV virus type A for the RNA2 & 3 with tetrad VCHG and no RNA5 was identified. Finally, the different commercial varieties that were included in the study displayed resistance levels in line with the requirements for tandem technology varieties. We hypothesize that in the field an interaction with another stressor (biotic or abiotic) occurs which could weaken the rhizomania tolerance of the resistant varieties.

HAMILTON, OLIVIA*[1], LORENA RANGEL[2] and MELVIN D. BOLTON[2], [1]North Dakota State University, [2]USDA-ARS, [1]1340 Administration Ave, Fargo, ND, 58102, [2]1616 Albrecht Blvd N., Fargo, ND, 58102
Identification of novel effector proteins in Cercospora beticola.

Cercospora beticola is a hemibiotrophic fungal pathogen responsible for Cercospora leaf spot (CLS) disease on sugar beet (*Beta vulgaris*). Secretion of so-called effector molecules by *C. beticola* aids in the establishment of CLS. Effectors are generally characterized as small, secreted, and cysteine-rich proteins. To explore potential virulence roles of effector molecules in *C. beticola*, a combination of proteomic and genomic approaches is currently being utilized. The use of bioinformatics established nine different candidate effectors which are in the process of being knocked-out from the *C. beticola* genome through split-marker polyethylene glycol (PEG)-mediated transformation. After genetic transformation, mutated strains will be evaluated for virulence in a greenhouse setting. Additionally, the search for novel effector proteins in this pathogen is being pursued among five additional candidate proteins, which were identified after observing necrosis upon infiltration into sugar beet leaves. To determine the cause of the observed necrosis, the infiltrated sample was fractionated and sent for mass spectrometry analyses. Candidate genes for these proteins identified are also undergoing PEG-mediated transformation and will be tested for potential virulence deficiencies in the greenhouse. Characterizing novel proteins through these approaches may provide a deeper understanding of the interaction between host and disease and provide a means to identify novel resistance genes in sugar beet.

HANSON, LINDA E.*[1], JAN BYRNE[2], EMMA M. SCHLACHTER[3] and JAIME F. WILLBUR[3], [1]USDA-ARS, [2]Michigan State University Plant and Pest Diagnostics, [3]Michigan State University, [1]612 Wilson Road, 37 Plant Biology, East Lansing, MI 48824, [2]578 Wilson Rd., Rm. 107, East Lansing, MI 48824, [3]612 Wilson Road, 35 Plant Biology, East Lansing, MI 48824 **Michigan beet anthracnose not caused by Colletotrichum dematium.**

Since 2016, sugar beet samples with unusual symptoms have been received at the Michigan State University Plant and Pest Diagnostics and the sugar beet pathology labs. Seedling stunting, foliar discoloration, and lesions on the leaf petioles were observed. In 2020, similar symptoms were observed on Swiss chard in Ingham county, Michigan. A *Colletotrichum* species was isolated from symptomatic plants and used in two inoculation trials on sugar beet: a detached leaf assay and spray inoculation of adult beet plants in the greenhouse. Inoculations with the *Colletotrichum* species caused stunting and foliar discoloration. *Colletotrichum dematium* was reported to cause similar symptoms on sugar beet in Japan and table beet in Canada. The morphology of the fungi isolated from sugar beet in Michigan matched that for strains in the *Colletotrichum dematium*-group. However, genetic analysis of the internal transcribed spacer (ITS) region and -actin gene confirmed that isolates belonged in the *Colletotrichum* curved spore species complex but was not sufficient to identify to any given species. Results did not support identification as *C. dematium*, giving closer sequence matches to *C. spaethianum* (99% similarity for ITS) and *C. incanum* (99% similarity for actin). To our knowledge, *Colletotrichum* species previously have not been reported on any *Beta vulgaris* (sugarbeet, table beet, or Swiss chard) in the United States. Samples with a *Colletotrichum* sp. have been collected from six different Michigan counties. Although defoliation and clear yield loss have not been observed, the cosmetic damage from spots on the leaves may be an issue for chard production for food or ornamentals.

HENDERSHOT, CARLY*[1], CHRIS BLOOMINGDALE[1], THOMAS GOODWILL[2], LINDA HANSON[2] and JAIME WILLBUR[1], [1]Michigan State University, Department of Plant, Soil and Microbial Sciences, [2]USDA – ARS, Department of Plant, Soil and Microbial Sciences, [1]612 Wilson Rd. Rm 35 East Lansing, MI 48824, [2]612 Wilson Rd. Rm 37 East Lansing, MI 48824 **Characterization of pathogens and foliar disease interactions impacting sugar beet storage.**

The US sugar beet production has a market value of over $5 billion. In Michigan, sugar beets (*Beta vulgaris*) are stored for up to 200 days post-harvest while awaiting processing. During this storage period there are several factors that cause the beets to rot, reducing the sugar content and overall profit. In addition to root degradation, fungal mycelium, lipopolysaccharides, and pectinase byproducts clog filters and slow the extraction process. Michigan Sugar estimates that delaying onset of storage rot one month could save the industry $1 million per year. Proper identification and characterization of the pathogens affecting stored beets will allow for better targeting of disease management. In addition to organisms that directly colonize the beet root, it is not well understood how foliar disease in the field will affect the storability of the beet. Cercospora leaf spot (CLS) is the most damaging and widespread foliar disease of sugar beet. To investigate the impact CLS has on pathogens colonizing the beet root, post-harvest trials will evaluate symptom development after inoculation with *Fusarium graminearum, Botrytis cinerea, Penicillium vulpinum,* and *Phoma betae* in beets with high or low in-season CLS severity. Beet root rot will be rated monthly between harvest and 120 days into storage. This study will also examine varietal effect on rate of rot using CLS resistant and susceptible varieties. In 2019, a preliminary screening was conducted at harvest on roots selected arbitrarily by agronomists in Bay, Saginaw, Tuscola, Huron, and Sanilac counties. At harvest 38% of roots were colonized with *Rhizoctonia* sp., 40% with *Fusarium* spp., 16% with *Geotrichum* sp., and 6% with *Trichoderma* spp. (n=85 beet roots). In 2019, storage samples with advanced stages of root rot were obtained five months into the storage period from Kinde and Sebewaing locations. *Aspergillus* sp., *Alternaria* sp., *Botrytis* sp., *Fusarium* spp., and *Penicillium* sp. were identified from symptomatic samples. Isolated organisms will be further characterized and may be used in future storage trials. Identification and characterization of post-harvest pathogens affecting sugar beets as well as studies of the effects of CLS on storability will help further inform beet storage management.

HERNANDEZ, ALEXANDRA*[1], DANIEL BUBLITZ[3], TOM WENZEL[3], CHRIS BLOOMINGDALE[1], CAMERON PINCUMBE[1], CHERYL TRUEMAN , LINDA E. HANSON[2] and JAIME F. WILLBUR[1], [1]Michigan State University, Department of Plant, Soil and Microbial Sciences, [2]Michigan State University, Department of Plant, Soil and Microbial Sciences; United States Department of Agriculture – Agricultural Research Service, [3]Michigan State University, Department of Plant, Soil and Microbial Sciences; Sugarbeet Advancement, University of Guelph – Ridgetown, [1]612 Wilson Rd. Rm 35 East Lansing, MI 48824, [2]612 Wilson Rd. Rm 37 East Lansing, MI 48824 **Epidemiological studies of Cercospora leaf spot of sugar beet for improved management.**

Cercospora leaf spot (CLS), caused by *Cercospora beticola*, is the most important foliar disease of sugar beets worldwide. In Michigan, CLS is difficult to manage because recent studies have shown that current models can be problematic and inoculum overwintering results in high disease pressure. In this work, predictive models using *C. beticola* spore presence and abundance and strategies to reduce inoculum survival were evaluated. Spore abundance and environmental factors were monitored in two locations for use in model development. Using this data, a preliminary model ($R^2 = 0.23$, $P < 0.0001$) was developed to predict daily *C. beticola* spore abundance using daily precipitation ($r = 0.22$, $P = 0.05$), minimum daily relative humidity ($r = 0.24$, $P < 0.01$), maximum daily soil temperature ($r = -0.24$, $P < 0.01$), and maximum daily wind speed ($r = 0.38$, $P < 0.0001$). For inoculum reduction practices plowing of plant residue, foliar heat treatment, and foliar desiccation were compared to a non-treated control. After end-of-season treatments, leaf samples taken at harvest were evaluated and leaf samples left in the field were assessed every 45 days to determine *C. beticola* viability. During the following season, disease ratings were recorded and lesions on sentinel beets were evaluated to determine inoculum levels present. These inoculum reduction treatments significantly impacted at-harvest CLS lesion sporulation ($P < 0.001$), *C. beticola* viability over the winter ($P < 0.05$), and number of lesions on sentinel beets, as well as disease ratings, in the following growing season (May 26-June 2: $P < 0.05$; June 2-9: $P < 0.01$) with significant reductions using the foliar heat treatment. Overall, these novel management practices will be further validated and can be used in sustainable management of CLS.

HOLLY J. CORDER*[1], J. MITCHELL MCGRATH[2], THOMAS R. GOODWILL[3] and LINDA E. HANSON[3], [1]Michigan State University, [2]Michigan State University, [3]USDA, [1]3775 S. Reese Rd, Frankenmuth, MI 48734, [2]612 Wilson Road, 37 Plant Biology, East Lansing, MI 48824, [2]612 Wilson Road, 37 Plant Biology, East Lansing, MI 48824 **Field testing for seedling response to Rhizoctonia damping-off.**

As well as causing Rhizoctonia root and crown rot, *Rhizoctonia solani* can cause stand loss in sugar beet seedlings as a damping-off. Previous research had shown adult plant resistance usually was not seen in seedlings, but testing in the greenhouse identified USDA germplasm with seedling resistance. A nursery for seedling Rhizoctonia has been developed to screen USDA germplasm and public releases. Original identification for seedling rhizoctonia resistance and recurrent selections for breeding lines with seedling Rhizoctonia resistance have been made using this nursery. Beets were inoculated with a lower rate of inoculum than used for adult beets, and water was applied to help the disease develop. Stand counts were taken early and throughout the year, and a final root rot rating conducted. Selections were made at the end of the season. Some germplasm have shown strong seedling resistance. It was previously understood that expressed resistance to Rhizoctonia happens in mature plants (transition at the 4-6 leaf stage), so observing reduced damage from *R. solani* at the seedling stage is a great step forward. Currently most screening has been to AG 2-2, but AG 4 has been tested as well, and varied response is present in germplasm.

HOLMQUIST, LOUISE, Hilleshög Seed, Säbyholmsvägen 24, Landskrona, Sweden **Further studies on Rhizoctonia resistance genes for improved screening of breeding lines.**

We have previously utilized transcriptomics to identify genes involved in Rhizoctonia resistance by comparing gene expression patterns between resistant and susceptible sugar beet lines during Rhizoctonia infection. These findings were confirmed by and expanded upon using a genome-wide association study where several significant QTLs where detected. With the use of whole-genome sequencing and an improved pan-genome annotation, we were able to identify several candidate genes located within the identified QTLs. These candidate genes were tested on an extended set of material resulting in the identification of several key genes involved in Rhizoctonia resistance. Additionally, this has led to the development of better genetic markers allowing for increased Rhizoctonia screening precision.

KOCH, AMANDA R.* and W. L. STUMP, University of Wyoming, 1000 E University Ave, Department of Plant Sciences, Laramie, WY 82071
Investigations of Cercospora leaf spot Biology in Sugar Beet.

The relative fitness of benzimidazole and strobilurin insensitive *Cercospora beticola* isolates were compared to a fungicide sensitive isolate on sugar beet in the greenhouse at the University of Wyoming. Disease development was determined on both a Cercospora leaf spot resistant and susceptible variety. The sensitive and insensitive isolates were recovered from sugar beet fields from the Western Sugar production region. After inoculation, parameters of lesion development, expansion and sporulation were measured up to 24 days post inoculation. Lesion numbers and expansion for those isolates were in general greater in the susceptible variety compared to the resistant. Lesion expansion showed differences in the isolates in how they responded to the cultivars. Disease severity (0-100) showed slight differences between isolates. Sporulation measurements were variable for the susceptible cultivar and consistent at zero for the resistant cultivar across all three isolates. This study is ongoing and currently in its second round at the university's greenhouse.

LENNEFORS, BRITT-LOUISE*[1] and DOUG RUPPAL[2], [1]MariboHilleshög Research AB, [2]Hilleshog Seed LLC, [1]Säbyholmsvägen 24, 261 91 Landskrona, Sweden, [2]1020 Sugar Mill Road, Longmont, CO 80501
Development varieties with resistance to *Alternaria* spp. *Alternaria* leaf spot (ALS) caused by *Alternaria* spp., is a widely spread disease.

Alternaria spp is a growing concern in markets like Michigan, and the disease has also been identified in eg the Minnesota and North Dakota growing regions. The severity of the disease has increased during the past 5 years and fungicide resistant isolates have been detected. A screening platform for identification of sugarbeet lines with resistance to *Alternaria* spp., has been established at Hilleshög. Resistant lines have successfully been identified and are selected for development of resistant hybrids. In US growing areas, field trials of sugar beet hybrids have been evaluated for resistance to *Alternaria* spp. Hilleshög varieties are tolerant to both Cercospora and *Alternaria* making them to a good choice for protection against a complex of leaf spot diseases. It is important to breed additional disease traits while focusing on the importance to maximize sugar production.

LIU, YANGXI*[1], AIMING, QI[2] and MOHAMED KHAN[3], [1]North Dakota State University, [2]University of Hertfordshire, [3]North Dakota State University & University of Minnesota, [1]Fargo, ND 58108, [2]Hatfield, AL10 9AB, U.K, [1]Fargo, ND 58108 **Responses of different fungicide-resistant Cercospora beticola populations to copper-based products.**

Cercospora leaf spot (CLS) is one of the most damaging foliar disease affecting the profitability of the sugar beet industry. Its management is to use resistant cultivars, rotate with non-host crops, and to apply effective fungicides in a timely manner. However, the causal fungal pathogen, *Cercospora beticola*, has developed multiple resistances against quinone outside inhibitor (QoI) and demethylation inhibitor (DMI) fungicides. Forty-seven (47) *C. beticola* field isolates with QoI and/or DMI resistance were tested using spore germination assay for the sensitivity to nine copper-based chemicals in an in vitro study. Significant differences were observed in EC_{50} concentrations among nine copper-based chemicals, but not among three fungicide-resistant groups. Fertileader had the lowest EC_{50} (1.726 µg/ml), Badge SC had the highest EC_{50} (7.523 µg/ml) and the other seven copper-based products had intermediate EC_{50} (3.195-4.870 µg/ml) concentrations. The spore germination assay was more sensitive than a mycelial assay where the EC_{50} concentration for Cuprofix was between 100 to 500 µg/ml. In the in vivo study, leaves of 6-leaf stage sugar beet were treated with nine copper-based products using labeled rates. After 24 hours, the treated leaves were inoculated with spore suspension of 4×10^4 conidia/ml from QoI- and/or DMI- resistant *C. beticola* isolates. The inoculated plants were incubated at 95 to 100% relative humidity in chambers with a 16-h photoperiod and average temperature of 28 ± 2°C. CLS severity was evaluated every other day between 9 and 17 days after inoculation (DAI). Area under the disease progress curve (AUDPC) was then calculated to compare the efficacy of different chemicals. Fertileader caused leaf injury, but the other tested chemicals provided significantly better control of CLS compared to the control check (58.75) with Badge X2 (7.81), Champion (6.23), Cuprofix (6.58), COCS and Ridomil Gold Copper (5.13) having significantly lower AUDPC ($P \leq 0.05$). This research suggests that copper-based chemicals have the potential as mixing partners with other multi-site or with high risk single-site fungicides to provide CLS control and to help manage fungicide resistance.

MINIER, DOUGLAS H.*[1] and LINDA E. HANSON[2], [1]Michigan State University, [2]USDA-ARS, [1]1066 Bogue St. East Lansing, MI 48824, [1]1066 Bogue St. East Lansing, MI 48824 **Histopathology of Rhizoctonia solani AG 2-2 infection of sugar beet.**

Rhizoctonia root and crown rot (RRCR), primarily caused by *Rhizoctonia solani* AG 2-2, is a major disease of sugar beet that can cause substantial losses in most regions where the crop is grown. The disease is characterized by dark, shallow lesions on the root surface that eventually expand to involve the entire root. While no sugar beet varieties are known to be fully resistant to RRCR, several varieties show delayed or limited disease progression and are considered moderately resistant or tolerant. Observations indicate that resistant varieties primarily delay the rate at which the fungus penetrates into deeper tissues thus limiting disease progression. We are building on the previous work of Ruppel (1985) examining the infection process and making comparisons of susceptible and resistant varieties using some more advanced histopathological techniques. Sugar beet varieties C869 (susceptible) and SR98/2 (resistant) were inoculated at six weeks after planting with an isolate of *R. solani* AG 2-2 and sampled at 3, 4, 5, 6, 7, 9, and 11 days after inoculation. Diseased tissue was excised, fixed in 10% formalin, embedded in paraffin, and sectioned on a microtome. Sections were stained with toluidine blue (general structure), berberine-aniline (suberin), ruthenium red (pectin), or wheat germ agglutin / propidium iodide (fluorescent observation of fungal and plant tissue) and viewed on both a light/fluorescence microscope and a confocal microscope. We have observed apparent suberization in the resistant variety in response to infection that is not present in the susceptible variety. While infection cushions and direct penetration are commonly observed, hyphae that are associated with lateral roots and vascular tissue progress deeper into the tissue more rapidly in both varieties. Hyphae that are not associated with vascular tissue are generally limited to the outer cortex layer, advancing into deeper tissue primarily where there are breaks in the outer vascular ring. The advanced microscopy techniques employed here are expected to provide new insights into the infection process of *R. solani* AG 2-2 in sugar beet and may lead to developing innovative approaches to resistance breeding.

MOE, PALOMA*[1], MARGARET REKOSKE[1], JAY MILLER[1], MARIO SCHUMANN[2] and MADAN BATTACHARYYA[3], [1]KWS LLC, [2]KWS SAAT AG, [3]Iowa State University, [1]1325 Valley View Road, Shakopee, MN 55379, [2]Grimsehlstrasse 31, 37555 Einbeck, Germany, [3]G303 Agronomy 716 Farm House Ln, Ames, IA 50011-1051 **Breeding For Sugar Beet Root Maggot Resistance.**

In the absence of control measures against sugar beet root maggot (SBRM), a yield reduction value of $446 million can be observed in the Midwest and Western sugar beet growing areas of the U.S. (Boetel *et al*. 2010; McConnell, 2020a). While the main control of SBRM relies exclusively on chemical pesticides, this breeding review addresses the bottlenecks and opportunities of sugar beet root maggot resistance breeding. To date, the two most promising sugar beet root maggot resistant germplasm releases, F1016 and F1024, were developed by conventional breeding methods by L. Campbell (USDA, Fargo) and selection based on naturally infested insect nursery. SBRM resistant material provides significant hybrid performance benefit under infestation by SBRM, (Campbell *et al*. 2008; 2019). However, under heavy pressure, root damage from the insect still occurs, while in the absence of pressure, performance of SBRM resistant material is lower relative to currently available commercial germplasm. Therefore, breeders have not yet been able to deliver highly resistant and diverse sugar beet root maggot lines for competitive hybrid development. The challenges of traditional field nurseries, lack of new chemistries and environmental and insect resistance concerns calls for a more efficient assay method to identity resistant phenotypes and foster subsequent genome studies. In the absence of desirable root maggot resistance genes attributed to host and pest evolution in two different geographical regions, mutation breeding method approach could generate desirable resistance.

NEUBAUER, JONATHAN*[1], MARK BLOOMQUIST[2] and MELVIN BOLTON[1], [1]United States Department of Agriculture, [2]Southern Minnesota Beet Sugar Cooperative, [1]1616 Albrecht Blvd, Fargo, ND. 58102, [2]83550 County Road 21, Renville, MN. 56284 **A new portable qPCR technology to identify Cercospora beticola in asymptomatic leaves of sugar beet.**

Cercospora leaf spot (CLS) of sugar beet is caused by the fungal pathogen *Cercospora beticola*. Management of CLS relies on timely fungicide applications. Efficacy of most fungicides is enhanced when applied prior to *C. beticola* infection. However, host genetics and environmental dynamics make it difficult to predict when *C. beticola* will infect sugar beet in the field. Consequently, there is a need for diagnostic tools that are highly sensitive, specific, and ideally are portable so analyses can be carried out in the field. In this study, we used a portable magnetic induction cycler (MIC) and qPCR probes specific to *C. beticola* to identify the pathogen in asymptomatic leaves harvested from growers fields in southern Minnesota. The MIC has the capability of detecting fluorescent probes during short run times (under 50 min). Starting in the first week of June, leaf samples were harvested from sugarbeet fields over a five-week period. Detection occurred in the first week (10%) and increased throughout the sampling (34%). Fields with early detection eventually (within 14-21 days) had visual symptoms. Consequently, knowledge of asymptomatic *C. beticola* infection informed growers that fungicides should be applied as soon as possible to help minimize the impact of CLS. Since MIC can detect a range of probes, future work utilizing this machine to detect fungicide-resistant *C. beticola* isolates is under development. Taken together, recent advances in portable qPCR technology has laid the groundwork for highly sensitive detection of *C. beticola*.

OLIVIER, AMAND*, HENDRIKX DIRK, HANSE LEENDERT, JAN SELS and HENDRIK TSCHOEP, SESVANDERHAVE, Industriepark 15, BE- 3300 Tienen **A breeding approach towards Root Knot Nematode resistant varieties – a perspective from SESVanderHave.**

Plant parasitic nematodes – especially root knot nematodes (*Meloidogyne* sp.) and cyst nematodes – can cause significant economic damage in important arable and open field vegetable crops. An important tool to control these nematodes is a well thought-out crop rotation with non-host plants or resistant crops. However, root knot nematodes in general, and *M. chitwoodi* and *M. fallax* in particular, are characterized by a wide range of host plants, ranging from monocotyledonous and dicotyledonous crops to a wide range of weeds. This makes it difficult to control root knot nematodes. Sugar beet breeder SESVanderHave has developed beet genetics with a high level of resistance to various root knot nematodes. Within the framework of a project co-financed by the sector organization Arable Farming, a collaboration was set up between

SESVanderHave and Wageningen University Research aiming to test this beet genetic as potential new control option to control *Meloidogyne chitwoodi*. A greenhouse trial, set up in 2018, confirmed very strong resistance, as multiplication of *M. chitwoodi* on the SESVanderHave variety was less than 0.2% of the multiplication on conventional (susceptible) variety. In 2019, this strong resistance was confirmed under field conditions. Further research to estimate the impact on a sensitive crop in the same rotation is being carried out. In 2020, official variety trials were started in the Netherlands with a combined root knot nematode and beet cyst nematode sugar beet variety. This could open up new perspectives in controlling root-knot nematodes. Growers that include *Meloidogyne* sensitive crops such as potatoes, seed potatoes, carrots and salsify in the rotation will be able to grow sugar beet as a 'break crop' to greatly reduce the risk of loss of quality, yield, and loss of phytosanitary certificate.

THOMAS, LACIE*, JAIME WILLBUR, DANIEL BUBLITZ, and KURT STEINKE. Michigan State University, 1066 Bogue Street, Plant and Soil Sciences Bldg., East Lansing, MI 48824. **Utilizing Foliar Boron for Managing Cercospora beticola.**

One of the more severe foliar pathogens capable of causing damage to sugarbeet is *Cercospora beticola*, the causal pathogen of Cercospora leaf spot (CLS). When not managed appropriately, CLS can reduce sugarbeet yield 40%. Although plant defoliation caused by the disease directly impacts root size and sugar quality, other factors including leaf regrowth and impurities within the root affect plant health and crop quality. Managing CLS remains difficult due to resistance to several fungicides. Management strategies including boron-containing compounds have been discussed as possibly containing fungistatic properties with the ability to reduce disease severity in the field. Field studies were established to investigate the effects of foliar applied boron on sugarbeet plant health and CLS disease severity. Treatments included a standard fungicide program, three foliar boron treatments (0.1, 0.25, or 0.5 lbs. B per acre) applied at 10-day intervals for 7 total applications without a standard fungicide program, three foliar boron treatments (0.1, 0.25, or 0.5 lbs. B per acre) applied at 10-day intervals for 7 total applications in conjunction with a standard fungicide program, and a nontreated check for a total of 8 treatments. Measureables collected include plant tissue nutrient analysis, percent canopy coverage, canopy normalized difference vegetation index (NDVI), visual disease incidence and severity, sugar quality, and yield. In addition, complementary *in vitro* studies will be conducted to test boron efficacy on pathogen growth. Preliminary results from the 2020 growing season will be presented and discussed as part of an integrated CLS management program.

VANDRSTUKKEN, MAARTEN*[1], KRISTOF GOVAERTS[1], MATT COFFMAN[2], JUAN VEGAS[1] and ERIK DE BRUYNE[1], [1]SESVANDERHAVE, [2]Magno, [1]Industriepark 15, BE- 3300 Tienen, [2]5908 52ND AVE S, Fargo, ND 58104 **UAV-based phenotyping of Fusarium tolerance.**

Today's sugar beet agronomy requires breeders to combine a high financial performance with an increasing number of disease tolerances. This further intensifies the "number's game" associated with variety development and creates a requirement for large disease nursery platforms where scoring by the visual operator becomes a bottleneck. In addition, visual scores are subjective and therefore error prone. Advancements in sensor and UAV technology offer valuable opportunities to address these challenges. SESVanderHave developed a set of proprietary UAV-based phenotyping methodologies to ramp up its breeding efforts and simultaneously obtain a higher selection accuracy. In this poster, we will present the methodologies developed for Fusarium and discuss its specifications in terms of throughput and accuracy.

WEILAND, JOHN*, ALYSSA FLOBINUS, VANITHARANI RAMACHANDRAN and MELVIN D. BOLTON, USDA-Agricultural Research Service, 1616 Albrecht Blvd. N, Fargo, ND 58102 **Next Generation Sequencing Applied to Known and Emerging Soilborne Viruses of Sugar Beet.**

Plant viruses constitute important agents of plant disease in sugar beet production. These range from the devastating effects of Rhizomania, caused by Beet necrotic yellow vein virus (BNYVV) to curly top and the yellows complex, caused by leafhopper- and aphid-vectored viruses, respectively. Traditional virology methods revealed the causal viruses of these and other diseases, yet were relatively time consuming and currently would be insufficient by themselves to keep pace with emerging crop disease consequent to the increasing international trade of plant materials. The development of Next Generation Sequencing (NGS) technologies, which are predicated on a naive, shotgun approach for the identification of all organisms in a biological sample, have now transitioned from their origins in the field of medicine to achieve broad application in the agricultural sciences, including plant virology. In proof of concept investigations, we demonstrate that the NGS technologies of RNA-seq and nanopore direct-RNA sequencing applied to sugar beet production field soils and roots detected the presence of, and produced near full genome sequences for, BNYVV and the co-resident soilborne beet viruses *Beet soilborne mosaic virus, Beet black scorch virus, Beet soilborne virus,* and in one case sample, *Tobacco rattle virus.* Novel virus agents discovered through the technology include the recently-reported *Beta vulgaris* Alphanecrovirus 1 (BvANV-1), a proposed *Tombusvirus* recombinant related to *Tomato bushy stunt virus,* and two satellite viruses. Validation of the approach was provided through use of the sequence in developing cloned DNA of the viral genomes from which infectious RNA could be produced. Inoculation of sugar beet plants with the infectious RNA and mutants of BvANV-1 possessing alterations in genes predicted to be involved in virus transmission through the soil and in potential disease induction in beet roots is under investigation.

WILLBUR, JAIME F.*, CHRIS BLOOMINGDALE, CAMERON PINCUMBE, DOUGLAS H. MINIER and LINDA E. HANSON, Michigan State University, 612 Wilson Rd 35, East Lansing, MI 48824
Azoxystrobin sensitivity of Rhizoctonia solani AG2-2 populations affecting Michigan sugar beet.

Rhizoctonia root and crown rot (RRCR) is caused by *Rhizoctonia solani* primarily AG 2-2 and continues to be a major disease of sugar beets. In Michigan, azoxystrobin (Quadris) is widely applied one to two times per season to manage RRCR. Azoxystrobin, a quinone outside inhibitor, targets a single site to inhibit fungal respiration and so possesses a high risk of fungicide resistance development. Continued reliance on this product has justified recent investigations of azoxystrobin sensitivity in Michigan *R. solani* populations. From 2018-2019, isolates were collected from research and commercial fields in the Michigan sugar beet growing region. Two additional baseline isolates, collected prior to azoxystrobin use in sugar beet, were included for comparison. Isolates were screened in half-strength clarified V8 broth amended with salicylhydroxamic acid at 10 µg ml^{-1} and azoxystrobin at concentrations: 0, 0.01, 0.1, 1, 10, and 100 µg ml^{-1}. Percent inhibition was calculated and effective concentrations for 50% inhibition of colony mass were determined using three-parameter logistic regression. In 2019, high frequencies of *Fusarium* spp. and *Geotrichum* sp. were also isolated from root samples; further molecular and morphological characterization will be conducted with these. Thus far, azoxystrobin insensitivity has not been observed in Michigan *R. solani* populations, however, additional testing is ongoing. In addition, evaluation of azoxystrobin efficacy, and potential alternatives, for RRCR management was conducted at the Saginaw Valley Research and Extension Center in Frankenmuth, MI.

Processing
Oral Presentations

ANDY MCCABE*[1], TODD MAURICE[2], GARY CORNELIUS[2] and ALISON LING[1], [1]Barr Engineering, [2]Southern Minnesota Beet Sugar Cooperative, [1]4300 Market Pointe Drive Suite 200, Minneapolis, MN 55435, [2]83550 County Road 21. Renville, MN 56284 **Evaluation of UV Disinfection for Sugar Beet Wastewater Applications.**

Southern Minnesota Beet Sugar Cooperative (SMBSC) conducted pilot testing to evaluate UV disinfection as an alternative disinfection strategy for treated wastewater. UV disinfection of SMBSC's wastewater (and sugar beet wastewater in general) is challenging for three reasons. Firstly, the wastewater's UV transmittance (UVT) is relatively low (typically about 30%), making it difficult to deliver disinfecting UV light into the water. Secondly, the wastewater is nearly saturated in calcium carbonate ($CaCO_3$), which can cause scaling on the UV reactor walls and lamp sleeves, reducing the effective output capacity of the lamp. Thirdly, testing results suggest the fecal coliform cells may be associated with suspended solids, shielding them from the UV light. Variability in suspended solids concentrations can thus result in variability in overall log-removal. These challenges will likely require higher than expected UV doses to achieve a given level of disinfection, however, relatively low amounts of fecal coliforms in plant influent mean that the required level of disinfection is much lower than in municipal applications. SMBSC piloted a closed-vessel, low-pressure ultraviolet (UV) disinfection reactor for 12 weeks during the 2019-2020 season. This pilot test was conducted to evaluate alternatives to chlorination/dechlorination in order to reduce effluent dissolved minerals and chlorine chemical safety considerations. The 2019-2020 UV disinfection pilot test program included continuous operation and monitoring of a low-pressure UV reactor, as well a challenge test to evaluate the achievable fecal coliform disinfection capacity. The key takeaways from the 2019-2020 UV pilot are summarized below:

- SMBSC wastewater treatment plant (WWTP) effluent requires about 0.7-log removal to consistently and reliably meet permit limits for fecal coliforms throughout the discharge season. Three seasons of monitoring also suggest that UV disinfection equipment at SMBSC should be sized for a UVT of about 25% (10^{th}percentile values).
- The low-pressure pilot UV reactor was able to achieve 4- to 5-log removal of added fecal coliforms during a challenge test at 30% UVT. Fecal coliform removal data from continuous operation of the UV pilot, however, did not necessarily show that this same level of removal was achievable with the native fecal coliforms. This result may suggest the native fecal coliforms are shielded from the disinfecting UV light by suspended solids.

- The lamp sleeves scaled after two to three weeks of operation. Clean-in-place (CIP) procedures restored UV lamp output to 80-100% of the initial capacity. On the full-scale, we expect the combination of CIP procedures and mechanical wipers to maintain the lamp sleeves at greater than 75% of initial transmittance with at least weekly CIP events.

ARNDT, OLIVER and EBERHARDT SCHWAB GMBH, Am Bauhof 17-21, 32657 Lemgo, Germany, **LIME KILNS ON NATURAL GAS – theory and practical experience in the US with this highly efficient fuel.**

In recent years natural gas has become the number one fuel option in the US beet sugar industry, both ecologicaly and economicaly driven. The increasing demand for capacity forces many of the US factories to consider new or upgraded lime kilns. After initial thoughts about the construction of a new coke/coal fired kiln unit, American Crystal Sugar decided to make the leap to natural gas combustion. This kiln was built in 2019/2020 to start serving the factory production within the forthcoming campaign. This paper addresses the following topics: (1) the motivation to use natural gas as a fuel alternative, (2) details of the new plant layout not only including the kiln but also the new milk of lime station, (3) operation and safety related measures (4) challenges during the engineering and erection phase, (5) testing procedures and operation during the commissioning period, (6) operational results with the new fuel, (7) direct practical comparisons of the technology and operation results using gaseous instead of solid fuels, (8) concluding the experiences and facts of using natural gas as fuel and the impact on production, ecological and economical aspects, (9) a sneak peek into the future of kiln technology showing first steps to alternative fuels and further digitalization of the process.

BOLIVAR FRANK, Sugar Technology International, 555 Republic Dr. Suite #115, Plano, TX 75074 **Simultaneous Sugar Cooling and Drying in a Retrofitted and Upgraded Granulator.**

Using In the drying step, the obvious goals are to consistently produce sugar of the desired moisture content and temperature. Our subtle goal is to prolong the drying step within the dryer to allow the greatest opportunity for crystallization of sucrose within the film around each crystal. The main objective is to define the best path to achieve the Sugar Production capacity and correct output conditions for the sugar within the budget and location constraints. Michigan Sugar Company – at its Caro facility needed to increase production and the bottle neck was the existing Hersey granulator (1911) model. Non desired sugar outlet conditions in terms of moisture content and temperature had been an

ongoing problem for CARO with reviews previously undertaken to determine the root cause. A decommissioned (1977) Sterns Roger Cooler Drum was therefore considered as a replacement by retrofitting and upgrading to a Modern Sugar Dryer-Cooler system. This paper describes the modifications to convert the cooler to a fully counter-current sugar dryer-cooler system together with control to significantly reduce the tendency for sugar of higher moisture content and temperature and provides initial performance results and energy savings compared with the original system.

BUSCHETTE, LYNN*[1], DAVID GROOM[1], JONATHAN NEUBAUER[2], REBECC SPANNER[2] and MELVIN BOLTON[2], [1]American Crystal Sugar, [2]USDA-Agricultural Research Service, Northern Crop Science Laboratory, [1]1700 North 11th Street, Moorhead, MN 56560, [2]1616 Albrecht Blvd. North, Fargo, ND 58102 **A field to factory comprehensive study of microbial flora of sugar beets and factory processing streams.**

During the past several campaigns, American Crystal Sugar factories have experienced periods of high unaccountable sucrose losses with consequent lower than expected recovery. Increased unaccountable losses have been highly correlated to increases in lactic acid and acetic acid along with other volatile fatty acids in the diffusion juice. In addition, increased levels of invert sugars and ethanol have been observed in process streams when unaccountable losses are elevated. Elevated sucrose losses tend to occur when cossette ethanol levels increase along with invert sugars. The response to various treatments to manage undesirable microbial activity during the process can vary greatly. Therefore, a comprehensive study was undertaken to identify microorganisms present in the beets, the soil, and the process streams, with the aim to correlate the presence and abundance of bacterial taxa with beet health and processing issues. To date, various classes of microorganisms have been identified in both the beets and process streams that include anaerobic and aerobic mesophiles and thermophiles along with aerobic psychrophiles. In the current study, deep sequencing of 16S rRNA gene PCR amplicons with the Minion sequencer (Oxford Nanopore Technologies) was used to identify bacteria present in factory samples. Preliminary sequencing experiments have demonstrated a high abundance of *Pseudomonas, Serratia* and *Yersinia* spp. across different processing stages and have also revealed the variable presence of lactic-acid producing *Carnobacterium, Trichococcus* and *Aerococcus* spp. and thermophilic *Thermoanaerobacter brockii*, amongst other bacterial taxa. By identifying the microorganisms underlying sucrose losses, it would be possible to tailor processing conditions and prescribe biocides to reduce losses due to microbial activity.

HOTCHKISS, ARLAND*[1], HOA CHAU[1], SENGHANE DIENG[2], STEFANIE SIMON[1] and JULIE HIRSCH[2], [1]USDA, [2]Ingredion Inc., [1]600 E. Mermaid Lane, Wyndmoor, PA 19038 USA, [2]10 Finderne Avenue, Bridgewater, NJ, 08807 USA **Red beet fiber composition comparison to sugar beet fiber.**

While the rheological properties of red beet pectin have been described, little is known about its bioactive properties. Red beet pomace consisted of a largely insoluble dietary fiber (40% IDF vs 10% SDF) with rhamnogalacturonan I pectin composition that was enriched in arabino- and galacto-oligosaccharide side chains. The red beet fiber had 10.2% protein, 8.7% moisture, 4.4% ash and 0.8% fat. The molar mass of red beet pomace was relatively low (67.5 kD) with low viscosity (0.06 dL/g) and a random coil shape (0.63 Mark-Houwink constant), while microwave-extracted red beet pectin had higher molar mass and a spherical shape with viscosity directly correlated with the molar mass. The red beet carbohydrate composition was very similar to sugar beet pectin and alkaline soluble sugar beet pectin composition. Therefore, both red beet and sugar beet fiber should be considered a source of bioactive prebiotic food ingredients with stabilizer hydrocolloid properties, while the low viscosity red beet fiber would not be a good thickening agent.

HOWE, ROBERT, BetaVA LTD **The Development of the Putsch Segment Filter.**

The capacity of the British Sugar Wissington Factory had increased significantly since its last major reconstruction some 23 years earlier. Continuous improvement had seen many parts of the operation now operating in excess of its original design capacity, one such process was the 2nd Carb filter station. With an operating filtration area of 4.8m2/100T beet slice this was proving inadequate for its Dorr carbonatation purification process and becoming a significant source of lost opportunity. For many years it was thought that the capital investment required to increase filtration area capacity did not offer the required Return on Investment (ROI). Through the close supplier relationship with Putsch the two companies worked closely to develop and confirm a new filtration concept in the segment filter which concluded with final installation in 2018. This paper discusses the development of the segment filter which ultimately enabled a 195% increase of the filtration area within the same footprint as the existing filter station. The paper will discuss the challenges set, the novel approach taken, the development and trial work conducted along with the benefits of such a filter over its competitors making the segment filter a very strong candidate for multiple filtration applications within a beet sugar factory.

KAHRE, SCOTT M., Sugars International LLC, 305 Inverness Way South Unit 204, Englewood, CO 80112 **Automated Factory Exception Reporting Using Sugars™ 4.1 Mass and Energy Balance Software.**

Sugar factory performance is often compared to a set of "standards" that are set at the beginning of each campaign based on anticipated average beet quality parameters. However, as beet quality and processing rates change, even the most optimized factory's results will vary. It is more beneficial to compare the actual factory operating data to an accurate mass and energy balance that accounts for the actual throughput and beet supply conditions. The latest major release of Sugars™ (version 4.1) includes a new feature that builds upon the existing XML Data Import/Export functions to automate model balances and results publishing. Factory personnel can now program their daily or weekly reporting system to generate a Sugars™ XML input file and schedule an automatic data import, balance, and results export within Sugars™. The exported model results can then be included in a periodic comparison report showing differences between actual factory performance and Sugars™ mass and energy balance predictions. Parameters with large deviations may direct factory staff's attention to opportunities for process improvement and/or measurement errors.

PETTYGROVE, MEGAN* and WILLIAM HENDERSON, ChemTreat, 10041 Lickinghole Road, Ashland, VA 23005 **Fluorescence Investigation of Sugar Beet Processing Liquids.**

Liquid samples from various stages of sugar beet processing were collected and analyzed via three-dimensional fluorescence from a scanning spectrofluorophotometer. At various processing stages, the fluorescence excitation and emission signals changed as fluorescent contaminants degraded. The evaporator process was successfully mimicked in the laboratory with a rotary evaporator and showed similar fluorescent signals. While the sugar molecule itself is not fluorescent, fluorescent compounds are carried through the process with sugar and other contaminants. The authors propose that this fluorescence is due to lignins, tannins and other organic contaminants present in the sugar beets themselves and offer an enhanced fluorescence process, using modified excitation and emission wavelengths as a way to more accurately track sugar contamination and evaporator carryover through a campaign.

REICHLING, JEAN-MARC, Solex Thermal, 250,4720-106 AVE S.E; Calgary Alberta, Canada T2C 3G5 **Used of indirect heat exchange technology to cool the sugar in order to decrease the energy consumption and air treatment.**

Factories are increasingly subject to environmental constraints. They must reduce their emissions as much as possible and they must treat all their smoke in order to comply with the environmental standards in force (NOX, Number of particles per m^3, etc.) Likewise, factories must reduce their energy consumption per ton of product produced. This reduction not only increases the profitability of the plant, but also reduces the carbon footprint. The company Solex Thermal, pioneers in vertical exchangers for bulk products in the form of powder, crystals or granules (Fertilizers, Potash, sugar, Polymer, oil seeds, salts, organic solid pellets, etc.) makes it possible. This technology works exclusively on heat exchange based on conduction. The particles to be cooled will flow by gravity between the plates and the refrigerant fluid (cold water, glycol water), will flow through the plates. There is therefore no use of air as a fluid allowing heat exchange. In the majority off application with crystal refined sugar there is not need to inject dry air with raw sugar a very small amount of sugar has to be injected to ensure that the temperature of the plates is higher than the dew point of the air surrounding the product. An Experiment has shown that replacing a fluid bed cooling technology could reduce the energy consumption between 4 to 8 times. A full example will be present where a sugar plant with a capacity of 65 tph did replace the fluid bed with very good results in term of ROI.

SCHÖPF STEFAN, Lenzing AG, Werkstrasse 2, 4860 Lenzing Austria
Molasses filtration with automatic discharge of dry solids.

Molasses contains approx. 60% of sugar. In order to extract this sugar and to increase the overall yield of a sugar mill, the molasses is processed in a chromatographic process into three phases. Whereas the natural betaine fraction is sold to third parties and the raffinate is added to sweeten animal feed, the sucrose extract is recirculated to the crystallization to recover additional sugar. This three phase separation happens in a chromatographic process, which needs to be protected through proper filtration as the resin bed of the columns is rather sensitive and very costly to exchange. Due to these facts precoat filtration using filter aid is the state of the art technology. As the sticky molasses is rather difficult to clean of the filter cloths usually a slurry discharge was used for cleaning, with the effect of efficient cleaning, but loss of product, respectively molasses. In order to be able to process 100% of the molasses the Lenzing Technik GmbH has gone through an intensive trial phase together with the customer for more than a year to optimize the settings, parameters and consumables used at the

Lenzing CakeFil equipment. These trials resulted in a dry solids discharge, molasses filtration process without product losses and additional recovery steps.

WAMBOLT, CAROL L.*, LARSON H. CALDWELL and KYLE LOMBARDO, Amalgamated Research, LLC., 2531 Orchard Drive East, Twin Falls, ID 83301 **Utilization of Near Infrared Spectroscopy (NIRS), in the Rusagro-Chernyansky Molasses Desugarization Plant, for Continuous Process Monitoring and Control.**

Still today, many sugar factories rely on controlling their processes manually. Samples are collected from select points in the process, analyzed in the laboratory and the generated data is used to control the factory. Because data collected in this manner cannot be provided instantaneously, operators never have immediate insight into how the process is running and cannot make rapid decisions necessary to prevent quality issues. NIRS calibration models were developed, by the analytical laboratory group at Amalgamated Research, LLC., which accurately predict dissolved solids, sucrose and betaine levels, allowing for real-time monitoring of the Molasses Desugarization Separator (MDS). This measurement technique was adopted by the Rusagro-Chernyansky MDS plant prior to start-up and has continued to remain as a very useful tool. The NIRS methodology provides plant operators with instantaneous data, allowing them to adjust and operate the process at optimum levels. The predictive performance and benefits of this methodology will be discussed.

Processing
Poster Presentations

BOUCHÉ, CATHERINE*, ITECA SOCADEI, 445 Rue Denis Papin Europôle de l'Arbois 13100 Aix-en-Provence FRANCE **How improving crystallization process leads to fast Return On Investment: a little nod to Pareto's law.**

It is widely acknowledged that any factory has to optimize its crystal sugar production and control its color to make good quality final product that meets customer's demands. This must be achieved under the ever increasing pressure on production costs, safety and environmental standards. Innovation and automation in the production process is the key to ensure stability, better efficiency and to reduce drastically the losses that have a huge financial impact on the factory's overall performance. By drawing on Pareto's law, stating that 80% of the effects come from 20% of causes, this paper describes how working on the root causes, responsible for the losses, brings substantial benefits with low investment. It shows how ITECA pan camera CrystObserver® is used to optimize MA and CV, diminish steam usage and especially reduce the number of fines. These improvements increase pan yield, quality and overall production while minimizing the costly recycling. They directly translate into benefits from water and energy savings, to packing and conditioning enhancements. The paper also studies the advantages of the centrifugal wash water control through the use of ITECA on-line colorimeter ColObserver®, and the additional gains a low number of fines bring at the centrifugal floor. The different steps in the process that are enhanced by ITECA online instrumentation are listed and the Return On Investment is analyzed and estimated whenever quantifiable.