ILLINOIS SOYBEAN ASSOCIATION (ISA)

Sudden Death Syndrome (SDS) Project
Bayer ILeVO product

1. Webinar: Solutions to effectively manage SCN and SDS
Ja son Bond, plant pathologist at Southern Illinois University, and Nick Tinsley, SeedGrowth™ technical representative at Bayer CropScience, discuss the basics of SCN and SDS management. They review where these pests thrive, symptoms of infestation and impact on yield, as well as conventional management practices and how **new seed and seed treatments provide control.**
http://ilsoyadvisor.com/agronomy/2017/march/webinar-solutions-to-effectively-manage-scn-and-sds/http
Date: March 13, 2017

2 Effect of planting date, seed treatment and cultivar on sudden death syndrome of soybean

Published on 13 Apr 2017, 08:00 AM • by: Yuba Kantel and Daren Mueller, Soybean Plant Pathologists, Iowa State University
Funded by the Illinois Soybean Association checkoff program

"Sudden death syndrome is difficult to manage. There are no soybean varieties completely resistant to SDS, although moderately resistant varieties are available. Planting moderately resistant varieties is the foundation of a SDS management strategy. With the support of the North Central Soybean Research Association, and the Ontario Farm Innovation Program in Canada, a team of plant pathologists in Illinois, Indiana, Iowa, Michigan, Wisconsin, and Ontario have been working together to develop an integrated pest management (IPM) plan for SDS which complements the use of moderately resistant soybeans.

Towards this goal, the team has been conducting regional field experiments to determine the effects of planting date, seed treatments, fungicide application methods, tillage, and the presence of soybean cyst nematode on SDS disease development and soybean yield.

Planting Date

The SDS pathogen overwinters in soil and crop residues and infects soybean seedling roots early in the season. Once the plant is infected, the pathogen can reside in the plant with no noticeable symptoms, although occasional early-season foliar symptoms may be seen. Foliar symptoms typically appear when the plant enters reproductive stages. If the cultivar is susceptible to SDS and weather conditions are favorable, foliar and root rot symptoms can progress quickly.

Cool, wet soil conditions can favor infection by soil-borne pathogens and, subsequently, could increase the risk for SDS development. For this reason, farmers may delay planting soybean until soil is warm and dry to minimize risk of infection.

In our regional field tests we did not find that early planting (first week of May in most locations) increased the amount of SDS that developed later in the season compared to mid-May and later plantings, nor did we find a correlation between soil temperature at planting and SDS development. The soil temperature at the early planting dates had reached 55 to 60° F., the minimum germination temperature for soybean.

However, late planting (middle-June) reduced yield significantly (up to 19 bu/a) compared to earlier plantings regardless of how much SDS developed. Therefore, we recommend from these studies that delayed planting only be considered in fields with a severe history of the disease.

We observed that rainfall during the reproductive phase of the crop was critical to SDS foliar symptom development, regardless of soil temperature at planting.

Host resistance

Our field studies confirmed that host resistance plays an important role in SDS management. We compared cultivars that were rated moderately resistant to those rated moderately susceptible by the seed company, and found that moderately resistant cultivars had significantly lower SDS disease index than the moderately susceptible cultivar at all planting dates.

Moderately resistant cultivars also yielded more than susceptible cultivars in all locations where SDS foliar symptoms developed. Significantly, when SDS did not develop, moderately resistant cultivars yielded the same as susceptible cultivars.

Seed Treatment

Foliar fungicides and most seed treatments are not effective in reducing SDS. However, the fungicide fluopyram (ILeVO ®, Bayer CropScience), applied as a seed treatment or in-furrow, has some efficacy against SDS, depending on the baseline level of disease. We found that fluopyram increased yield at some locations when SDS disease pressure was high, as measured by the amount of foliar symptoms in control plots. There was no effect on symptoms or yield when disease pressure was low. Fungicide treatments did not affect the amount of the pathogen detected in plant roots.

There were a few locations where SDS levels were high but fluopyram did not consistently reduce SDS severity compared with the control. This inconsistency is common and is sometimes observed with moderately resistant cultivars as well. This reinforces the concept that SDS is difficult to manage and is probably strongly affected by soil and environmental factors. Farmers should consider more than one management practice to prevent yield loss due to SDS disease.

It is important that farmers understand that fluopyram is an added expense to soybean production, and our research suggests that even with SDS risk factors present, disease may not develop to a level that reduces yield, thereby reducing the economic benefit of the fungicide seed treatment.

SDS Resources

Our research group summarized the current management recommendations for SDS in the recent publications Sudden Death Syndrome and Scouting Sudden Death Syndrome. See also Using ILeVo with preemergence herbicides.

View the video Scouting for Sudden Death Syndrome on YouTube.

This research has recently been published as Effect of planting date, seed treatment, and cultivar on sudden death syndrome of soybean and Fungicide and cultivar effects on sudden death syndrome and yield of soybean in the journal Plant Disease (2016)."

http://ilsoyadvisor.com/disease-management/2017/april/effect-of-planting-date-seed-treatment-and-cultivar-on-sudden-death-syndrome-of-soybean/

Date: April 13, 2017

3. SCN andSDS – TWO SOYBEAN PESTS WORTHY OF YOUR ATTENTION

Nick Tinsley, Bayer US *Funded by the Illinois Soybean Association checkoff program*

"SCN and SDS represent large threats to soybean production in Illinois. Attend the upcoming webinar "Solutions to effectively manage SCN and SDS" sponsored by the Illinois Soybean Association and ILSoyAdvisor. Presenters will be Jason Bond, plant pathologist from Southern Illinois University and Nick Tinsley with Bayer Crop Science.

Sudden death syndrome (SDS) and soybean cyst nematode (SCN) are two of the most economically significant diseases affecting soybeans grown in Illinois and throughout much of the Midwest. In fact, the soybean cyst nematode (Heterodera glycines) and the pathogen that causes SDS (Fusarium virguliforme) have been documented in almost every state where soybeans are produced and have become a major challenge to manage.

Growers typically notice SDS during midsummer, when the aboveground symptoms of interveinal chlorosis begin to appear. These irregularly shaped yellow patches on the leaves eventually expand in size and then turn necrotic after a period of time. Once aboveground symptoms are noticed, yield loss is inevitable and cannot be recovered. What many growers may not realize is that infection occurs early during the growing season and that the pathogen that causes SDS also causes a root rot, resulting in an unhealthy root system. Accompanying high densities of SCN can result in poorly developed root systems as well, which may cause soybean plants to appear stunted and chlorotic. However, it is also not uncommon for plants infected by SCN to display no aboveground symptoms at all.

The environmental conditions promoting yield loss from SCN and SDS are quite different. Yield loss from SCN tends to be more pronounced during hot, dry summers. Conversely, yield loss from SDS tends to be more severe with cool, wet conditions following planting—these conditions favor infection by the SDS pathogen. Additionally, heavy rains and saturated soil conditions during midsummer promote the upward movement of toxins in plants affected by SDS, resultung in familiar aboveground symptoms.

Depending on the year, yield losses from SCN and SDS can be variable. Because a soybean field can be infected with SCN without noticeable aboveground symptoms, yield loss is often underestimated. However, in heavily infested fields, yield loss from SCN can exceed 30 percent. The severity of yield loss from SDS depends on when the aboveground symptoms are first observed, with an earlier onset of symptoms resulting in greater yield loss.

Managing these two important pests can prove to be challenging. Rotating away from soybean is certainly effective for reducing densities of SCN; however, this practice fails to reduce the risk of SDS development. Resistant varieties are commercially available for both SCN and SDS. While varieties resistant to SDS help manage foliar symptoms, they do not protect against the root rot caused by F. virguliforme. Furthermore, there is growing concern about the inability of SCN-resistant varieties to manage SCN populations adequately. The primary source of resistance, PI88788, occurs in the vast majority of varieties and has since the 1990s. There are some areas where this source of resistance does not seem to be as effective as it has been in the past.

For growers concerned about preventing yield loss caused by SDS and SCN, ILeVO® seed treatment offered by Bayer has demonstrated consistent results since its commercialization in 2015. The active ingredient in ILeVO (fluopyram) has activity against the pathogen causing SDS, as well as nematodes in the seed zone. Complementing their current SDS and SCN management tactics with ILeVO seed treatment offers growers a solution to reduce risk and preserve yield potential."

http://ilsoyadvisor.com/disease-management/2017/february/scn-and-sds-two-soybean-pests-worthy-of-your-attention/

Date: February 20. 2017

4. 2016 SDS Commercial Variety Test Results Availible *(XX Available)*

Angie Peltier, Extension Educator in Commercial Ag for the University of Illinois Extension.

Funded by the Illinois Soybean Association checkoff progra

"This past growing season personnel from Southern Illinois University, Iowa State University and University of Illinois evaluated more than 580 soybean varieties from 22 seed companies in USB-sponsored sudden death syndrome (SDS) variety trials. The varieties that were evaluated ranged from the very early (MG 0) to late (MG V) maturity groups. Maturity groups were divided into early and late categories; for example, MG II was split into early (2.0 to 2.4) and late (2.5 to 2.9) categories in order to more easily monitor crop development and assess disease at the appropriate growth stage (Figure).

At one or more locations in Illinois and/or Iowa each variety within a maturity group category was randomly assigned to a two-row plot within a block (replication); each variety was planted in three replications. Production of the crop within these trials followed university Extension recommendations and was similar to soybeans produced in any Midwestern farm field with a couple of exceptions: 1) to provide a disease-favorable environment irrigation water (where available) supplemented rainfall, and 2) to increase the chance that germinating seedlings would be exposed to the pathogen, at planting time sorghum seed infested with Fusarium virguliforme, the fungus that causes SDS, was placed in-furrow.

Plots were monitored throughout the growing season for growth and development. At the R6 or full seed growth stage, disease incidence and severity ratings were collected for each plot. In each maturity group category, varieties known to have high levels of SDS resistance or susceptibility were included as ‘checks’. Sufficient disease in the susceptible check varieties was required in order for data from a particular trial to be included in the final report.

The final report is available for download here. *(30 page report)*

While the data may be of use to crop producers to use as a reference when making their 2017 seed selections or for crop advisors or seed company representatives to use when advising their clients, the final report is forthcoming with its limitations:

“Data presented here is from a single year at one or two locations. Varieties may perform differently in other environments.”

“Plots were not harvested for yield in this program because yield comparisons can be misleading from disease nurseries utilizing small plots. Accurate yield data for commercial varieties should be obtained from state variety trials.”

http://ilsoyadvisor.com/agronomy/2016/december/2016-sds-commercial-variety-test-results-available/

Date: December 20, 2016

5. FAQS ON ILEVO

Eric Ifft, Agronomist with Bayer CropScience

Funded by the Illinois Soybean Association checkoff progra

"ILeVO® is another solution for controlling Sudden Death Syndrome. It joins rotation, variety tolerance, drainage and delayed planting as another management option and growers are asking what it is and how it works.

What is ILeVO? ILeVO seed treatment is a soybean seed-applied fungicide that provides protection from Sudden Death Syndrome (SDS), as well as providing additional control of Soybean Cyst nematode (SCN) in the root zone.

Is ILeVO applied alone? ILeVO is a supplemental fungicide applied to control SDS and provide additional control of SCN. It joins a suite of other important seed treatments including fungicides, insecticides and VOTiVO® for SCN.

How does ILeVO work? Fluopyram, the active ingredient in ILeVO, is absorbed into the germinating seed and moves systemically into the soybean seedling’s roots, cotyledons and unifoliate leaves. Fluopyram provides protection from Sudden Death Syndrome, a disease that is found in most Illinois soils. Besides providing protection from SDS, it also acts as a nematicide for controlling SCN and other nematodes that feed on roots. These feeding “wounds” allow Fusarium virguliforme, the causal agent of soybean Sudden Death Syndrome, to enter the roots. This early nematicidal activity is important because research has shown that the most common source of in-plant SCN resistance, the PI88788 event, is beginning to become less effective in controlling SCN.

Does ILeVO work on any other fungal diseases? While ILeVO provides protection against 2 of the top 4 yield robbers in soybeans (SCN and SDS), it doesn't replace other seed treatment fungicides that protect against Rhizoctonia, Phytophthora, and Pythium, which are also major problems in most Illinois soils.

How can I tell ILeVO is working? As the ILeVO-treated seedling emerges and is exposed to sunlight, the edge of the cotyledons (VC stage) will show a yellowing color that appears as a "Halo." This Halo effect is a reaction to a very high concentration of ILeVO in the perimeter cells of the cotyledon and indicates that the seedling is now protected. It is not seen in the unifoliate (V1) or first trifoliate (V2) stages. The Halo effect is a cosmetic indicator and doesn't affected stand counts or seedling vigor, it is just the soybean plants' reaction to fluopyram.

ILeVO Works! A 4-year university study was conducted with ILeVO. The results were analyzed based on SDS disease incidence. According to the graph below (*not reproduced)* , the higher the SDS disease incidence, the greater the yield response to ILeVO. However, even under no SDS disease incidence, there was enough yield response to pay for the product".

http://ilsoyadvisor.com/disease-management/2016/april/faqs-on-ilevo/

Date: April 28, 2016

6. SDS CONTROL NOW COMES ON THE SEED

Dr. Daniel Davidson, Agronomist, posts blogs on agronomy-related topics.

Contact him at djdavidson@agwrite.com.

"Sudden Death Syndrome (SDS) is a major soybean disease in Illinois and across the Corn Belt—flare-ups are still unpredictable and can be especially devastating. Flare-ups are usually associated with early planting and wet, compacted soils that remain saturated during emergence. The only solution has been to make sure the soils and headlands have internal drainage, delay planting till later in May when soil conditions are drier and warmer, and plant a variety that tolerates SDS.

Soybean cyst nematodes (SCN) can worsen the SDS problem. SDS invades roots during seedling emergence and infects the crown region of the soybean seedling. Conditions favorable for SDS include fields that have a high-yield environment, compacted soils, early-planted soybeans, cool/wet soils at planting and wet weather prior to and during flowering. And growers need to remember that SDS—like SCN—doesn't always show symptoms but still can impact yield.

The increase in SDS outbreaks in the past decade has frustrated scientists and farmers alike—the problem seems to be getting worse and there has been no real effective solutions presented. And you can't simply rotate out of the problem by planting corn for a couple years because corn residue is actually a host for this Fusarium disease.

But now there are two seed treatments available that are promising, not as a total solution but in addition to using the above mentioned management techniques.

In 2015 Bayer CropScience commercialized ILeVO®, a seed treatment that can control SDS. ILeVO is a hard chemistry containing fluopyram. It is not a biological product like Bayer's SCN product VOTiVO®. However, ILeVO has both fungicide and nematicide properties, provides control of both SDS and SCN, and supplements VOTiVO. A year ago Michael McCarville, seed treatment technical manager at Bayer CropScience, told the ILSoyAdvisor that they have measured a 2-bushel increase in absence of foliar SDS symptoms and a 4 to 10-bushel increase in the presence of SDS symptoms, when using ILeVO seed treatment.

Syngenta has a similar 2-product combination; Clariva™ and Mertect® 340-F. Clariva seed treatments offer protection against SCN which also reduces the likelihood of an SDS infection. Mertect 340-F has direct activity on SDS.

Both companies stack these two SCN and SDS products along with base fungicides (usually 2 or 3 modes of action) and insecticides. Individual growers have to decide if the cost of this protection is justifiable and if they will receive an actual return from this investment.

Seed treatment fungicides protect your seed investment when soil conditions are less than ideal for germination—a good risk management tool. But the EPA and universities are questioning whether neonicotinoid seed treatments are really that effective in soybeans and worth the investment. Adding on SCN and SDS control will add considerable cost to seed treatments and cost of seed per acre. Each grower has to weigh the cost against the perceived economic benefit."

http://ilsoyadvisor.com/disease-management/2016/april/sds-control-now-comes-on-the-seed/

Date: April 4, 2016

7. SOYBEAN DISEASE MANAGEMENT

Using ILeVO® with preemergence herbicides

"Fluopyram (ILeVO®; Bayer CropScience) is a fungicide seed treatment used to manage soybean sudden death syndrome (SDS). Use of ILeVO® can result in cotyledon discoloration known as the “halo effect” (Fig. 1). (*Photos did not reproduce with script.)*

Farmers and crop advisors question if seedling damage is more severe when preemergence herbicides are applied to fields that have been planted with ILeVO® treated seed since preemergence herbicides can also injure seedlings (Figs. 2, 3). To answer this question, a two-year study in Indiana and Iowa examined the impact of ILeVO® and common preemergence herbicides on phytotoxicity, stand, and yield.

This research found no negative effect on plant stand and soybean yield from phytotoxicity caused by ILeVO® or preemergence herbicides. Although visual damage may seem severe when ILeVO® and preemergence herbicides are used together, there was no detectable interaction between ILeVO® and the preemergence herbicides tested in this experiment. This means that ILeVO® did not increase seedling damage from herbicides and herbicides did not increase damage from ILeVO®. In all treatments, phytotoxicity was gone by growth stage V4 and any damage caused by preemergence herbicides did not make ILeVO® less effective.

Cool, wet conditions make phytotoxicity worse for both ILeVO® and preemergence herbicides. These conditions also favor infection by the fungus that causes SDS. Research conducted by several Land Grant Universities and Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) indicates that ILeVO® may be a useful SDS-management strategy in fields with a history of SDS that will be planted in less than ideal conditions.

The Soybean Disease Management series is a multi-state and international collaboration sponsored by the North Central Soybean Research Program (NCSRP). This project was funded in part through Bayer CropScience and Growing Forward 2 (GF2), a federal-provincial territorial initiative. The Agricultural Adaption Council assists in the delivery of GF2 in Ontario. Contributors to this series come from Land Grant universities in the North Central states and Canada. The Crop Protection Network is a multi-state and international collaboration of university/provincial Extension specialists and public/ private professionals that provides unbiased, research-based information to farmers and agricultural personnel. This information is provided only as a guide, and the authors assume no liability for practices implemented based on this information."

http://soybeanresearchinfo.com/pdf_docs/CPN1013_ILeVO_herbicides.pdf

Date: January 2016

8. FACULTY AND STUDENT RESEARCH LEADS TO NEW SOYBEAN LINES

"Southern Illinois University Carbondale's Soybean Breeding and Genetics Program has produced several new, high-yield, disease-resistant soybean lines in recent years.

SIU's three most recent soybean germplasm lines, SIU4915A, SIU4915B and SIU4915C, are keeping up the SIU standard of disease-resistance and high-yield. The SIU Soybean Breeding and Genetics Program, under the guidance of Stella K. Kantartzi, associate professor of plant, soil and agricultural systems, conducted yield trials on the three new lines in 2009 and in 2010 in three distinct Southern Illinois locations: Carbondale, Dowell and Belleville.

All three lines proved to combine a high crop yield with disease resistance to three devastating diseases: sudden death syndrome, frogeye leaf spot and soybean cyst nematodes. SIU soybean lines are conventionally-bred lines, not genetically modified organisms.

SIU will make these three lines available to the public, which means they are available for use in public breeding programs."

http://coas.siu.edu/news/2015/04-27-2015.html

Date: April 27, 2015

9. ISA RESEARCH CONFERENCE PREVIEW: SEED TREATMENTS

"-------- research being done through the Iowa Soybean Association and universities across the country. -------- Tristan Mueller, operations manager of agronomic research for the Iowa Soybean Association (ISA) On-Farm Network® combines work being done by ISA and universities.
An in-depth research projects between the ISA On-Farm Network and Iowa State University has been the testing of seed treatments that are new to the market.

In 2014 and 2015 the On-Farm Network and the Plant Pathology and Microbiology departments at ISU worked together to test two products recently introduced to farmers. Clariva, a biological nematicide from Syngenta that targets soybean cyst nematode, and ILeVO, a fungicide from Bayer CropScience designed to control sudden death syndrome (SDS) and soybean cyst nematode were both studied as part of on-farm research and as part of university plot trials.

ILeVO trials were conducted across the Midwest and even north of the border. Universities in Illinois, Indiana, Iowa, Michigan and Ontario performed dozens of trials over three years comparing ILeVO against other products claiming to offer protection against SDS. Trials compared ILeVO + Pancho/VOTIVO with Mertect and HeadsUp. The studies found that HeadsUp and Mertect didn't offer any additional control of SDS or a yield response. ILeVO, on the other hand, reduced SDS and on average contributed to a four bushel/acre yield increase.

"The severity of SDS in the untreated was a very good indicator of how much of a yield response there would be from ILeVO," Mueller said. "But even when there was no visible SDS there was still on average a 1.6 bu/a yield response."
Mueller went on to say that the more disease pressure a field experienced the higher the positive yield response. This increase maxed out at around five and a half bushels/acre."
http://www.iasoybeans.com/news/articles/isa-research-conference-preview-seed-treatments/
Date: January 14, 2016

10. Transgenic approach in managing sudden death sindrome in soybean

Iowa State University, Department Agronomy

Project Director: Bhattacharyya M.K.

Project start date: 1 January 2013

Project end date: 31 December 2018

Non Technical Summary

"Our investigation is expected to identify gene(s) of F. virguliforme that are vital for infection and disease development and reveal if suppression of the expression of these genes in the pathogen is feasible by expressing relevant transgenes in soybean. If demonstrated, we would develop an innovative approach to manage SDS. In addition, sequence analyses of 175 SDS pathogen isolates will reveal the molecular complexity of the pathogen. Expected actions are: Incorporation of one or more of the selected transgenes will result in elite soybean lines with enhanced SDS resistance and consequently increased profitability for soybean growers who chose to use this transgenic technology to manage the SDS. Expected changes in conditions are: Our project is expected to result in reduced soybean yield losses from SDS; improved farm economy from growing elite transgenic soybean lines with enhanced SDS resistance; development of a new generation of teachers, educators and scientists, who will contribute towards enhanced crop production for sustainable food securit **y."**
https://portal.nifa.usda.gov/web/crisprojectpages/0231462-transgenic-approaches-in-managing-sudden-death-syndrome-in-soybean.html
Date: 2017

11. Soybean Sudden Death Syndrome (SDS)

"According to University of Illinois research, the initial SDS infections that occur on the roots and crowns of young soybean plants occur as early as the seedling stage. Roots have a blue coloration when infected and subsequent Root rot affects seedling health.

SDS strips soybeans of production potential. But proper early-season preparations can help alleviate possible late-season losses.

- SDS is caused by the fungus Fusarium virguliforme, which spreads through soil movement from field to field. The fungus can survive and overwinter in crop residue.

Melissa Chu, ILeVO® product manager, urges growers to pay attention to the possibility of SDS in their field. Once SDS is in a field, it stays there, and it's a disease growers have been fighting for decades. Studies at Southern Illinois University Carbondale confirmed greater soil compaction leads to higher levels of SDS.

- Often SDS develops in cool, wet weather and in compacted soil.

- More moisture for longer periods of time in the soil enables the SDS pathogen to penetrate the soybean plant via the root system and put stress on the plant.

At flowering, the SDS fungus produces toxins that cause foliar destruction, including leaf drop and aborted pods. Plants may pull easily from the soil. Soybean stem tissue turns white, while areas between leaf veins turn bright yellow and then brown. The brown tissue may fall out and leave large holes in the leaves. Toxin production and symptom severity will vary by climatic conditions and the level of SDS resistance in the varieties grown.

An integrated approach should be taken to manage and prevent SDS.

- Though there are no seed varieties with the greatest resistance to SDS for fields with a history of the disease, and consider improving soil drainage in fields with recurring problems.

Partner your variety selection with ILeVO. The seed treatment has shown efficacy on SDS in university field trials. Daren Mueller, assistant professor at Iowa State University, says, "Having an integrated management approach with the addition of products such as ILeVO would provide a sound set of tools for growers to protect their crop when [variety] resistance may not be enough. We've tested ILeVO, and it appears to be a very effective product in preventing damage from SDS."

ILeVO is unique in that it protects against both the foliar (above-ground) and root-rot (below-ground) phases of the disease, making it the most complete SDS protection available on the market. In addition, ILeVO provides broad-spectrum protection against all plant-parasitic nematode species in the seed zone, including Soybean Cyst Nematode (SCN), which, when present in a field, can exacerbate the SDS disease.

Field trials show yield are 2-10 bushels per acre higher when ILeVO is used, depending on pest severity. Including ILeVO and Poncho®/VOTiVO® as part of an Integrated Pest Management (IPM) program ensures soybeans perform better, even in high-risk areas".

https://www.cropscience.bayer.us/products/seedgrowth/ilevo/soybean-sudden-death-syndrome?xtor=SEC-166-[GOO]-[SuddenDeathSyndrome]-[b]-S-[sds%2

Date; Last Updated May 30, 2017

12. **NCSRP Production Research**

The North Central Soybean Research Program (NCSRP), a collaboration of 12 state soybean associations, invests soybean checkoff funds to improve yields and profitability via university research and extension.

http://www.ncsrp.com/NCSRP_research.html#sdsipm

"The NCSRP Board approved the following research projects for funding for fiscal year 2017. Several of the projects are being jointly funded by the United Soybean Board and state checkoff boards.The areas emphasized for the coming year are soybean diseases, soybean cyst nematode, soybean entomology, genetic and biotechnology studies toward the improvement of host resistance and yield, and outreach.

1. Developing an Integrated Management and Communication Plan for Soybean Sudden Death Syndrome (SDS) in the North-Central Region

The foundational management strategy for SDS is resistant cultivars. However, in some years when environmental conditions are especially favorable for SDS, it's been evident that resistance alone does not provide adequate control. The main goal of this project is to develop crop managment strategies that will ensure that SDS-resistant cultivars will be effective as possible.

This research project will evaluate current and future crop production practices and/or products, how these practices fit into an IPM strategy for SDS and if they enhance the efficacy of SDS-resistant sobyean cultivars.

Read the latest **progress report** (April 2017)

North Central Soybean Research Program Developing an integrated management and communication plan for soybean SDS.

Daren Mueller and Leonor Leandro (Co-Project Leaders),
Kiersten Wise (Purdue University),
Martin Chilvers (Michigan State University),
Febina Mathew (South Dakota State University) and
Damon Smith (University of Wisconsin)
(dsmueler@iastate.edu) and (lleandro@iastate.edu).

Progress Report March 2016 - April 2017

The foundational management strategy for sudden death syndrome (SDS) is using resistant cultivars. However, in years such as 2010 when environmental conditions are favorable for disease development, resistance alone does not provide adequate control or reduce farmer risk sufficiently. Also, SDS continues to move into new areas. The main goal of this project is to investigate management options that will help ensure resistant cultivars will be as effective as possible even in unusually conducive SDS conditions.

Project Objectives

1. Evaluate if soybean root health can be improved to reduce SDS or be used as an indicator of SDS risk;
2. Determine how shifts in soybean production practices affect the risk of SDS development; and
3. Communicate research results with farmers, agribusinesses and other soybean stakeholders.

Results

We published Fungicide and Cultivar Effects on Sudden Death Syndrome and Yield of Soybean in the journal Plant Disease on the previous two years' evaluation of products. In the last two years' evaluation, IleVO seed treatment or in-furrow application was superior to manage SDS than other fungicide products.

In 2016, we conducted field experiments in Iowa, Indiana, Michigan, South Dakota, Wisconsin and Ontario, Canada including new fungicide products to compare them with base seed treatment and ILeVO in their ability to reduce SDS. We evaluated eight fungicide products applying on seed and foliage on SDS susceptible and resistant cultivars. Plant population, root rot, foliar SDS incidence and severity, and yield data were recorded using standard protocols. Root samples have been collected and are being processed to quantify F. virguliforme in soybean root tissue using a qPCR assay identified in a NCSRP-funded project. Data collection from participating states and analysis is in process.

We completed a study evaluating planting date and seed treatment effect on SDS development and published a manuscript in Plant Disease Effect of Planting Date, Seed Treatment, and Cultivar on Plant Population, Sudden Death Syndrome, and Yield of Soybean in the journal Plant Disease. The ILeVO seed treatment reduced disease severity and increased yield nearly in all plantings and cultivars, with a maximum yield response up to 21% at the Roland, Iowa location. No clear link between early planting and SDS was observed. Planting earlier than Mid-May did not increase the risk of SDS being developed. Mid-June plantings yielded lower grain up to 19 bu/A compared to early May plantings. In all experiments, early-May plantings resulted in lower or similar FDX as treatments planted in mid-May or early June. We learned from this study that planting should not be delayed for management of SDS.

Field trials investigating planting date and cultivar effects on SDS development and yield were conducted in Wisconsin in 2013 and 2014 (See Revisiting Planting Date and Cultivar Effects on Soybean Sudden Death Syndrome Development and Yield Loss in Plant Disease). Similarly, despite the most symptom development, results of this 2-year study (2013, 2014) suggest that early May planting coupled with appropriate cultivar selection provides maximum yield potential and profitability in Wisconsin.

We completed field experiments on determining how increasing SCN resistance to SCN-resistant cultivars will affect SDS resistance performance. Data analysis is complete and manuscript is near submission to publish in Plant Disease. So far, we found PI88788 resistance source has been broken by nematode population in all tested sites except in Rodney,Ontario. SCN resistance played a critical role on SDS development. Cultivars with no resistance SCN had the highest disease and lowest yield. Fall season SCN population density and SDS were positively correlated.

We established field experiments in Iowa, Indiana, Michigan, and Wisconsin and Ontario to investigate the effect of corn residue on SDS development. We compared two levels of residue removals and two tillage systems in corn and soybean rotation system. The first year of data on plant population, root rot, foliar SDS, and yield were collected. Soil samples for determining SDS and SCN level on soil will be collected and processed in fall. Data are being gathered and analyzed.

We developed two regional publications through the Crop Protection Network: Scouting for Sudden Death Syndrome in Soybean and Soybean Disease Management: Sudden Death Syndrome.

April 2017 Fluoyram (ILeVO, Bayer CropScience) seed treatment or in-furrow application was found superior to manage SDS than other fungicide products evaluated. We published a manuscript (Plant Disease 100:1339-1350). We continue evaluating fungicides including new products to compare them with base seed treatment and ILeVO in their ability to reduce SDS. In 2016, we conducted field experiments in Iowa, Indiana, Michigan, South Dakota, Wisconsin and Ontario, Canada. We evaluated eight fungicide products applied as seed and foliar applications on SDS susceptible and resistant cultivars. Plant population, root rot, foliar SDS incidence and severity, and yield data were recorded using standard protocols and data analysis has been complete. Root samples were collected to quantify F. virguliforme in soybean root tissue. DNA extraction has been complete and DNA samples are being processed for qPCR.
We established field experiments at locations in Iowa, Indiana, Michigan, Wisconsin and Ontario for a study coordinated by Dr. Shawn Conley to investigate the economic risk and profitability of seed treatments on soybeans planted at different populations. The three seed treatments consisted of untreated control (UTC), a commercial base treatment (CB), and CB treatment + IleVO were compared at different plant populations. Soybean yield was evaluated in fields with and without a history of SDS. We collected data on plant population, SDS incidence and severity multiple times,

and yield. A manuscript has been accepted in Crop Science and an extension publication was written and posted in the CoolBean website. Economic risk and profitability of seed treatments and seeding rate for each seed treatment was also estimated using different soybean prices. The CB and ILeVO seed treatments increased profit at each grain sale price and across all seeding rates compared to the UTC.
We completed a study evaluating planting date and seed treatment effect on SDS development and published a manuscript (Plant Disease 100:1735-1743). To summarize, ILeVO seed treatment reduced disease severity and increased yield nearly in all plantings and cultivars, with a maximum yield response up to 21% (Roland Iowa). No clear link between early planting and SDS was observed. Planting earlier than Mid-May did not increase the risk of SDS being developed. Mid-June plantings yielded lower grain up to 19 bu/A compared to early May plantings. In all experiments, early-May plantings resulted in lower or similar FDX as treatments planted in mid-May or early June.
We established field experiments in Iowa, Indiana, Michigan, Wisconsin and Ontario to investigate the effect of corn residue on SDS development. We compared two levels of residue removals and two tillage systems in corn and soybean rotation system. The first year of data on plant population, root rot, foliar SDS, and yield were collected and are being analyzed. Preliminary data analysis showed that SDS was higher in residue not removed treatment than in residue removed for both tilled and no-tilled trials in Iowa. Michigan and Wisconsin did not detect significant difference between treatments in the no-tilled and tilled trials.
We completed field experiments on determining how increasing SCN resistance to SCN-resistant cultivars will affect SDS resistance performance. Manuscript has been accepted for publication and will be published in Plant Disease. We found PI88788 resistance source has been broken by nematode population in all tested sites except in Rodney, Ontario. SCN resistance played a critical role on SDS development. Cultivars with no resistance to SCN had the highest disease and lowest yield. Even though, the PI 88788 type resistance was not holding up, any type of SCN resistance led to greater yields, lower SDS, and lower SCN reproduction than the cultivars with resistance. Fall season SCN population density and SDS were positively correlated.

We presented our research reports at professional meetings, on Plant Management Network, many state or province level talks, seminars, media interviews, talk in field days and conferences for farmers and also published in state newsletter articles, several media releases etc. To communicate with researchers, we published 4 manuscripts and two manuscripts are accepted in peer-reviewed journals. We also had several press releases, including some jointly with NCSRP, based on results from this project. We developed two regional publications through the Crop Protection Network (Scouting for Sudden Death Syndrome on Soybean and Soybean Disease Management: Sudden Death Syndrome). These are linked to the SRII site. We also updated SRII with information from this proposal.
The result from this study will have directly benefited soybean farmers in the North Central region and also establish foundation to address future research and management questions. "
http://www.ncsrp.com/pdf_doc/Progress%20reports%202017/Mueller_April2017.pdf
Date; 2017

Projects completed in FY 2016

1. **Breeding to Improve Resistance to SDS in Soybean as a Means to Protect Yield – Delivering Resistant Varieties and Lines**

"The project draws upon the expertise of a multi-state group of researchers who are collaborating closely to develop varieties and breeding lines with SDS resistance. The goal is to deliver SDS-resistant soybean varieties to farmers, and experimental lines to the seed industry for breeding. Varieties and lines will be developed for maturity groups I to VI.

Up to now, breeders have been mostly working independently, with funds provided by state checkoff funds. This has the drawback that promising genetic lines are generally not exchanged among researchers until the time of releasing the new material, often after 8 to 10 years of work. By the close collaboration established in this project, researchers have first-hand knowledge of promising lines early in their development, reducing the time from crossing to the release of public lines.

Read the final report (October 2016)
Breeding to improve resistance to SDS in soybean as a means to protect yield: Delivering resistant varieties and lines
Silva Cianzio (Project Leader, Iowa State University),
Jim Orf (University of Minnesota),
Dechun Wang (Michigan State University),
Jason Bond and Stella Kantartzi (Southern Illinois University),
Pengyin Chen (University of Arkansas),
Brian Diers (University of Illinois) and
Glen Hartman (USDA/ARS/University of Illinois);
(scianzio@iastate.edu)

Final Report 2016
Sudden death syndrome (SDS), caused by the fungus Fusarium virguliforme, is one of the diseases that migrated from the southern area of soybean production regions. Depending on environmental conditions, SDS can cause yield losses from 10 to 50%. Planting the most resistant varieties available is the foundation of an SDS management program. There is no completely resistant soybean variety to date, but planting partially resistant varieties will minimize yield loss.

Project objective
To develop high-yielding, SDS-resistant soybean cultivars for farmers and germplasm lines for the seed industry for maturity groups I to VI.
Results
Releases: 6 releases of SDS-resistant germplasm lines
Detailed work by researcher/institution:
P. Chen (UA). NCSRP SDS Variety Trial. A total of 13 conventional and one RR-Y2 advanced lines were entered in 2016 NCSRP SDS Variety Trail MG 4. A total of 16 conventional, three RR, and two RR-Y2 advanced lines were entered in the 2016 NCSRP SDS Variety Trial MG 5. SDS reaction and yield of these lines will be used to make release decisions in the future. Among the MG 4 and 5 lines entered NCSRP SDS Trial, two MG 4 and one MG 5 high-yielding lines are derived from 5002T (resistant parent), while one MG 4 and two MG 5 high-yielding lines are derived from LS03-4294 as a source of SDS resistance (Table 1).
Promising Lines in the USDA Uniform Tests. Three advanced lines with potential resistance to SDS were entered in the 2016 USDA Uniform Test and additional two advanced lines were entered in the 2016 USDA Preliminary Test. When evaluated in 2015 USDA Uniform Test MG 6 across 11 locations, R11-171 exhibited good yield potential (60.8 bu/ac) compared to the commercial check AG6534 (55.8bu/ac) and low DX for SDS (DX=10). R11-171 is being re-evaluated in the 2016 USDA Uniform Test MG 6.
S.R. Cianzio (ISU). Will be released: 1 line highly resistant to SDS and to SCN, currently under evaluation on the Soybean Uniform Regional Tests. Releases of 3 experimental lines highly resistant to SDS and to SCN are in preparation.
B. Diers (UI). The University of Illinois breeding program develops and release experimental lines with SDS resistance. During the summer of 2016, new experimental lines were developed and evaluated for yield and agronomic traits. Based on the performance of lines in 2016 tests, new lines will be considered for release with winter.
S. K. Kantartzi (SIU). Will be released: 1 line highly resistant to SDS. Research work: it is expected that the new genetic populations developed (LS07 3131 x Forrest; LS03-4294 x Ripley; and LS03-

4294 x LS05-3229), will identify new QTL for resistance to SDS. A manuscript is in preparation.
J. Orf (UM-St Paul). Work in progress to release new advanced germplasm SDS resistant lines.
D. Wang (UM). 1 SDS resistant variety was released in the spring of 2016. Eighteen lines with SDS resistance were entered in the 2016 regional SDS test. Seventy three advanced breeding lines were evaluated in our Decatur SDS disease nursery and new lines with strong SDS resistance were identified.

Identification of new sources of resistance accomplishments

J. Bond (SIU).
Regional germplasm testing and coordination. In 2016, 11 testing locations across 6 states and Canada were planted. This was a good symptomatic year for the regional trials. The level of resistance established for most entries is valuable information for germplasm development and germplasm releases to the seed industry. During the summer of 2016, new experimental lines were developed and evaluated for yield and agronomic traits. Based on the performance of lines in 2016 tests, new lines will be considered for release with winter.

G.L. Hartman (USDA-ARS at the University of Illinois.
Greenhouse germplasm evaluations: Several tests were completed during this period for evaluation of both foliar and root resistance in a set of 350 accessions of soybean and 81 wild soybean (G. soja). The phenotype information will be used for genome-wide association studies. For the field evaluations we provided SIU with SDS data for the North Central Regional Trials (maturity groups II, III, and IV) and USDA Trials (maturity group I and II) that were planted in three replicated experiments in Urbana, IL. All entries were inoculated at planting, irrigated through the season, and notes recorded for SDS. Also, the USDA Trial (two replicated experiments, MG I and II) were planted in western Illinois at the University of Illinois Monmouth Research Station. All entries were inoculated at planting. Notes on SDS were recorded by a cooperator that lives near the Monmouth Research Station.
The check stocks, partially resistant and susceptible based on foliar symptoms, did not show great differences in root assays. There has been an on-going effort to discover better sources of root resistance to this fungus, and so far, we have not found any new sources of root resistance. Over 10,000 plant introductions are being assembled with a draft manuscript completed with one additional repeat of an experiment needed to complete the study. In addition, several other manuscripts were published and/or accepted for publication during this reporting period.

Publications
Cianzio, S.R., P. Lundeen, M.K. Bhattacharyya, S. Swaminathan, G. Gebhart, and N. Rivera-Velez. 2016. Registration of AR11SDS soybean germplasm Resistant to Sudden Death Syndrome, soybean Cyst Nematode, and with Moderate Iron Deficiency Chlorosis Scores. J. Plant Registrations 10: 177-188.
Chang, H.-X., Domier, L. L., Radwan, O., Yendrek, C. R., Hudson, M. E., and Hartman, G. 2016. Identification of multiple phytotoxins produced by Fusarium virguliforme including a phytotoxic effector (FvNIS1) associated with soybean sudden death syndrome foliar symptoms. Molecular Plant-Microbe Interactions 96:96-108.
Chang, H.-X., Lipka, A., Domier, L. L., and Hartman, G. L. 2016. Characterization of disease resistance loci in the USDA Soybean Germplasm collection using genomewide associations. Phytopathology 106:http://dx.doi.org/10.1094/PHYTO-1001- 1016-0042-FI.
Chang, H.-X., Yendrek, C. R., Caetano-Anollés, G., and Hartman, G. 2016. Genomic characterization of plant cell wall degrading enzymes and in silico analysis of xylanses and polygalacturonases of Fusarium virguliforme. BMC Microbiology 16:147 DOI 10.1186/s12866-12016-10761-12860.
Swaminathan, S., Abeysekara N.S., Lin, M., Cianizo S.R., and Bhattacharyya, M.K. 2015.

Identification of quantitative trait loci underlying the sensitivity of soybean to the Fusarium virguliforme that induce foliar soybean sudden death syndrome in soybean. Thero. Appl. Genet. DOI.10.1007/s00122-015-2643-5.
Xiang Y., Scandiani M.M., Herman T.K., Hartman G.L. (2015) Optimizing conditions of a cell-free toxic filtrate stem cutting assay to evaluate soybean genotype responses to Fusarium species that cause sudden death syndrome. Plant Disease 99:502-507. "
http://www.ncsrp.com/pdf_doc/Progress%20Reports%202016/SDS_Cianzio_Oct2016.pdf
Date; 2016

2. Evaluation and Development of a Biological Control Product to Control Sudden Death Syndrome (SDS) and White Mold

"In the past few years, several new biological fungicides have been marketed or are in development in private industry that are reported to be effective in controlling SDS and/or white mold. These biological control agents are easy to reproduce and can be applied to soil as a bio-fungicide before planting. They are reported to establish in soil, killing the SDS and white mold fungus, and preventing new infection from occurring. In this study, we are conducting regional field tests in Iowa, Illinois, and Minnesota to test the effectiveness of these products as well as an experimental biocontrol agent isolated from Iowa soil.

Read the final report (April 2017)

(The report is 18 pages. Only the summary is given here)

"NCSRP Project Final Report
Project Title: Evaluation and Development of a Biological Control Product to Control Soybean Sudden Death Syndrome and White Mold
Principle Investigator and Co-PIs:
X.B. Yang, Iowa State University, xbyang@iastate.edu
Shrishail Navi, Iowa State University, ssnavi@iastate.edu
Youfu Zhao, University of Illinois, zhao888@illinois.edu
David Schiler, USDA Bioprotection, david.schisler@ars.usda.gov
Carl Alan Bradley carlbrad@illinois.edu
James Kurle kurle001@umn.edu.

Summary
"During this three-year project period, we tested biological control agents against soybean white mold and soybean sudden death syndrome. Our data from university research farms and production farms in three north central states (IA, IL, MN) show that BCA increased soybean yields in fields severely infested with SDS or white mold. BCA can be an effective tool to manage both SDS and white mold in farms of north central regions. In university research plots where SSD risk was high from artificial inoculation, BCA has consistently show good control of SDS and increase soybean yields over the project periods. It was effective both used for seed treatment or soil sprays. Large field trials conducted in growers' fields have shown excellent results in control SDS or white mold. Producer reported good control to white mold with BCA-1 and an increase of 9.9 bu/acre compared with no check area. Second type of biological control agent BCA-2 also had 7 bu/acre yield increase. The control effects of BCA in growers fields were visible from satellite as images in the treated crop showed healthy soybean growth with higher NDVI values in areas treated with BCA. Because BCA can suppress various soilborne fungi which are pathogenic to both soybean and corn, soil applications of BCA can be an economic mean of keeping soil healthy. In fields rotated soybean with corn, an application in soybean or corn should help reduce stalk rots besides control soybean diseases. This provides a potential tool for soil health. A producer told us that "Im looking forward to using bca on all corn acres when it becomes available".
http://www.ncsrp.com/pdf_doc/Progress%20Reports%202016/Yang_final.pdf

Date: 2017

3. Increasing profits through genetic resistance to SDS

North Central Soybean Research Program
'Brian Diers (Project Leader) and Osman Radwan (University of Illinois),
Jason Bond (Southern Illinois University),
Dechun Wang (Michigan State University), and
Glen Hartman (USDA/ARS/University of Illinois); bdiers@illinois.edu

Final Report, October 2016
Sudden death syndrome (SDS) is an important disease of soybean and was estimated to cause annual losses averaging 34 million bushels each year from 2006-2010. SDS has recently moved north and has now become a major concern in MG I and II growing regions. Resistant varieties are the most effective management option for growers to control this disease. Some varieties show good resistance to SDS, however, the inheritance of this resistance is complex because it is controlled by many genes. The research in this proposal is focused on improving our understanding of the genetic basis of resistance to SDS, which should help breeders become more efficient in developing new, high yielding, SDS resistant varieties. Growers will see the benefits of this project through increased SDS resistance in private and public varieties.
Project Objectives
1. Map the locations on chromosomes of genes that confer resistance to SDS and develop molecular markers linked to resistance genes;
2. Confirm the effects of mapped genes so they can be bred into elite soybean breeding lines as part of the breeding proposal; and
3. Identify genes related to SDS resistance by gene expression profiling soybean roots and leaves.

Summary of Results
The goal of this objective was to identify genes breeders can be used to successfully improve SDS resistance. All genes were detected in at least one environment, resulting in their confirmation. With the exception of lines in the CHR18 population, lines with a resistance gene had a reduced average disease severity, disease incidence, and/or disease severity compared to lines with the susceptible allele. cqSDS-001 was detected in the LD02- 4485, LD01-5907, and LD00-3309 backgrounds and within multiple environments. The chr 1 resistance allele from PI507371 significantly reduced SDS foliar symptoms within three environments and across all environments. While differences between lines containing the resistance alleles and lines containing the susceptible alleles were observed, they were often minor. It is possible these genes would have a greater effect on resistance in different genetic backgrounds or within different environments. Additionally, cqSDS-001 and CHR10 were detected in populations and environments where symptom development was minor. Nonetheless, yield loss can still occur when symptoms are mild.

The genetic backgrounds used in this study were selected because they are characteristic of high yielding, SCN resistant MG II-IV cultivars grown across Illinois and other soybean growing states in the midwestern USA. LD02-4485, LD01-5907, and LD00-3309 are also moderately resistant to SDS, and this could have been another barrier to obtaining good foliar symptoms and an explanation for the small effects observed for the genes within the populations. These three backgrounds contain rhg1 for SCN resistance, and this genetic region also has been associated with improved resistance to SDS. For the most part, we were able to consistently achieve symptoms and collect leaf scorch data in the susceptible background, Spencer. In future SDS confirmation studies, it may be more effective to select high-yielding genetic backgrounds that have been previously evaluated to be moderately susceptible or susceptible to the disease.

 In some environments, SDS symptoms were most likely present, but we could not collect reliable data due to the presence of other pathogens. Several other fungal diseases of soybean including brown stem rot (causal agent-Phialophora gregata), red crown rot (Cylindrocladium parasiticum), charcoal rot (Macrophomina phaseolina), and stem canker (Diaporthe phaseolorum var. meridionalis, Diaporthe phaseolorum var. caulivora) have foliar leaf scorch symptoms similar to SDS. Destructive sampling is often the only way to tell the diseases apart, which is not necessarily feasible in field experiments with many locations, replications, and entries. Additionally, it can be common for plants to be infected with several other pathogens that produce symptoms that make the visual diagnosis of SDS difficult or impossible. This is especially the case when SDS symptoms appear late in the growing season around the R7 growth stage or at a lower position a plant's canopy. The Shawneetown, IL location often had other foliar symptoms that confounded our SDS ratings. The complex nature of screening for resistance to SDS demonstrates the importance of extensive multi-environment field experiments in effectively breeding for enhanced SDS resistance.

The genes evaluated in this study could be used to pyramid resistance genes into elite cultivars for more durable resistance. While the genetic mechanisms of the genes we evaluated are unknown, stacking the two distinct SDS resistance mechanisms, resistance to root rot and leaf scorch, could also be a strategy to increase resistance. Although stacking multiple genes into a single cultivar is a time consuming endeavor, MAS improves efficiency and reduces the time needed to do so. In the future, predictive modeling in combination with high throughput genetic data could conserve the resources and time needed to incorporate multiple resistance genes into elite cultivars. It would also help capture the resistance of multiple small effect genes.
There are numerous challenges a breeder must overcome to improve resistance to SDS in their programs. These include difficulty in accurately evaluating symptoms and the complex genetic nature of resistance. Nonetheless, genetic resistance remains critical in limiting the yield loss caused by SDS. This study indicates there are several sources including PI567374 and PI507371 a breeder can use to enhance SDS resistance in their program. It also highlights both the necessity and complicated nature of multiyear field testing to evaluate symptoms, and the importance of evaluating genes across multiple genetic backgrounds prior to incorporating them into a breeding program.
It is expected that advances in high throughput genotyping and phenotyping will offer better insight into the complexity of sudden death syndrome and will ultimately result in improved cultivars for producers. In the meantime, implementing MAS using confirmed genes such as cqSDS-001 and CHR1 and the continued evaluation of mapped genes are effective methods to mitigate losses due to this devastating disease. "
http://www.ncsrp.com/pdf_doc/Progress%20Reports%202016/SDS_Diers_Oct2016.pdf
Date: 2017

10.

UNIVERSITY OF GEORGIA

Resistance breeding for Root-knot nematodes

1 Advancements in breeding, genetics, and genomics for resistance to three nematode species in soybean.

Kim KS1,2, Vuong TD3, Qiu D3, Robbins RT4, Grover Shannon J5, Li Z6, Nguyen HT7.

Abstract

KEY MESSAGE:

"Integration of genetic analysis, molecular biology, and genomic approaches drastically enhanced our understanding of genetic control of nematode resistance and provided effective breeding strategies in soybeans. Three nematode species, including soybean cyst (SCN, Heterodera glycine), root-knot (RKN, Meloidogyne incognita), and reniform (RN, Rotylenchulus reniformis), are the most destructive pests and have spread to soybean growing areas worldwide. Host plant resistance has played an important role in their control. This review focuses on genetic, genomic studies, and breeding efforts over the past two decades to identify and improve host resistance to these three nematode species. Advancements in genetics, genomics, and bioinformatics have improved our understanding of the molecular and genetic mechanisms of nematode resistance and enabled researchers to generate large-scale genomic resources and marker-trait associations. Whole-genome resequencing, genotyping-by-sequencing, genome-wide association studies, and haplotype analyses have been employed to map and dissect genomic locations for nematode resistance. Recently, two major SCN-resistant loci, Rhg1 and Rhg4, were cloned and other novel resistance quantitative trait loci (QTL) have been discovered. Based on these discoveries, gene-specific DNA markers have been developed for both Rhg1 and Rhg4 loci, which were useful for marker-assisted selection. With RKN resistance QTL being mapped, candidate genes responsible for RKN resistance were identified, leading to the development of functional single nucleotide polymorphism markers. So far, three resistances QTL have been genetically mapped for RN resistance.
With nematode species overcoming the host plant resistance, continuous efforts in the identification and deployment of new resistance genes are required to support the development of soybean cultivars with multiple and durable resistance to these pests."

Theor Appl Genet. 2016 Dec;129(12):2295-2311

.https://www.ncbi.nlm.nih.gov/pubmed/27796432

Date December 2016

2. Discovery of novel nematode resistance genes and development of productive soybeans with multiple nematode resistance

"Currently, only a few sources of resistance to Soybean cyst (SCN), Root-knot (RKN), and Reniform (RN) nematodes are used in soybean breeding and it is essential to identify additional sources of resistance and incorporate them into elite soybean germplasm to enhance nematode resistance.

The overall objectives of this project are to evaluate soybean germplasm (cultivated, wild, and perennial soybeans) for soybean cyst, Root-knot and Reniform nematode resistance, discover novel nematode resistance genes/QTL, develop robust molecular markers for selections, and incorporate these genes/QTL into productive cultivars/germplasm. This USB project is involved in scientists from eight Universities/USDA in Midwest and South of the U.S. and the results will significantly impact soybean breeding and production.
https://www.soybeanresearchdata.com/Project.aspx?id=32486
Date: 2014

Soybean nematodes include soybean cyst nematode (SCN), root-knot nematode (RKN), and reniform nematode (RN) in general is one of the most destructive pests in soybean production. These nematodes are able to live in the soil for years and cause significant loss of soybean yield. It was estimated that 4 million metric tons and over billion dollar yield loss annually (Wrather et al. 2003). Although crop management practices, (rotating soybean with non-host or poor host crops and use of nematicides) help to reduce the loss from nematode damage, these soil-borne pathogens have a wide range of hosts and it requires applications of large amounts of chemicals with specialized equipment for the nematode control in the field which is not economically and environmentally friendly. Development of nematode resistance soybean varieties is the most effective way to controlling nematodes in soybean production. "
https://www.soybeanresearchdata.com/Project.aspx?id=51975
Date: 2015

3. Identification of quantitative trait loci underlying resistance to southern root-knot and reniform nematodes in soybean accession PI 567516C

Yongqing Jiao, Tri D. Vuong, Yang Liu, Zenglu Li, Jim Noe, Robert T. Robbins, Trupti Joshi, Dong Xu, J. Grover Shannon, and Henry T. Nguyen

,

Go to:

Abstract
“Soybean cyst nematode (SCN, Heterodera glycine Ichinohe), southern root-knot nematode [SRKN,Meloidogyne incognita (Kofoid and White) Chitwood] and reniform nematode (RN, Rotylenchulus reniformisLinford and Oliveira) are three important plant–parasitic pests in soybean. Previous study showed that plant introduction (PI) 567516C harbored novel quantitative trait loci (QTL) conferring SCN resistance to soybean. However, QTL underlying resistance to SRKN and RN in PI 567516C remain unknown. The objectives of this study were to identify QTL for resistance to SRKN and RN in PI 567516C. Two hundred and forty-seven F6:9recombinant inbred lines, derived from a cross between cultivar Magellan and PI 567516C, were evaluated for resistance to SRKN and RN. Two hundred and thirty-eight simple sequence repeats and 687 single nucleotide polymorphism markers were used to construct a genetic linkage map. Three significant QTL associated with resistance to SRKN were mapped on chromosomes (Chrs.) 10, 13 and 17. Two significant QTL associated with resistance to RN were detected on Chrs. 11 and 18. Whole-genome resequencing revealed that there might be Peking-type Rhg1 in PI 567516C.

Our study provides useful information to employ PI 567516C in soybean breeding in order to develop new cultivars with resistance to multiple nematodes.”

. Mol. Breed; 2015; 35(6): 131.
Published online 2015 May 23. doi: 10.1007/s11032-015-0330-5
https://www.readbyqxmd.com/read/26028986/identification-of-quantitative-trait-loci-underlying-resistance-to-southern-root-knot-and-reniform-nematodes-i
Date 2015

DR. BRENT HULKE ON ABIOTIC STRESS

USDA,ARS,NCSL

FARGO , ND

1. **Research Project: Genomics of Abiotic Stress Resistance in Wild and Cultivated Sunflowers**

Project Team

- **Hulke, Brent**

Start Date: Jan 1, 2016
End Date: Dec 31, 2020

Objective:
"The specific goals of this project are to: (1) assess resistance to drought, flooding, salt, and low nutrient stress in cultivated sunflower and its wild relatives using traditional and high-throughput phenotyping approaches; (2) associate variation in abiotic stress resistance with specific genes, regulatory networks, and/or causal variants; (3) determine the mechanistic basis of stress resistance via physiological and transcriptomic characterization of genotypes with divergent stress responses; (4) address major biological questions concerning the types of genes, their network positions, and the nature of physiological trade-offs involved in the evolution of abiotic stress resistance; (5) identify suitable stress resistance alleles (i.e., those exhibiting resistance in multiple genetic backgrounds, ideally with minimal tradeoffs) for use in sunflower breeding programs and potentially for improvement of other oilseeds; and (6) explore strategies for addressing significant negative impacts of international treaties on the use of plant genetic resources by private and public sector breeding programs in Canada and worldwide as part of our Genomics and its Ethical, Environmental, Economic, Legal and Social aspects (GE3LS) research. The subaward to ARS will focus on goals 1, 2, and 5 above, but will involve coordination with investigators working on the other portions.

Approach:
The ARS investigator will contribute the following to the team: 1. Co-Develop a multispecies, advanced generation intercross (MAGIC) population which includes USDA breeding program germplasm (already transferred under MTA), released lines, and wild species from the USDA Plant Introduction collection. USDA will assist in the intermating and line development processes as well. 2. Conduct salt tolerance testing on a uniformly saline soil in the Fargo, ND, area. This may be done in partnership with NuSeed Americas, another cooperator on this project, or by USDA independently. Factors to be investigated are seedling vigor, plant height, visible damage due to

salts, yield, and oil of the lines per se. 3. Consult on the analysis of the data in the framework of association mapping and joint AM-QTL analysis. 4. Contribute knowledge of the breeding system and marketing of sunflower to the team to maximize impact of any inventions that result from the work."

https://www.ars.usda.gov/research/project/?accnNo=430337

Date: Last Modified: 07/25/2017

2. **Research Project: Flood Tolerance Screening of Sunflower**

"**Project Team**

- **Hulke, Brent**

Start Date: May 1, 2016
End Date: Oct 31, 2020

Objective:
Conduct field screening for flood tolerance using separate case and control plots.

Approach:
Each year, two separate plot areas will be seeded to 289 lines of sunflower, using a randomized complete block design with imbedded 17x17 lattice and three replications for each of the case and control fields. The sunflowers on the control field will not be subject to irrigation, however, the flood treated field will be irrigated to maintain the soil above field capacity for 7-14 days. Notes, stress measurements, and harvest will be conducted thereafter."

https://www.ars.usda.gov/research/project/?accnNo=430729

Date: Last Modified: 07/26/2017

3. **Research Project: SUNFLOWER GERMPLASM DEVELOPMENT FOR IMPROVED** INSECT AND DISEASE RESISTANCE

"Title: Association of freezing tolerance to LpCBFIIIb and LpCBFIIIc gene polymorphism in perennial ryegrass accessions

Publication Date: 9/1/2012
Citation: Hulke, B.S., Bushman, B.S., Watkins, E., Ehlke, N.J. 2012. Association of freezing tolerance to LpCBFIIIb and LpCBFIIIc gene polymorphism in perennial ryegrass accessions. Crop Science. 52:2023-2029.
Interpretive Summary: Lolium perenne L. or perennial ryegrass, is an important turfgrass and forage grass around the world. It is also a seed production crop in the USA. Its value is diminished by its lack of winterhardiness in colder regions, where it is susceptible to winterkill. In this study, we attempted to find whether or not a gene family that has been important for cold tolerance in other crops such as barley, may have an effect on cold tolerance in perennial ryegrass. An association mapping population was assembled, screened for freezing tolerance in the laboratory, and sequenced completely at two CBF/DREB genes. The result was the discovery of one major mutation leading to changes in freezing tolerance, and several minor mutations that appear to also affect freezing tolerance.
Technical Abstract: CBF/DREB related genes are considered important genes for regulation of abiotic stress in plants. In this study, CBF/DREB genes in perennial ryegrass (Lolium perenne L.), also known as LpCBF genes, were resequenced from several cultivated and landrace plants from a worldwide collection. The same plants were subjected to freezing tolerance testing and the data subjected to mixed model analysis to determine whether the freezing tolerance is related to SNP and

indel markers of two genes, LpCBFIIIb and LpCBFIIIc. One major QTL was discovered in LpCBFIIIc for freezing tolerance. Several minor QTL were also discovered for freezing tolerance and cloning tolerance, a different abiotic stress."
https://www.ars.usda.gov/research/publications/publication/?seqNo115=273709
Date:Last Modified: 07/26/2017

4. 14TH ANNUAL NATIONAL SCLEROTINIA INITIATIVE MEETING

"Last week, Brent attended the 14th annual national Sclerotinia initiative meeting (Minneapolis, MN) and gave a talk on our lab's related Sclerotinia project. The title of his talk was "Using genomic selection to optimize prediction of Sclerotinia and agronomic phenotypes for more efficient breeding".
The primary goal of the Sclerotinia project is to better balance the intensity and efficiency of selection for Sclerotinia resistance and other agronomic traits, and to make more breeding progress per generation on all traits relative to their actual value to the producer. In collaboration with the Dr. Nolan C. Kane lab at the University of Colorado, we employ genomic selection (GS), a new statistical technology, to achieve this goal. In the talk, Brent presented that we have conducted resequencing of all 2009 to current experimental inbred lines from the USDA sunflower breeding program that have both yield and Sclerotinia resistance data. We have also developed a relational database system (mySQL) that will allow us easy access to nursery, field phenotyping trial, and genomic datasets to conduct model fitting. In the next several months, we will use the phenotypic and genotypic data to perform the preliminary analysis for each line."
http://hulkelab.org/2016/01/27/14th-annual-national-sclerotinia-initiative-meeting/
Date: January 27, 2016

5. Publication by Dr. Hulke

Hulke, B.S., and T.J. Gulya. 2015. Registration of the oilseed restorer sunflower germplasms RHA 472, RHA 473, RHA 474, and RHA 475, possessing resistance to Sclerotinia head rot. J. Plant Registrations 9:232-238.

http://hulkelab.org/publications/

Date: Updated 2017

5. Genomics of abiotic stress resistance in wild and cultivated sunflowers

"Dr. Loren H. Rieseberg of the University of British Columbia and John Burke of University of Georgia are leading an international team investigating why wild plants are more resistant to environmental stresses. The team is focusing on the sunflower, a $20 billion crop that is the only oilseed in the Global Crop Diversity Trust's list of 25 priority food security crops because it is grown widely in developing countries. "
https://www.genomecanada.ca/en/genomics-abiotic-stress-resistance-wild-and-cultivated-sunflowers
Fiscal Year Funded:

2015-2016

6. **Evolutionary Genomics of Abiotic Stress Resistance in Wild and Cultivated Sunflowers**

"Start Date:	August 15, 2015
End Date:	July 31, 2020 (Estimated)

PI: John M. Burke (University of Georgia-Athens)
Co-PIs: Lisa A. Donovan (University of Georgia-Athens), Loren H. Rieseberg (Indiana University), Khaled M. Bali (University of California Division of Agriculture & Natural Resources), Pedro Andrade-Sanchez (University of Arizona), and Jennifer M. Dechaine (Central Washington U.)
Key Collaborators: Jeffrey W. White (USDA-ARS/Maricopa) and Nicolas B. Langlade (INRA, France)
Wild and cultivated plants are regularly challenged by a variety of abiotic stresses resulting from factors such as drought, soil salinization, and low nutrient availability.
This project involves a detailed investigation of the genomic and physiological basis of drought, salt, and low nutrient stress resistance in cultivated sunflower and its reproductively compatible, stress-adapted wild species that are potential donors of beneficial alleles."
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1444522
Date: August 2015

7. **Plant Stress and Germplasm Development Research**
"USDA, ARS, PA, CROPPING SYSTEMS RESEARCH LAB
Lubbock TX
Mission:
The mission of Plant Stress and Germplasm Development research unit (35 people) is to conduct fundamental and applied research on the response of plants to thermal and water stress and to develop, through traditional and molecular approaches, appropriate germplasm to reduce the impact of these stresses on crop yields and product quality.

Start Date: Apr 1, 2016
End Date: Mar 31, 2019"

https://iapreview.ars.usda.gov/research/projects_programs.htm?modecode=30-96-05-10

Date: 2016

SCLEROTINIA INITIATIVE

1. **National Strategic Plan for the Sclerotinia Research Initiative Integrated Research for Disease Management in Sunflower, Canola, Dry Bean, Pea & Lentils and Soybean 2017 to 2021**

"Executive Summary

Vision Statement: An integrated research approach is needed to guide effective development of diagnostic technologies, disease management systems, genomic resources, and crop germplasm exhibiting durable resistance to Sclerotinia sclerotiorum. Strategic deployment of these resources will help sustain global food security through increased competitiveness of U.S. canola, pea, lentil, chickpea, common bean, soybean, and sunflower producers.

Process & Development of the Strategic Plan for the National Sclerotinia Research Initiative - 2017-2021:

On January 20-22, 2016, approximately 60 scientists and stakeholders with knowledge of the fungal pathogen, Sclerotinia sclerotiorum participated in an annual workshop hosted by the United States Department of Agriculture's Agricultural Research Service (ARS) in Minneapolis, MN. ARS, the National Sunflower Association, the U.S. Canola Association, the USA Dry Pea and Lentil Council, the U.S. Dry Bean Council, and the United Soybean Board co-organized this program. Participants reviewed annual research accomplishments and peer assessment of program performance toward that targeted improved understanding and management of Sclerotinia disease in canola, dry edible beans, peas & lentils, soybean, and sunflower. A summary (pending addition of 2015 data) of program performance against priorities of the USDA ARS National Sclerotinia Research Initiative (NSI) strategic plan for 2013 to 2017 follows: *(the table was not reproduced with cut and paste)*

Summarized the program perfornmance for 2013 and 2014 respectively were :

Achievement rating (%) 54,4 and 73,4

Total projects 21 and22

Total publications 263 and 283

Germplasm/Varieties released 41 and 9

ARS leadership considered stakeholder input in the overall assessment of the NSI program performance and in determining the research needs of industry. Reviews of ARS projects associated with NSI also were conducted by the Office of Scientific Quality Review to ensure relevance, quality and performance in meeting goals of ARS national programs. USDA-ARS leadership of NSI included:

Dr. Roy Scott, National Program Leader, Office of National Programs, Beltsville MD

Dr. John McMurtry, Area Director, Northern Plains Area, Ft. Collins, CO

Dr. William Kemp, Agricultural Administrator, Red River Agricultural Research Center, Fargo ND

Stakeholder and scientists worked in concert during the 2015 calendar year to gather and develop input for highest research priorities for the next 5-years. These data were compiled for final edits by stakeholders and scientists during break-out sessions the annual NSI meeting in January, 2016. There was consensus that genetic as well as management solutions to the Sclerotinia problem were attainable. This optimism was largely due to NSI scientist applications of advances in molecular biology to characterize genes involved in Sclerotinia resistance genomic data of soybean, dry bean, Medicago truncatula, the pathogen and other plant genomes. Implementation of molecular tools in breeding programs and the availability of genome sequence resources has greatly enhanced gene discovery and characterization of NSI data through on-line genomic research tools. Three goals plus performance measures and milestones were agreed upon for the NSI Strategic Plan 2017 to 2021. The following individuals lead teams that developed and edited this Strategic Plan:

Goal 1: Germplasm Resources & Translational Genomics--Phil Miklas, USDA ARS, Prosser WA
Goal 2: Pathogen Biology & Mechanisms of Resistance--Jim Steadman,Univ.Nebraska,Lincoln, NE

Goal 3: Disease Management & Crop Production-Michael Wunsch, ND State Univ., Fargo ND .

This strategic plan encompasses the breadth of research disciplines necessary to better understand the disease and to provide significant management options for the affected producers across the U.S. To achieve the strategic goals and research objectives, this plan emphasizes achievements that hinge on teamwork throughout the Sclerotinia research community. All actions and results will be attained in a manner that is both inclusive and open to public scrutiny.
"https://www.ars.usda.gov/ARSUserFiles/30000000/WhiteMoldResearch/SI-Strategic-PLan_%202017-2021_v1_0_Jan16.pdf

Date: 2016

2. BEE VECTORING TECHNOLOGIES INTERNATIONAL INC. (BVT) (FORMERLY UNIQUE RESOURCES CORP.) MISSISSAUGA, ONTARIO

MANAGEMENT'S DISCUSSION & ANALYSIS

"BVT is a development stage company which owns the patent pending technology specifically designed to utilize bees as natural delivery mechanisms for a variety of powdered mixtures comprised of organic compounds or currently used products which inhibit or eliminate common crop diseases, while at the same time promoting the growth of the same crops. This application process is without the use of water which is beneficial to areas under strict water management practices. In addition independent companies can deliver their biocontrol's through the BVT platform allowing a broad spectrum of applications.

The bees walk through the powder mixtures as they exit their hive and the mixture becomes temporarily attached to their legs en-route to the flowers containing the crops of interest. The BVT System consists of a dispenser tray that is incorporated into the lid of commercially reared bumblebee hives. The dispenser has a removable tray that can contain non-toxic, organic, pesticides and fertilizers in powdered form, including BVT's proprietary carrier Vectorite™. Vectorite allows the bumblebees to effectively pick up the inoculums on their way out of the hive. Multiple inoculums for a variety of different pathogens can be mixed in the Vectorite™ in a process called "stacking". BVT has its own bio control organic inoculant fungi, BVT-CR7, used to inhibit and control pathogens in high value crops such as strawberries, blueberries, Tomatoes, Canola, Sunflowers.

Sclerotinia

The soil borne pathogen Sclerotinia causes white mold diseases can seriously damage and in some cases quickly and completely destroy a crop. Numerous kinds of crops can be attacked, including canola, sunflowers, blueberries and strawberries.

------ two diseases, Botrytis and Sclerotinia, are very closely related and part of the reason BVT's patent pending biological control agent (bio-control) works on both pathogens. BVT's bio-control controls diseases by spatial 4 occupation of plant tissues and preempting tissue invasion by pathogens. As soon as bees deliver BVT's patent pending bio to flowers, the fungus germinates and colonizes the flower tissues without causing any harm or symptoms. It colonizes earlier and faster than disease organisms and thereby occupies space the disease organisms would normally use while attacking the plant.

Principal Products

BVT has patents pending for the following technologies:

1. a bio-control called "BVT-CR7": a particular strain of fungus acting as a beneficial endophyte controlling targeted crop diseases and increasing crop yield;
2. Vectorite™: a recipe of ingredients that allows bees to carry BVT-CR7 and other beneficial fungi or bacteria in their outbound flights to the crops; and
3. An integrated dispenser and removable and sealable tray system in which the Vectorite containing BVT-CR7 is placed through which the bees pass and pick up the BVT-CR7.

BVT-CR7, is an organic strain of a natural occurring endophytic fungus. It has not been genetically modified or altered in any way. Bees and plants are well accustomed to this kind of fungus and it is harmless to humans. After delivery by the bees to the crops it dies out naturally within 24-48 hours if it is unable to find suitable host plants. BVT-CR7 is a selected strain of a fungus that is common found in a large diversity of plants and soils all around the world. It grows harmlessly in the inside of plant tissue. BVT-CR7 is able to control numerous diseases but is especially effective for controlling those caused by the fungal pathogens, such as Botrytis and Sclerotinia discussed above. BVT-CR7 is endophytic in flowers, fruits, leaves, stems, and roots of plant hosts. It does not cause disease or substances toxic to plant tissue. Other microbial agents are not endophytic or have very limited endophytic ability.

As an endophyte, BVT-CR7 also enhances plant growth by organically increasing nutritional uptake, improving root size and structure, improving vegetative growth and size of plants, increasing the number of flowers and flower size, increasing resistance to diseases and environmental stresses, and preventing Botrytis and Sclerotinia development. BVT-CR7 has no re-entry issues (i.e. the time workers have to be excluded from the greenhouse to allow conventional pesticides to dissipate), it can be used up to the day of harvest, it's organic, and its beneficial effects last longer than traditional chemical fungicides."

http://www.beevt.com/wordpress/wp-content/uploads/2017/02/BVTMDA2016Q4final.pdf

Date:January 27 2017

3. Bee Vectoring Technologies Confirms Key Demonstration on Sunflower Crop

"Independent plant pathologist, Dr. Michael Wunch Ph.D., commented, *"Sclerotinia or "head rot" is a primary disease affecting sunflowers. Currently there is no viable economic system to manage this serious problem. If the BVT system works it could be a possible solution for sunflower crops affected by Sclerotinia."*

BVT conducted previous trials on sunflowers with results being favourable in controlling Sclerotinia, producing higher yields, and furthermore, the BVT system is organic.

Within sunflowers, the principle point of infection comes through the plants' bloom which lasts for approximately 11 days. Due to the nature of the BVT system, inoculant is able to be delivered directly to each plant each day, via bees, during this key period of exposure. The mode of action of the BVT compound, BVT CR7, is spatial occupation, meaning the disease is prevented from entering the plant altogether. The BVT active ingredient, *Clonostachys rosea*, is an ISR which results in stronger more vigorous plants producing higher yields. Additionally, the BVT system does not lead to pathogen tolerance - which can render chemical inoculants ineffective over time - meaning the system has an opportunity to become a foundational program able to maintain effectiveness and sustainability, year after year.

Additional information can be viewed at the Company's website **www.beevt.com**."

http://www.marketwired.com/press-release/bee-vectoring-technologies-confirms-key-demonstration-on-sunflower-crop-tsx-venture-bee-2109729.htm

Date March 29, 2016

4. Bee Vectoring Technologies Confirms Successful

Sunflower 2016 Trial Results

"The field trials were designed to evaluate the ability of the BVT system to manage sclerotinia

head rot -------.

In replicated trials conducted at North Dakota State University using bumblebees, the BVT system delivered a 36% reduction in incidence and a 22% reduction in the severity of the disease on average across three different observations. These reductions in disease incidence and severity were statistically significant. The BVT system produced a yield increase in the crop of 8%.

In replicated trials conducted in Serbia in collaboration with the Arthur Dobbs Institute and the Serbian Institute of Field and Vegetable Crops and its commercial arm "NS seme", the BVT system delivered a 43% increase in disease-free flowers, a 25% yield increase and a 5% higher bulk density which is an important quality attribute of the sunflower seed.

In addition, a trial conducted on a sunflower crop in Ontario, Canada resulted in a 46% increase in yield."

http://www.marketwired.com/press-release/bee-vectoring-technologies-confirms-successful-sunflower-2016-trial-results-2177784.htm

Date: November 22, 2016

4. **Bee Vectoring Technologies Receives Chinese & Canadian Patent Approvals**

"Canadian Patent Application No. 2,867,076
Entitled: A FORMULATION COMPRISING A PARTICULATE CALCIUM SILICATE AND CLONOSTACHYS ROSEA FOR TREATING PLANTS
Application relates to a formulation comprising a particulate calcium silicate and can contain Clonostachys rosea for treating plants (Vectorite™). BVT's Vectorite™ is a proprietary mixture of products that allows the inoculant to get attached to a bee's hairy legs and body as it walks through the tray on their way out of the hive. The Vectorite allows for delivery of BVT inoculums (including BVT CR7) either individually or together with other bio-controls and crop controls.

Chinese Patent Application No. 201280028052.9
Entitled: APPARATUS FOR TREATMENT OF PLANTS
Application relates to specialist apparatus for the treatment of plants (inoculum dispenser and tray). The BVT inoculum dispenser system is incorporated into the lid of commercial bumble bee hives. In the dispenser is a removable tray that contains, in powder form, the inoculant crop control and a mixture of products (Vectorite™) that allows the bees to effectively pick up the product on their way out of the hive.
BVT's proprietary inoculant BVT CR7 is comprised of a specific strain of Clonostachys, a naturally occurring, organic fungus which is commonly ingested by humans and is 100% safe for consumption. Once in contact with plants, it acts as an Endophyte and plant protector, blocking highly destructive diseases like Botrytis, Sclerotinia, Rhizupus, Anthracnose, and Alternaria."
http://www.firmenpresse.de/pressrelease479645/bee-vectoring-technologies-receives-chinese-und-canadian-patent-approvals.html
Date: June 23. 2016

5. **Potential biological control agents found for fungal diseases of soybean**

"We may not give much thought to fungal viruses, or mycoviruses, but new research from the University of Illinois suggests they deserve a closer look**.**

also found some encapsidated forms that were similar to plant viruses. Those were the ones we were most interested in, because they reduce fungal virulence and can be transmitted outside the fungus," he says.

This key combination may make it possible for these viruses to be used as biological control agents. "Some mycoviruses have been shown in laboratory or greenhouse studies to be very effective biocontrol agents," Domier says. One day, the encapsidated forms they discovered may be sprinkled on a field to kill pathogenic fungi and improve soybean yield.

The research was funded by the National Sclerotinia Initiative and the United States Department of Agriculture's Agricultural Research Service. "

http://newherald.news/potential-biological-control-agents-found-for-fungal-diseases-of-soybean-p475-43.htm

Date: January 25, 2017

6. SCLEROTINIA RISK IN CANOLA

"This forecasting program has been developed by the North Dakota State University Canola Pathology program with support from the Sclerotinia Initiative, the Northern Canola Growers Association, and the Minnesota Canola Council. While the information presented by this program is based on data generated through extensive research, it is only intended to serve as a guide for growers.

This forecasting program has two components, a general risk map and a risk calculator. The general risk map uses weather information to estimate risk of disease development throughout the canola growing areas of the state. This map is updated twice every week starting in mid June and continuing during the canola flowering period. The risk calculator combines information on cultural practices and the field past history of Sclerotinia with weather information retrieved from the nearest NDAWN weather station to estimate the risk of disease development for a specific field. To access the risk calculator visitors are asked to set an account and to provide information pertinent to the field of their interest.

Reading Sclerotinia Risk Maps

The risk map will be available this year starting on June 18th. Maps showing the estimated risk of development of Sclerotinia stem rot on canola will be produced daily for the duration of the flowering period. When reading the maps growers should be aware that the estimated risk applies only to canola crops that are entering the flowering period or are already flowering. This risk is calculated considering the effect of environmental factors. A risk calculator that combines the effect of weather variables, cultural practices, and history of Sclerotinia is also available. While this information is intended to advise growers when conditions may be favorable for disease development, the final decision on whether to spray a fungicide or not should include economic considerations such as the potential yield of the field and the potential market price for the commodity. Growers are encouraged to look for apothecia in their fields before making spraying decisions, especially if their fields are located in areas with intermediate or high risk."

https://www.ag.ndsu.edu/sclerotinia/

Date: June 2017

7. RHA 478, 479, 480, AND HA 481 RELEASE

"Our lab (*Hulke Lab)* is proud to announce the release four oilseed sunflower germplasms: RHA 478, 479, 480, and HA 481. RHA 478 is an imidazolinone tolerant, Sclerotinia head and basal stalk rot resistant, high oleic F8-derived F9 restorer oilseed sunflower line. RHA 479 is a Sclerotinia head rot and Phomopsis stalk canker resistant F8-derived F9 restorer oilseed sunflower line with a linoleic oil profile. RHA 480 is an imidazolinone tolerant, Phomopsis stalk canker resistant F8-derived F9 restorer oilseed sunflower line with a linoleic oil profile. HA 481 is an imidazolinone tolerant, high oleic F8-derived F9 maintainer oilseed sunflower line with moderate resistance to Phomopsis stalk canker and Sclerotinia head an basal stalk rots."

For more detailed information, check out the official release below!http://hulkelab.org/2017/01/25/rha-478-479-480-and-ha-481-release/

Date: January 25, 2017

UNITED STATES DEPARTMENT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE WASHINGTON, D.C

and

NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION NORTH DAKOTA STATE UNIVERSITY FARGO,ND

NOTICE OF RELEASE OF OILSEED SUNFLOWER GERMPLASMS RHA 478, RHA 479, RHA 480, AND HA 481

"The United States Department of Agriculture, Agricultural Research Service, and the North Dakota Agricultural Experiment Station (NDAES), Fargo, ND, announce the release of four oilseed sunflower germplasms in 2016. These germplasms have been developed to provide diversity for resistance to Sclerotinia head and basal stalk rot [caused by Sclerotinia sclerotiorum (Lib.) de Bary], and Phomopsis stalk canker [caused by Diaporthe helianthi Munt.-Cvetk., Mihaljc. & M. Petrov] in a high yielding genetic background, and are available for use by industry and public researchers to create parental lines or germplasms.

Germplasm Pedigree Descriptions:

RHA 478 is an imidazolinone tolerant, Sclerotinia head and basal stalk rot resistant, high oleic F8-derived F9 restorer oilseed sunflower line selected from the cross RHA 443/RHA 455. RHA 443 (PI 639166) is an imidazolinone herbicide tolerant, downy mildew and Sclerotinia resistant oilseed restorer line released by the USDA and the NDAES in 2003. RHA 455 (PI 642774) is a Sclerotinia resistant, high oleic oilseed restorer line released by the USDA and the NDAES in 2005.

RHA 479 is a Sclerotinia head rot and Phomopsis stalk canker resistant F8-derived F9 restorer oilseed sunflower line selected from the cross RO 12-13//RHA274/DOB/3/PSC8/4IRHA 418/RHA 419/3/R012-13/IRHA 2741PRS5,with a linoleic oil profile. RO 12-13was developed in Romania and was entered into the 1999 Food and Agriculture Organization (FAO) Hybrid Sunflower Yield Trial. RHA 274 (PI 599759) is the male of Hybrid 894 and was released by the USDA and Texas Agricultural Experiment Station in 1973. Dobritch is a hybrid developed in Bulgaria and was entered in the 1997 FAO Hybrid Sunflower Yield Trial. PSC8 and PRS5 are Sclerotinia head rot resistant restorer lines obtained through a germplasm exchange with Dr. Felicity Vear, Station d'Amelioration des Plantes, INRA, Clermont-Ferrand, France. RHA 418 (PI 607508) is a sunflower midge tolerant restorer line released by USDA and NDAES in 1998 Office of the Administrator Jamie L. Whitten Federal Building, Room 302-A 1400 IndependenceAvenue, SW. Washington, D.C. 20250 USDA is an Equal Opportunity Provider and Employer and RHA 419 (PI 619204) is a downy mildew resistant restorer line released by USDA and NDAES in 1999.

RHA 480 is an imidazolinone tolerant, Phomopsis stalk canker resistant F8-derived F9 restorer oilseed sunflower line selected from the cross RHA 443/01ivko, with a linoleic oil profile. Olivko was a hybrid entered in the Food and Agriculture Organization (FAO) Hybrid Sunflower Yield Trial from Serbia.

HA 481 is an imidazolinone tolerant, high oleic F8-derived F9 maintainer oilseed sunflower line with moderate resistance to Phomopsis stalk canker and Sclerotinia head and basal stalk rots, selected from the cross HA 441/HA 444/4/HA 4111ROMPHl3/HA 425/87 CAEBIIHA 434IHA 412. HA 441 (PI 639164) and HA 444 (PI 639167) are Sclerotinia resistant oilseed maintainer lines released by the USDA and the NDAES in 2003. HA 444 also possesses genes for high oleic acid in the seed oil. HA 411 (PI 603992) and HA 412 (PI 603993) are Sclerotinia resistant oilseed maintainer lines released by the USDA and the NDAES in 1995. ROM PH is a Phomopsis stalk canker resistant population obtained from a germplasm exchange with the Agricultural Research and Development Institute, Fundulea, Romania. HA 425 (PI 617098) is an imidazolinone tolerant oilseed maintainer line released by the USDA and the NDAES in 2000. 87 CAEB is a short-statured line with excellent lodging resistance obtained through a germplasm exchange with W.J. Vermeulen, Oil and Protein Seed Centre, Potchefstroom, South Africa. HA 434 (PI 633744) is a high oleic maintainer oilseed line released by USDA and NDAES in 2001.

Days from planting to flowering were measured on the finished germplasms in Rancagua, Chile. RHA 478, RHA 479, RHA 480, and HA 481 reached 50 percent bloom 67, 71, 65, and 70 days after planting, respectively. RHA 478, RHA 479, and RHA 480 contain genes for recessive branching and restoration of PET1 male sterile cytoplasm.

Sclerotinia Head Rot Evaluations:

Sclerotinia head rot resistance ofRHA 478, RHA 479, and RHA 480 was determined by evaluating testcross hybrids of these lines with either HA 412HO (PI 642777) or HA 412, the former being a BC4-derived, high oleic acid version of the latter. HA 481 was evaluated as a testcross hybrid with RHA 377 (PI 560145). These hybrids were tested at the Carrington Research and Extension Center in Carrington, ND, in 2007,2009, and 2010; the Bayer CropScience research station at Sabin, MN in 2009, 2010, and 2011; and the Central Lakes College Agriculture and Energy Center in Staples, MN, in 2011, under artificially inoculated conditions. Ascospores ofSclerotinia sclerotiorum pv. 'NEB 274' were sprayed on each head in each plot during bloom, and the plots subjected to mist irrigation to ensure proper conditions for spore germination and infection. Incidence and severity were measured by scoring each individual plant on a 0 to 5 scale for severity (0 for uninfected; 5 for all quadrants of the head infected), and considering any plant with a score of 1 to 5 as being infected in order to determine percentage incidence.

Average incidence of head rot in plots of testcross hybrids with RHA 478, RHA 479, RHA 480, and HA 481 was 30.8, 38.0, 62.9, and 49.4 percent, respectively, compared to an average of69.0 percent for Cargill 270, 51.4 for NK 277, 31.0 for Croplan 305, and 32.0 for Croplan 343 (CV = 38.9 percent). RHA 478 and RHA 479 had similar performance to the highly resistant checks P.0042.16 Page 2 of4 Croplan 305 and Croplan 343 and were significantly higher performing than the susceptible check Cargill 270. HA 481 was not statistically different from any check. RHA 480 was similar to the susceptible check, indicating poor resistance to Sclerotinia head rot.

Sclerotinia Basal Stalk Rot Evaluations:

Sclerotinia basal stalk rot resistance evaluations were conducted on the same testcross hybrids as in the head rot evaluations. The hybrids were tested at the Carrington Research and Extension Center in Carrington, ND, in 2008,2009, and 2010; and the Croplan Genetics field site at Crookston, MN, in 2009, under artificially inoculated conditions. Millet grain infested with live mycelia ofSclerotinia sclerotiorum pv. 'NEB 274' was sidedressed in the root zone of the plants using a tractor-mounted Gandy applicator. Incidence was measured after physiological maturity as the percentage of plants exhibiting the sign of mycelia at the base of the stalk.

Incidence in these experiments was generally low. RHA 478, RHA 479, RHA 480, and HA 481 averaged 0.0,3.2,4.5, and 16.0 percent infection, respectively, compared to an average of 12.5 for Cargill 270, 4.6 for NK 277,3.0 for Croplan 305, and 3.7 for Croplan 343 (CV = 118 percent). RHA 478 was the only line statistically superior to the susceptible check, but all four lines were statistically similar to the two most resistant checks.

Yield, Phomopsis Stalk Canker, and Agronomic Evaluations:

Yield and oil content ofRHA 478, RHA 479, and RHA 480 were determined by evaluating hybrids ofthese lines with the testers HA 412 (or isogenic line HA 412HO), and HA 445 (PI 639168). Hybrids ofHA 481 were made with RHA 377 and RHA 373 (PI 560141) as testers. Evaluations were conducted at the NDAES Agronomy Seed Farm in Casselton, ND, in 2008,2009, and 2010; the Carrington Research and Extension Center in Carrington, ND, in 2009 and 2010 (under different field conditions than the Sclerotinia head rot tests); Okaton, SD, in 2010; and Eureka, SD, in 2011. Data on yield at Okaton, SD, in 2010 were not considered in the averages because of poor germination in the plots; however, the oil percentage values are included in the averages. The best female tester (HA 412HO) mated with RHA 478, RHA 479, and RHA 480, resulted in 2836 kg ha-1 (25321bs A-I), 2549 kg ha-1 (22761bs A-I), and 2971 kg ha-l (2653 lbs A-I) yields, respectively. HA 481 mated with the best male tester (RHA 377) resulted in 2612 kg ha-1 (23321bs A-I) yield. Testcrosses with RHA 478 and RHA 480 were significantly greater than the average yield of 2306 kg ha-l (20591bs A-I) for check Hybrid HA 412HO/RHA 377, and all four testcrosses were statistically similar to check hybrid Croplan 3080 at 2774 kg ha-l (24771b A-I; CV = 18.8 percent). Seed oil content of those same hybrids with RHA 478, RHA 479, RHA 480, and HA 481 were 416 g kg-l , 419 g kg-l , 400 g kg-l , and 395 g kg-I, respectively, compared to 423 g kg-l and 421 g kg-l for HA 412HO/RHA 377 and Croplan 3080, respectively (CV =4.2 percent). All but the HA 481 testcross were statistically similar to the two check hybrids. Phomopsis stalk canker incidence was measured in four environments with substantial natural infection (range 0 to 100 percent). The same hybrids with RHA 478, RHA 479, RHA 480, and HA 481 had 5.5,0.0,2.5, and 24.5 percent infection, compared to 27.9 and 20.6 percent for HA 412HOIRHA 377 and Croplan 3080, respectively (CV = 64.2 percent). RHA 479 and RHA 480 are statistically superior to both checks, RHA 478 is statistically superior to HA 412HOIRHA 377, and HA 481 is statistically similar to both checks.

Availability:

Small quantities of seed of each germplasm will be available from the North Dakota P.0042.16 Page 3 of4 Signatures: Foundation Seed Stocks Project, NDSU Dept. 7670, P.O. Box 6050, Fargo, ND 58108-6050. Seed of these releases will be deposited in the National Plant Germplasm System, where it will be available for research purposes. U.S. Plant Variety Protection will not be requested for RHA 478, RHA 479, RHA 480, and HA 481. It is requested that appropriate recognition be made if these genetic stocks contribute to the development of a new germplasm, breeding line, or cultivar. These germplasms were developed with support from the National Sclerotinia Initiative, USDA-ARS.

ARS GIVES NO WARRANTIES OR GUARANTEES, EXPRESSED OR IMPLIED, FOR THE MATERIAL, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Signatures:

Vice President for Agricultural Affairs North Dakota State niversity Date 12/2/16

Deputy Administrator, Crop Production and Protection Agricultural Research Service, U.S. Department of Agriculture ."

Date 12/15/16

8. 14TH ANNUAL NATIONAL SCLEROTINIA INITIATIVE MEETING

"Last week, Brent attended the 14th annual national Sclerotinia initiative meeting (Minneapolis, MN) and gave a talk on our lab's related Sclerotinia project. The title of his talk was "Using genomic selection to optimize prediction of Sclerotinia and agronomic phenotypes for more efficient breeding".

The primary goal of the Sclerotinia project is to better balance the intensity and efficiency of selection for Sclerotinia resistance and other agronomic traits, and to make more breeding progress per generation on all traits relative to their actual value to the producer. In collaboration with the Dr. Nolan C. Kane lab at the University of Colorado, we employ genomic selection (GS), a new statistical technology, to achieve this goal. In the talk, Brent presented that we have conducted resequencing of all 2009 to current experimental inbred lines from the USDA sunflower breeding program that have both yield and Sclerotinia resistance data. We have also developed a relational database system (mySQL) that will allow us easy access to nursery, field phenotyping trial, and genomic datasets to conduct model fitting. In the next several months, we will use the phenotypic and genotypic data to perform the preliminary analysis for each line."

http://hulkelab.org/2016/01/27/14th-annual-national-sclerotinia-initiative-meeting/

Date: January 27, 2016

jdup/jul 2017