North Dakota Soybean Council

Our World Is Growing.

Research Update 2010-11

Determining Soybean Variety Response to Tile Drainage in the Red River Valley

Principal Investigator: Dr. Hans Kandel, NDSU. Cooperating Scientists: Jack Brodshaug, Dr. Joel Ransom, Dr. Dean Steele, Sheldon Tuscherer, Dr. Samuel Markell, Dr.Tom Scherer, Dr.Tom DeSutter and Chad Deplazes, NDSU; Dr. Gary Sands, U of M; and Bill Schuh, ND State Water Commission

Description of the importance of the project

From the 1990's through 2011 excess water has significantly impacted crop production in the region. Besides acres not seeded due to water logged conditions in the spring of the year, excess water during the growing season caused yield losses on acres that were harvested. The fall of 2010 was wet and harvest in some fields was delayed.

Research Objectives

The objectives of this research were to determine the level of yield loss associated with excessive soil moisture during the season and to evaluate the water table level and soil response to tile drainage. Soybean varieties were tested including genotypes with known tolerance to excess moisture and genotypes with traits that are known to be influenced by excessive water (iron chlorosis and disease). The study was conducted in 2009-2010 on the NDSU research farm, Northwest 22, near Fargo, ND. The soil in the research area is a Fargo ryan sitly clay.

Results

The soybean yields between drained and undrained treatments were not significantly different according to the combined analysis. This was due to 2009 being a relatively dry year. However, in 2010, the non-GMO soybean cultivars and the cultivars chosen for their resistance to Phytophthora sojae were significantly higher yielding under tile drained conditions. In 2009 and 2010, drained treatments had a significantly higher soil penetration resistance. The soybean measurement site had a value of 1,137 kPa in the drained soil while the undrained soil had a value of 1,021 kPa. The water table was lower on drained soil compared to the undrained soil early and late in the growing season, causing the differences in soil penetration resistance.

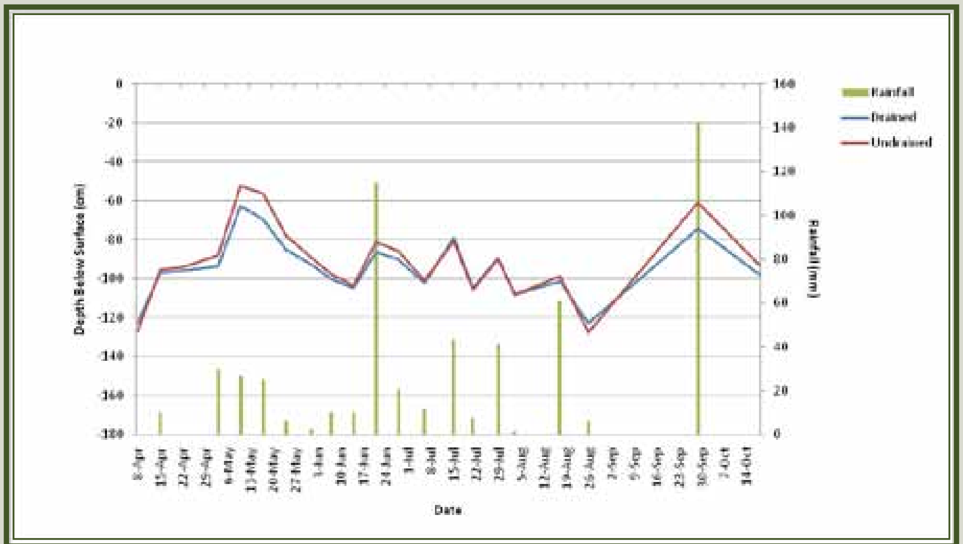


Fig. 1. Depth of the water table as affected by subsurface drainage over time, with rainfall for the week. Measurements were taken in 2010.

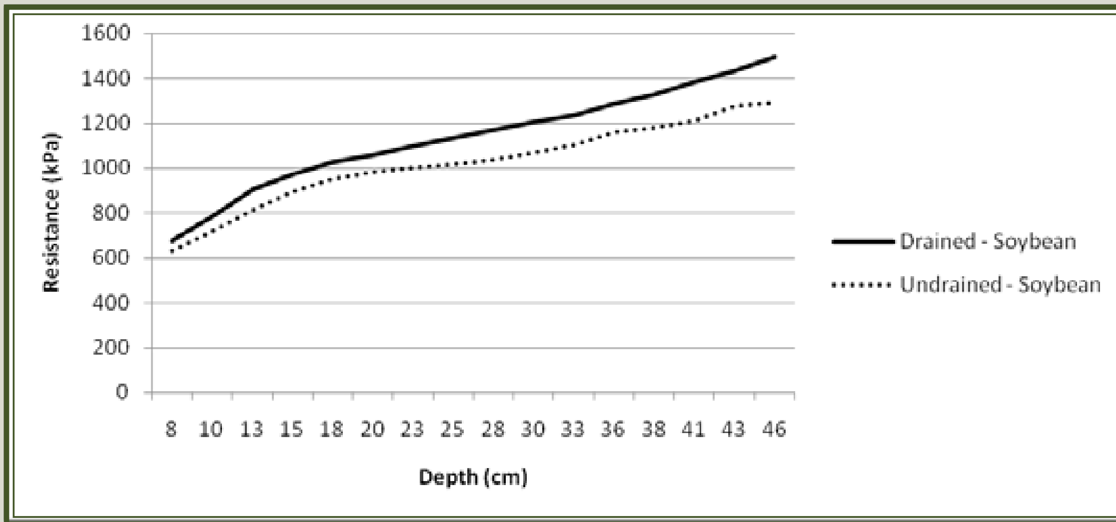


Fig. 2. Resistance values for depths 8-46 cm on drained and undrained ground seeded into soybean, averaged over 2009 and 2010.

Identifying Intensive Management Practices to Increase Soybean Net Return, 2010

Principal Investigators: Greg Endres [1], Dr. Hans Kandel [1], Blaine Schatz, Dr. Sam Markell, Steve Metzger, Chad Deplazes, NDSU

Overall goal of this study
Identify individual and/or combination of factors including row spacing, planting rate, and special foliar inputs that will economically increase yield for ND soybean growers.

Materials and Methods
2010 was the third year of the multi-year field study conducted at two high-yielding locations [Carrington Research Extension Center (CREC) – irrigation; Prosper]. Experimental design was a randomized complete block with split plot arrangement with four replications. Whole plots were row spacing (14 and 28 inches) and split plots consisted of a factorial combination of cultivars, planting rate (150,000 and 200,000 pure live seeds/A), and foliar inputs versus untreated check. Inoculated Peterson Farms Seed RR cultivars '1000' and '0806' were planted on May 14 at the CREC and May 20 at Prosper.

Foliar treatments were applied with a CO_2-pressurized hand-boom sprayer using TJ Technologies 'Sunflower/Canola/Soybean Mix' at 48 fl oz/A plus an experimental EMD Crop BioScience 'LCO promoter' at 4 fl oz/A at the second to third trifoliate stages (V2-3), followed by an early-pod development stage (R3) application of Headline fungicide at 6 fl oz/A + NIS at 0.125% v/v. Plant disease was evaluated but notes were not taken due to very low incidence.

Results
At both locations, soybean seed yield was statistically similar between row spacings (Table). At Carrington, the high planting rate resulted in a seed yield advantage of 1.4 bushels/A. Yield was 3.3 bushels/A at Carrington with use of the foliar inputs compared to the untreated check.

Using the yield mean of the two sites and economic assumptions listed in Table 1:
*net income for the narrow row spacing was $14.40/A compared to the wide row.
*net income of $8.50/A occurred by using the high planting rate.
*use of the special foliar inputs resulted in a net gain of $5.00/A compared to the untreated check.

Factor interactions affecting yield and other agronomic factors will be discussed at the completion of the study. Additional study details may be obtained by contacting the principal investigators[1].

The study continues in 2011 at Fargo and Carrington.

Late-season view of Carrington trial (CREC, September, 2010)

Table. Yield and net return with main factors in soybean intensive management study, ND, 2010						
	Yield (bu/acre)*					
	Row spacing (inches)		Planting rate (pls/acre)		Special foliar inputs	
Location	14	28	150,000	200,000	Yes	No
CREC (irrigated)	71.2	69.4	69.6	**71.0**	**71.9**	68.6
Prosper	55.2	54.5	53.6	56.0	55.7	54.0
mean	63.2	62.0	61.6	63.5	63.8	61.30
Net $/acre**	14.40			8.50	5.00	

** Bold numbers indicate statistically significant differences for respective treatments (LSD 0.05) at each location.*
*** Assumptions: $12/bu soybean price; seed costs: $40/50 lb unit (RR); $5/acre foliar application cost; $20/acre foliar input cost.*

Late-season view of Prosper trial (September, 2010)

Controlling Volunteer Roundup Ready Canola & Evaluating the Micro-rate Concept in Soybean

Principal Investigator: Dr. Rich Zollinger, Department of Plant Sciences – NDSU

The wide adoption of Roundup Ready (RUR) crops has allowed growers to manage weeds with glyphosate while maintaining crop safety. Without additional herbicides included in the tankmix, volunteer RUR crops can provide additional weed management issues. Data has shown that volunteer RUR canola can easily be controlled at earlier stages with conventional herbicides, but beyond the six-leaf stage, control becomes increasingly more difficult. With the abundance of moisture that has been observed the last couple of years, soybean planting can be delayed and thus the first herbicide application. This can impact the amount and type of herbicide necessary for control of volunteer RUR canola at the advanced stage. New herbicides are available and may aid in greater control while offering additional tools to diversify a weed management portfolio.

The micro-rate concept originally developed for sugarbeets also has been adapted for corn and dry beans. With the success and grower acceptance in dry beans, a similar plan could be developed for soybeans. It can be assumed that the micro-rate concept could be of great benefit for conventional soybean growers; however, it would offer producers that utilize multiple RUR crops a tool for resistance management.

The objectives of the research conducted were two-fold: to identify conventional herbicides that control volunteer RUR canola in soybeans and develop a micro-rate system with conventional herbicides in soybeans.

In April of 2010, a field experiment was established near Casselton, ND. RUR canola was established alone to provide a situation where crop competition would not influence control. Herbicides were applied to canola in early bud (3.2) and bloom (4.1) stages. Treatments included FirstRate, Flexstar, Cadet, Sharpen, Ignite, Extreme, and Raptor at either one or two rates recommended on product labels. Control ratings ranged from 12 to 99% at both evaluation timings, with Flexstar providing the best control, greater than 93% control at both growth stages. Sharpen provided greater than 94% control (at both stages) 14 days after application (DAA), with control ratings dropping to 75 (3.2) and 85% (4.1) at the 28 day rating. Cadet provided the least control overall, with ratings less than 27% at all evaluations.

Conventional soybeans were planted in May of 2010 at the NDSU Research Farm in Prosper, ND where there is a diverse weed population that allows for the collection of excellent weed control data. Although there was one objective, there were various components of interest to evaluate regarding the system including herbicides (2 combinations [either Flexstar or FirstRate with Basagran, Poast, Raptor, and Select), spray volumes (8.5 and 17 gpa), application timings (3 timings) and a single-pass versus two-pass applications.

Control ratings were greater (99%) in plots where the weeds were 1 to 2 inches and 3 to 4 inches in height at application 14 DAA, this was true for both the FirstRate and Flexstar programs. In addition, plots where applications were made to 1 to 2 inch weeds and received a 10 day sequential application also received ratings greater than 98%. Control was also enhanced with the higher spray volume by 3% to 28%.

Flexstar at 0.5 to 3.2 canola

New Iron Fertilizers by Incorporating EDDHA/EDTA into Polymer Macromolecules

Principal Investigators: Dr. A.Voronov, Coatings and Polymeric Materials, Dr. R. J.Goos, Department of Soil Science, NDSU

When plants cannot obtain adequate iron from the soil, a yellowing, called chlorosis, may result.

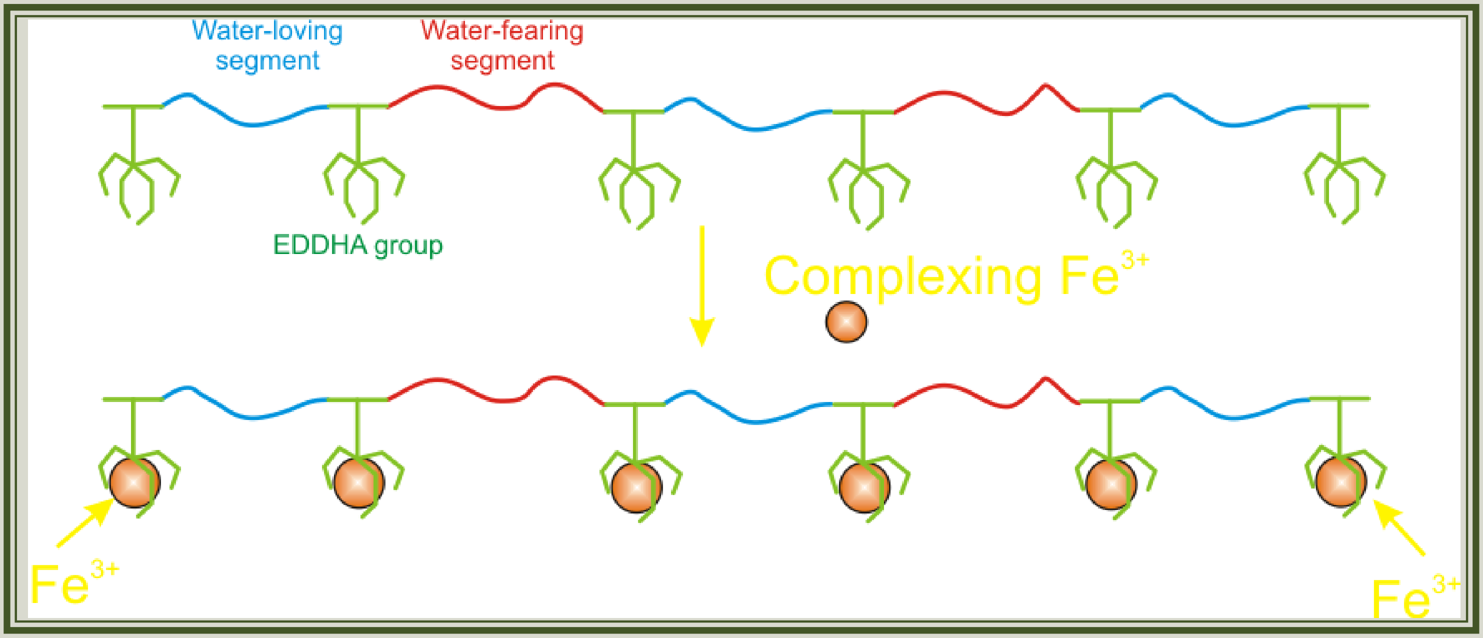
Iron deficiency chlorosis is a common yield-limiting factor for soybeans produced in North Central USA. Soil |applied synthetic chelates are the most efficient and common approach taken for the prevention of IDC. Chelated compounds are labeled with a series of capital letters following the iron symbol (Fe).

The best chelate identified to date for calcareous soils is Fe-EDDHA. The use of Fe-EDDHA to correct chlorosis has achieved some acceptance in this region, being most widely known by the trademark "Soygreen". Initial results with "Soygreen" are encouraging, especially when placed with the seed of soybeans planted in wide (30") rows. The two major problems with the chelates are that the expense of the product limits the amount that can be economically applied to an amount that is not always effective (2 lb/A), especially with narrow rows. The other major problem with Fe-EDDHA is that it freely moves with water in the soil, and its effectiveness is diminished by heavy rain... precisely when chlorosis is the most severe.

To overcome these problems, new iron fertilizers have been developed in our previous study supported by the North Dakota Soybean Council. The iron fertilizers, proposed and developed in our group, have been based on polymers having water-loving and water-fearing fragments, so they have efficiently interacted with soil particles. Complexing ferrous iron with these polymers did lead to an increase Fe level as compared to ferrous sulfate alone, in the soil test.

As a further development, new polymeric iron chelate fertilizers (Fe-PCF) have been designed by combining the polymers, developed in our previous project, and traditional chelating agent EDDHA in one macromolecule. Special new non-toxic and biodegradable chelating polymers were synthesized. The new Fe-PCF combines the advantages of both traditional chelates and the polymeric fertilizers developed in our previous research (see Fig.). Like in traditional chelates, Fe^{3+} ions can be complexed by the chelating groups of the polymers and prevent the precipitation of ferric ions in the soil. The water-loving and water-fearing fragments of the chelating polymers can interact with water-loving (clays, sand, water absorbed to clays and sand) or water-fearing (certain organic groups on humus) constituents of soil (similar to the recently developed polymeric fertilizers). Being physically coupled to the soil particles the Fe-PCF is not be influenced by leaching, as traditional chelates are.

As a result of our research, chelating ferrous and ferric irons with synthesized Fe-PCF did lead to an increase in the soil test Fe level. Polymeric iron chelate fertilizer based from specific polymer composition appeared to be the most effective of the polymers tested. We wish to continue evaluations of the polymeric iron chelate fertilizer, as foliar sprays and will have field plots in 2011.



Whole-field Comparison of Soybean Production Using Strip Till, Conventional Till, & No-Till Grown on Wheat & Corn Stubble

Principal Investigators: John Nowatzki and Dr.Ganesh Bora, Department of Agricultural and Biosystems Engineering, NDSU

Progress Report

Compare soil conditions and soybean plant growth, development and yields between strip till, conventional till and no-till in wheat and corn stubble.

The cooperating farmer for this project is Jeremy Wilson, 1317 4th AVE NE, Jamestown, ND 58401. The research is on two of his fields in Stutsman County, North Dakota.

Summary

The soil moisture in the strip tilled areas was lower than the soil moisture no tilled areas in both wheat and corn stubble. The strip tilled soil temperature was higher than in between the strips in wheat stubble, but lower than in between the strips in corn stubble.

Research Objectives

The four objectives of this project were to:

1) compare the effects of strip till, conventional till and no till on soybean growth and yield;

2) compare soil moisture content and temperature in strip till, conventional till and no-till soybeans planted on wheat and corn stubble;

3) monitor air temperature, rainfall, leaf wetness, relative humidity, and light intensity in both the corn and wheat stubble fields both remotely and onsite; and

4) display the remotely sensed soil conditions and soybean plant growth and development data on the Internet.

Wet Field Conditions

The wet field conditions in the fall of 2010 and spring of 2011 prevented the cooperating farmer from effectively doing strip till in the demonstration fields, resulting in the inability to complete the first objective. The cooperating farmer attempted to conduct strip tilling in November 2010, however the excessive soil moisture prevented the strip till machine from functioning effectively. He did make several passes in the 2010 wheat stubble to allow installation of the soil temperature and moisture sensors. The 2010 corn was harvested too late to facilitate strip tilling after harvest in the wet soil. Similar conditions in the spring of 2011 prevented spring strip tilling.

However, all of the remote monitoring and communication supplies will be maintained to allow redoing the research project beginning in the fall of 2011 and completing it during the 2012 growing season.

The other three objectives dealing with remote monitoring and displaying information on the Internet were accomplished.

Soybean Production Procedures

The researcher and cooperating farmer selected a 2010 wheat field, and a 2010 corn field to conduct the project. Both fields were left untilled after harvest in August 2010. Each field was to be divided into sections and assigned randomly as strip till, conventional till or no-till. Small sections of the wheat field were strip tilled and the remainder of the field was left untilled. Excessively wet field conditions prevented effective strip till or conventional till operations. All sections of the fields were planned to be planted with the same planter in the spring of 2011. The corn field was to be treated similarly after the corn harvest. However, the wet field conditions prevented corn harvest until mid-November and freeze up occurred immediately after harvest.

The cooperating farmer was able to plant a small section of the wheat stubble field to soybeans in May 2011. However, most of the field was too wet to plant. Sections of the corn stubble field were also planted to soybeans in late May 2011. Since the strip tilling could not be done effectively in either field, the information on crop growth and development, and the soybean yield data are not being collected in 2011. A simulated strip till was done by hand with a spade on small section of the corn stubble field to facilitate installing soil moisture and temperature sensors to allow data collection for strip till in corn stubble conditions.

Remote Monitoring Procedures

The researchers used electronic sensors to collect field data, data loggers to record the data, cellular communications to transfer the data to a computer, and a computer server to display the field data on the Internet throughout the project period. Electronic Onset Sensors were installed to monitor soil temperature, soil moisture, air temperature, rainfall, leaf wetness, relative humidity, and light intensity each hour under each tillage system. The data was transferred four times daily to a computer server using a cellular communication.

Soil moisture and temperature sensors were installed to monitor soil conditions in strip tilled rows, between the strip tilled rows, and in the no tilled area. Leaf wetness, rainfall, wind speed, relative humidity, and light intensity sensors were only installed in the corn stubble field because of the corn and wheat stubble fields were adjacent to each other. Sensors and modems will be replicated for the wheat and corn stubble fields.

The data logger at each location is connected to a cellular modem. A remote computer is programmed to contact the cellular modem hourly to transfer the data to a computer that serves the data on the Internet at: http://www.ageng.ndsu.nodak.edu/farmmonitor

Comparison of Soil Moisture in Strip Till and No Till

Soil moisture and temperature conditions were monitored on the wheat stubble field beginning in in late November, 2010. Sensing began in the corn stubble field in early April, 2011. Sensing is continuing in both fields throughout the 2011 growing season.

The soil moisture was considerably lower in the strip tilled area in wheat stubble than in the no tilled area. (Figure 1) The lower moisture in the strip tilled area was evident in late fall 2010, and continued throughout the 2011 spring and summer growing season.

In the corn stubble, the soil moisture in the strip tilled area was lower than the soil moisture in the conventional tilled area, but similar to the moisture in the no tilled area. (Figure 2).

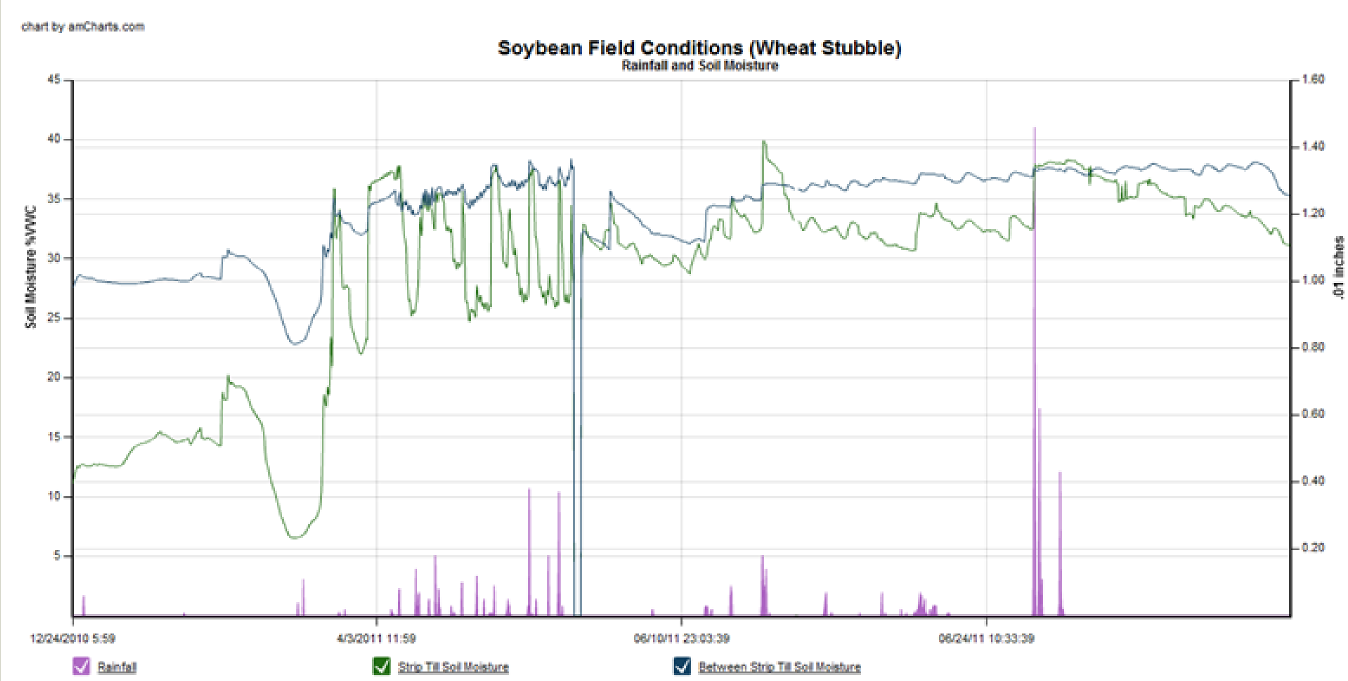


Figure 1 Soil Moisture in Wheat Stubble

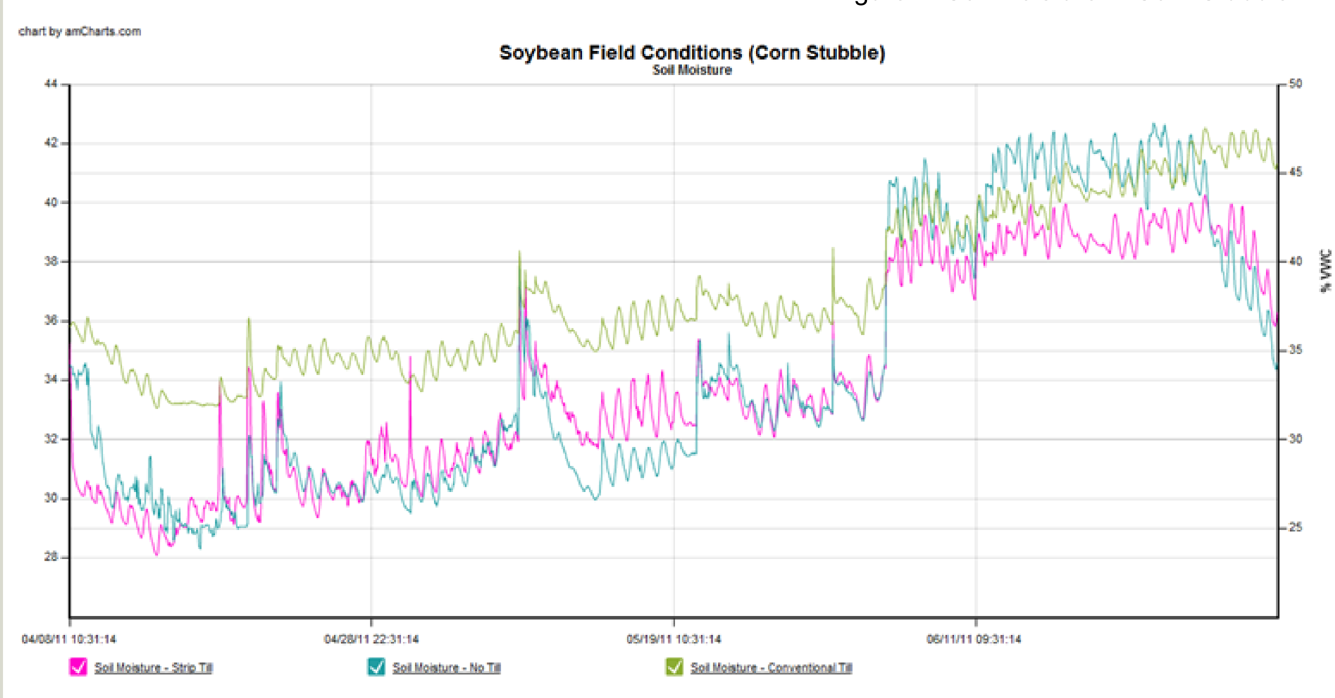


Figure 2 Soil Moisture in Corn Stubble

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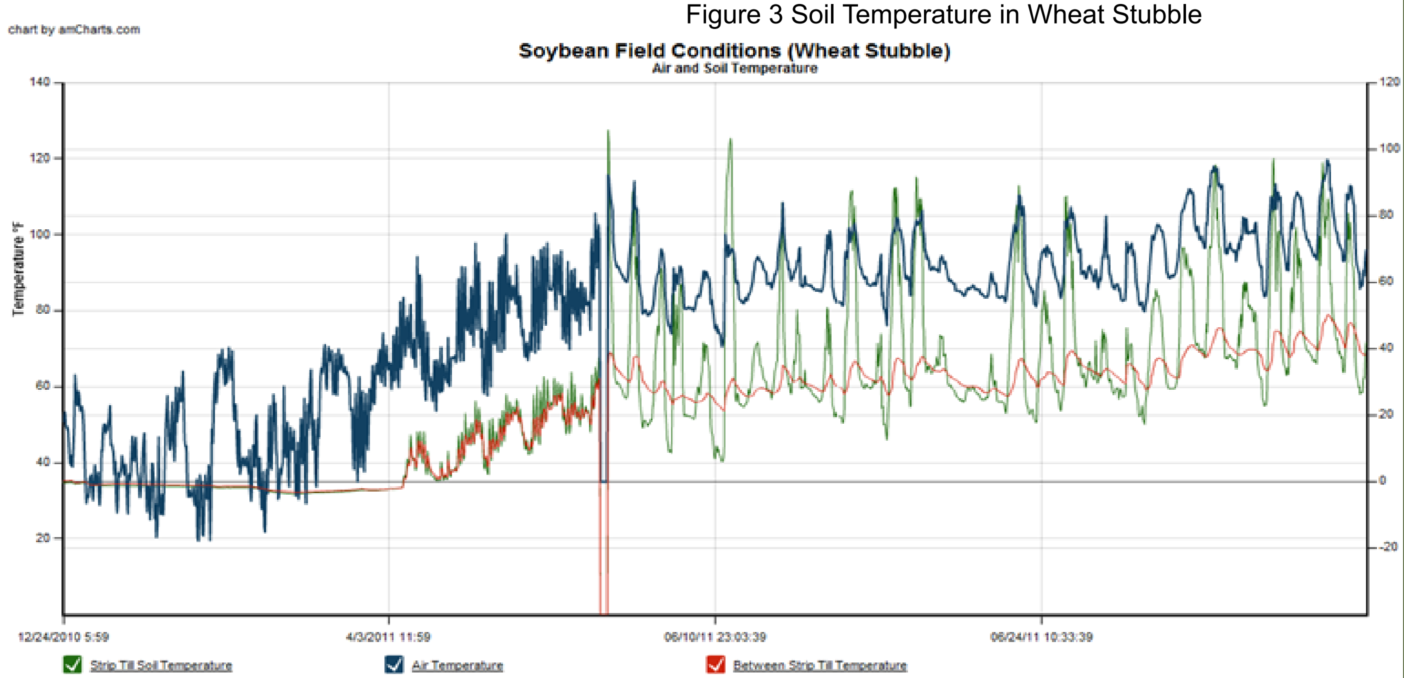
The soil temperature was considerably higher during the days and cooler during nights in the strip tilled area in wheat stubble than in the no tilled areas between the tilled strips. (Fig. 3) The higher soil temperature in the strip tilled area was evident in late fall 2010, and continued throughout the 2011 spring and summer growing season.

In the corn stubble, the soil temperature in the strip tilled area was generally lower than the soil temperature in the conventional tilled and no tilled areas. (Fig. 4)

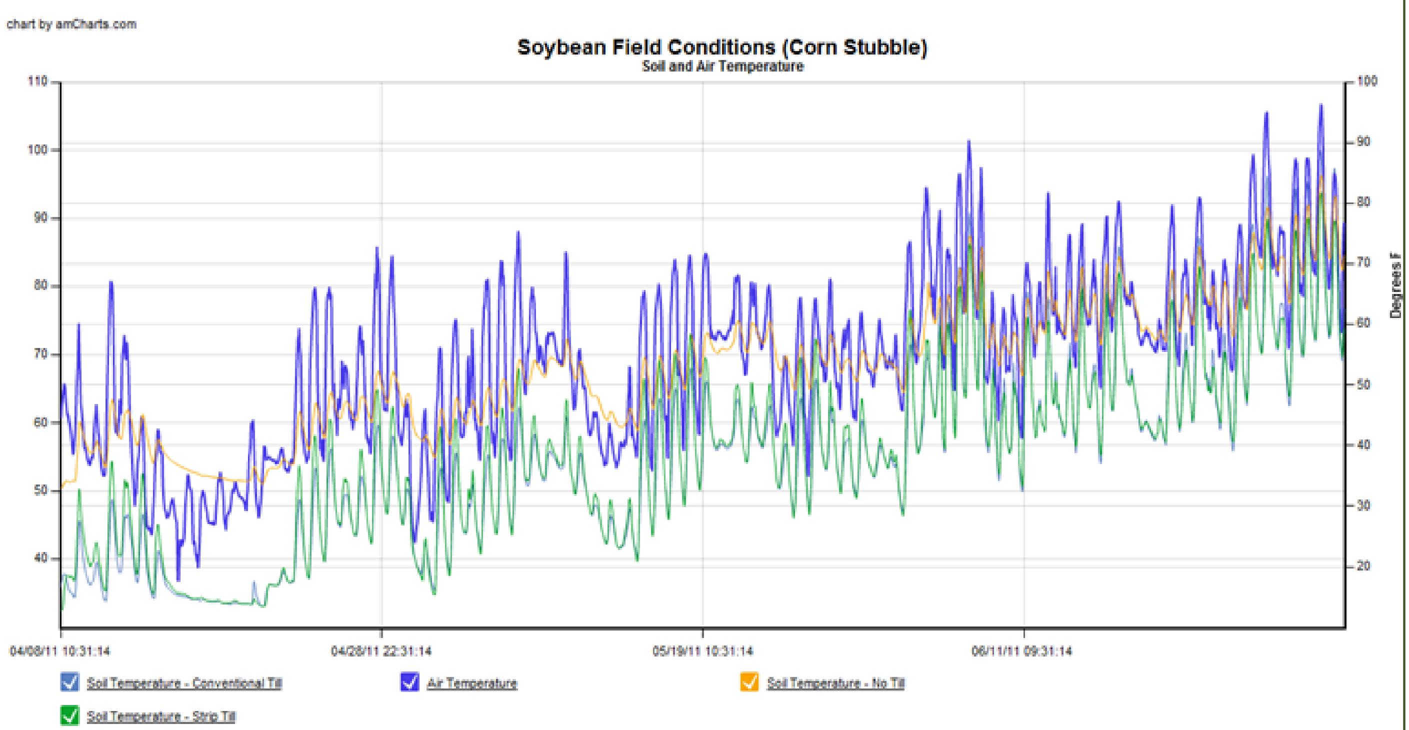
Soybean Tillage Comparison - Temperature (Wheat Stubble)

Figure 3 Soil Temperature in Wheat Stubble



Soybean Tillage Comparison - Temperature (Corn Stubble)

Figure 4 Soil Temperature in Corn Stubble



Durable Soy-based, Thiol-ene and Thiol-urethane Thermoset Coatings

Principal Investigator: Dr. Dean C. Webster, Department of Coatings and Polymeric Materials, NDSU. Cooperating Scientist: Dr. Zhigang Chen, Center for Nanoscale Science and Engineering, NDSU

With the rapidly increasing interest in the use of renewable resources in materials such as coatings, inks, composites, and adhesives, the exploration of new biobased technologies which can yield the properties required by today's applications is needed. In this project, a series of novel highly functional compounds having multiple thiol functional groups was synthesized using sucrose soya ester (SSE) resins. The synthesis was carried out using a process discovered in the previous year's NDSC funded project. The resins were then crosslinked with two different commercial polyisocyanates to form thiourethane coatings.

All of the coatings had excellent adhesion and high gloss. The coatings exhibited a range of physical properties depending on the thiol resin and crosslinker used. The use of the more rigid cycloaliphatic crosslinker resulted in harder glassy coatings while the use of the flexible aliphatic crosslinker resulted in softer and more elastic coatings. Thus, it is possible to achieve a range of material properties by tuning the composition of the biobased resin and the crosslinker. This outcome of this project is a new soybean oil based technology which can lead to new opportunities for the use of soybean oil derivatives in high value added products.

Control of Soybean Diseases

Principal Investigator: Dr. Berlin D. Nelson, Dept. Plant Pathology, NDSU. Cooperator: Dr. Ted Helms, Soybean Breeder, Dept. Plant Sciences, NDSU

The primary goal of this project is to develop controls for the major diseases of soybeans in North Dakota. There is a large emphasis on soybean cyst nematode (SCN) since this is a major threat to production. We evaluated 24 commercial soybean cultivars for resistance to SCN in the field during the summer of 2010.

The tests were conducted at three SCN sites in Cass and Richland Counties. We measured SCN reproduction on the roots of these cultivars by sampling SCN at planting and again after harvest and then determining egg numbers in the soil at the two sampling dates. We also evaluated the resistance of the cultivars under controlled conditions in our greenhouse SCN screening system. Results between field sites varied. Most cultivars reported as resistant showed resistance. But, some cultivars showed resistance at one site but not at another site based on SCN reproduction on the roots. Results from the greenhouse testing did not always correlate with the results from the field. A few cultivars with high levels of resistance in the controlled tests did not appear to have resistance in one of the field sites. These results suggest that soil characteristics and environmental conditions may modify the level of resistance that is expressed in the field.

The results of the SCN testing are published by the NDSU Extension Service. One unexpected outcome of the field testing of soybean cultivars for SCN resistance was what we found at one SCN testing site on heavy clay soil. We determined that there was no reproduction of SCN on the cultivars in that site even though there was a high egg density in the soil at planting. We attribute this to a season long high soil moisture in combination with the clay soil created an environment that was not favorable for nematode activity. These results demonstrate that environmental conditions during the growing year can have a strong influence on development of disease caused by SCN, especially in the clay soils in the Valley. In other research on SCN we continued monitoring SCN egg levels in 16 commercial soybean fields under normal crop rotation practices. Soil samples are taken in spring and fall after harvest and egg numbers determined. We plan on finishing this project and publishing the results after evaluation of data collected in the spring of 2011. We also continued our efforts to incorporate resistance to *Phytophthora sojae* ,the cause of Phytophthora root rot, into public germplasm and cultivars. We screened 100 soybean lines to the most common races in our area, and 58 lines contained a resistance gene. To maintain the screening program for *Phytophthora,* we store a variety of races or virulence types in the laboratory. Each year, we grow the isolates and test them on selected soybean lines with known resistance genes to verify the virulence type before we use them in screening for resistance. In other research, we found no evidence of sudden death syndrome in the southeast part of the soybean production area.

We have been searching for evidence of this new disease since it is steadily moving north in Minnesota. We initiated two new studies in the spring of 2011. One is on the reproduction of SCN on weeds growing in ND, and the second is about Pythium damping-off of soybean.

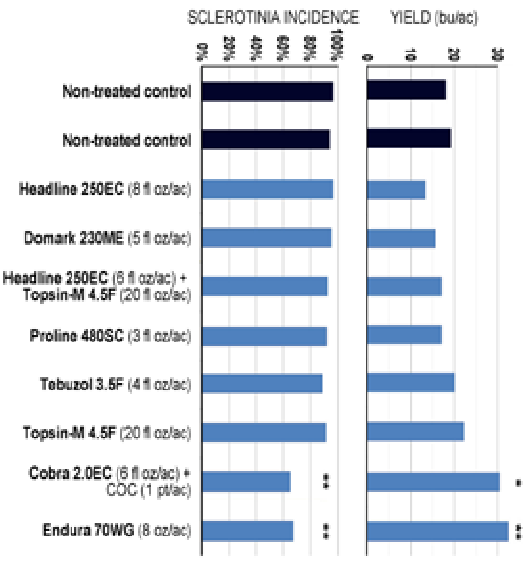
Using Fungicides to Manage Sclerotinia Stem Rot of Soybeans

Principal Investigators: Dr. Michael Wunsch, Plant Pathology, and Blaine Schatz, NDSU Carrington Research Extension Center

In fungicide testing conducted at the Carrington REC in 2010, the fungicide Endura (8 oz/ac) and the herbicide Cobra (6 fl oz/ac + 1 pt/ac COC) reduced Sclerotinia stem rot and increased yields when applied as a single application at early bloom (R1/early R2 growth stage). Under the conditions tested, none of the other registered products that were evaluated showed efficacy against Sclerotinia on soybeans. When applied as a single application at early bloom (R1/early R2 growth stage), Headline (8 fl oz/ac), Topsin-M (20 fl oz/ac), Headline (6 fl oz/ac) tank-mixed with Topsin-M (20 fl oz/ac), Proline (3 fl oz/ac), and Tebuzol (4 fl oz/ac) neither reduced Sclerotinia incidence nor increased soybean yield relative to the non-treated control. The label for Proline has recently been changed to permit applications of 4.3 fl oz/ac for Sclerotinia control on soybeans and the higher application rate of Proline may be more effective. It is being tested in 2011.

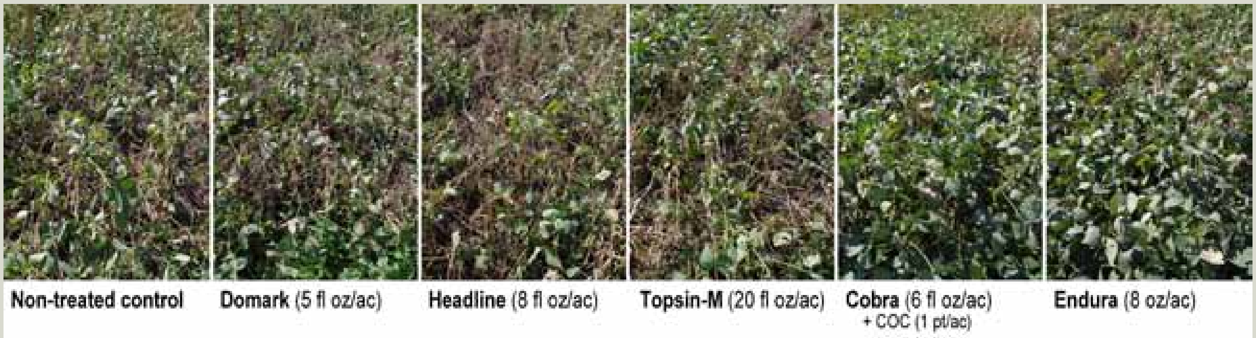
Soybean producers are cautioned that applications of Cobra that are timed for optimal white mold control (R1 growth stage) will likely reduce soybean yields if white mold pressure is low. Research conducted in Michigan suggests that Cobra applications made at early bloom (R1 growth stage) consistently reduce Sclerotinia stem rot incidence on soybeans. But, Cobra reduces soybean yields when white mold pressure is low to moderate (0 to 30% incidence in a non-treated check), leaves yields unchanged when white mold pressure is somewhat higher (30 to 40% incidence), and only increases yields when white mold pressure is high (at least 40% incidence in a non-treated check).

Seven experimental chemistries were evaluated and three of these chemistries showed moderate efficacy against Sclerotinia. One of these products will likely be labeled for use on soybeans in 2012 or 2013. None of the experimental chemistries were as effective as Cobra or Endura, but if priced affordably, the most effective experimental chemistries may be good alternatives to Endura if they are labeled.



Effect of fungicides & the herbicide Cobra on Sclerotinia stem rot incidence & soybean yield in a trial conducted at the Carrington REC in 2010. All products were applied at early bloom (R1/early R2 growth stage).

The study suggests that fungicide usage for control of Sclerotinia stem rot of soybean is unlikely to be profitable using the fungicides and application rates tested in this study. For every 10% increase in SSR incidence, soybean yields dropped approximately 3.2 to 4.6 bu/ac in our trials (soybean variety: Dairyland 'DSR0401'). If soybeans are selling for $12/bu, these results indicate that Endura (8 oz/ac) would only be profitable if Sclerotinia incidence would have been at least 45 to 64% if no fungicide were applied. Topsin-M (20 fl oz/ac) would only be profitable if Sclerotinia incidence would have been 71 to 100% if no fungicide were applied, and Proline (3 fl oz/ac) would only be profitable if Sclerotinia incidence would have been 83 to 100% if no fungicide were applied. Headline (6 fl oz/ac) and Domark (5 fl oz/ac) would not have been profitable under any level of Sclerotinia pressure. However, these results should be considered preliminary, as they are based on data collected from a single variety planted at single location in a single year. To establish more robust assessments of fungicide efficacy and the impact of SSR on soybean seed yield and quality, additional testing is being conducted in 2011.



When applied as a single application at early bloom (R1/early R2 growth stage), the fungicide Endura (8 oz/ac) and the herbicide Cobra (6 fl oz/ac + 1pt/ac COC) reduced Sclerotinia relative to the non-treated control. Domark (5 fl oz/ac), Headline (8 fl oz/ac), and Topsin-M (20 fl oz/ac) were not effective.

Fuels, Chemicals, and Polymers from Soybean Oil

Principal Investigator: Dr. Wayne Seames, Chemical Engineering, UND. Cooperating Scientists: Drs. Steve Benson, Robert Wills, and Brian Tande of ND Chemical Engineering; Drs. Alena Kubtova and Evguenii Kozliak, UND Chemistry

This is the last of eight straight years in which the North Dakota Soybean Council has provided funding to assist in the development of a suite of technologies that will convert soybean oil into advanced biofuels and renewable chemicals. NDSC funds are highly leveraged by funds from other sources include the North Dakota Commerce Department Centers of Excellence program.

The basic technology is ready for commercialization and is expected to be licensed to commercial entities this year. NDSC funding was used to support students working on improvements to the basic technology as well as on additional technologies that add value and allow expanded opportunities to convert soybean oil into chemicals, polymers, and composite materials.

Personnel: The North Dakota Soybean Council provided partial support for Michael Linnen, Dennis Vosgerau, Nathan Bosquez, Nahid Khatibi, and Jeremy Elbers, graduate students in Chemical Engineering plus Jana Stavova and Ashwini Geetla, graduate students in Chemistry.

Accomplishments: Under high heat and pressure, soybean oil can be thermally converted into hydrocarbons with a similar chemical makeup and properties to petroleum. The process is known as thermal cracking. Cracked soybean oil can be processed directly into diesel fuel, jet fuel, kerosene, and gasoline. This fuel is free of heavy metals and has very low sulfur, making it very attractive. Work progressed in a number of areas related to this technology.

Thermal Cracking: Thermal cracking breaks the long soybean oil triglycerides into smaller hydrocarbon-like components. As in the petroleum industry, the hydrocarbons are grouped and marketed per their heating volatilty (naphtha cut, kerosene cut, diesel cut, etc.). The research has shown that cracked soybean oil provides components primarily in the diesel range. By adjusting the cracking temperatures and pressures, the products can be shifted toward the jet fuel range. A detailed study was completed that correlates the inlet oil composition to the quantities of the various products that are generated. Soybean oil was found to be an excellent feedstock particularly when one class of by-products, short chain fatty acids, is desirable

Decarboxylation: Carboxylic acids present in soybean oil have to be removed or converted to other chemicals prior to final fuel production. A catalytic process, known as decarboxylation, removes the acidic portion of the carboxylic acid, leaving the hydrocarbon portion behind for fuel. Studies were performed to generate the process data necessary to scale this technology to the commercial scale. This involved evaluation of catalyst deactivation rates, fouling rates, and diffusion limitations. As is often the case, highly selective catalysts perform well, but are often costly to purchase or difficult to regenerate. Alternative catalysts may offer better pricing, but may require more volume of catalyst or longer run times. Studies were performed to assess the feasibility of replacing the preferred, but expensive catalyst with less costly alternatives. This work appears promising and is expected to result in a substantial reduction in the capital and operating costs for a commercially viable soybean oil refinery.

Acid Extraction: As an alternative to decarboxylation, the carboxylic acids can be wholly extracted as a side product during fuel production. Although this extraction reduces the overall fuel yield of the process, the acids are valuable themselves as a feedstock for the chemical industry. With the continual push to reduce dependency on fossil fuels, chemicals from renewable sources are of high interest.

Work was completed at the bench-scale to generate the process data necessary for pilot scale facility design. Basically, this side process is now ready for scale-up for commercialization. A scoping study was also performed by a student group to evaluate the economics of this side process. This study showed that for large scale facilities (for example, a facility processing 100 million gallons per year of soybean oil), this side process adds substantially to the economic value of the process.

Aromatic Extraction: Aromatics are a category of cyclic chemicals that include benzene and toluene. They are of critical importance to the chemical industry for making plastics, paints, and resins. UND researchers have been investigating a process to extract and recover aromatics from the cracked soybean oil. Bench-scale experimental work is nearing completion and this side process should be ready for commercialization within the next year.

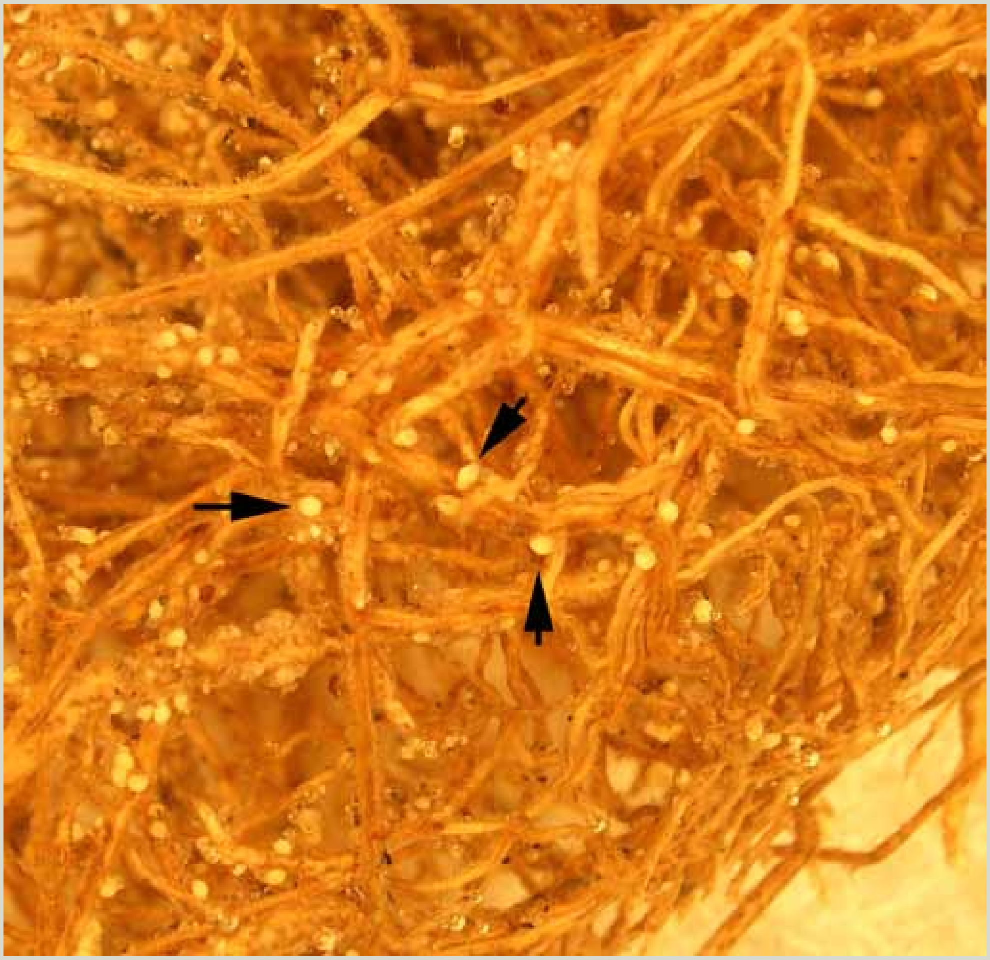
Tar Carbonization: Lab-scale experiments have shown that the tars produced during soybean oil cracking can be converted into a pure, granulated carbon product that is used in many products such as spark plug rods. This conversion, known as carbonization, occurs at reasonable reaction conditions. Work was conducted to begin developing the specific process steps necessary for a commercial process. This requires a series of lab and benchscale experiments coupled with process modeling and design activities. While substantial progress was made this year, significant work remains before this technology is ready for commercialization.

Effect of Soil Type on Soybean Cyst Nematode

Principal Investigator: Dr. Berlin D. Nelson, Dept. Plant Pathology, NDSU
Cooperator: Dr. David Hopkins, Dept. Soils, NDSU

The objective of this project was to determine the effect of different North Dakota soil types on reproduction of soybean cyst nematode (SCN) on soybeans. We examined10 soil types obtained from commercial soybean fields that are representative of the soils in North Dakota: Emrick (coarse-loamy), Heimdal (coarse- loamy) , Barnes (fine-loamy),Svea (fine-loamy), Embden (coarse-loamy), Overly (fine-silty) , Great Bend (fine-silty), Bearden (fine-silty), Hegne (fine) and Fargo (fine). Based on soil characteristics we believed that the heavy clay soils in the Red River Valley might support less reproduction of SCN on roots. We established one field experiments in 2009 and two in 2010 (in Cass Co.) and we currently have two more in progress in 2011. The soils were placed in 2.5 gallon plastic pots and were infested with 1,000 eggs/100 cc of soil.

The pots were then buried in the soil in the field plots. Barnes soybean was planted and plants grew under field conditions. After plants matured, the soil was processed to extract the cysts and the number of cysts per 100 cc soil and the number of eggs per cyst were determined. The results from 2009 showed significant differences between soil types in the amount of SCN reproduction. The fine silty clay soils such as Fargo, and Overly had significantly fewer females per 100 cc soil compared to the coarse loams such as Emden and Emrick. For example, in the Fargo soil, there was an average of 23 females per 100 cc soil, while in the Emden and Emrick soils the average was 135 and 124, respectively. Reproduction in eight of the soils was significantly less than in Emden and Emrick. The number of eggs per female was similar between most soils except Svea which had fewer eggs per female than other soils. The results from the two experiments in 2010 were different from those of 2009. In general, the lighter soils such as coarse loams and fine loams showed greater SCN reproduction and the fine, silty soils showed less reproduction. The Fargo soil showed lower reproduction (71 and 56 cysts/100 cc soil) and Emrick showed the highest reproduction (185 and 149 cyst/100 cc soil) in both experiments. However, the coarse loamy soils did not consistently show the highest reproduction and some were not significantly different from the Fargo soil. For example, reproduction in the Heimdal soil was not significantly different from the Fargo soil in both 2010 experiments. There were no significant differences between soil types for the number of eggs per cyst in 2010. The weather, especially rainfall, (which affects both soil moisture and soil temperature), probably played a role in the outcome of these experiments. Rainfall in 2010 (18.8 in) was higher than in 2009 (15.4 in) and the June to August rainfall for 2010 compared to 2009 was 10.2 inches and 5.7 inches, respectively. Higher soil moisture can affect SCN activity in different ways and could be one factor affecting these results. These results indicate in general that the heavy clay soils more typical of the Red River Valley will likely support less reproduction of SCN and therefore may require more time for SCN to build up populations compared to lighter and sandier soils. However, eventually SCN populations will build up in such soils and can cause damage to soybeans. Our field observations of SCN in commercial fields support these conclusions.



SCN Females on soybean

Influence of Tillage System and Previous Crop on Soybean Production

Prinicpal Investigator: Ezra Aberle, NDSU. Cooperating Scientist: Blaine Schatz, Carrington Research Extension Center, NDSU

The trial was conducted at the Carrington Research Extension Center in 2010. It is a component of the Long Term Cropping Systems study that has been established since 1987. Farm equipment sized tillage systems are conventional, minimum, and no till. Four nitrogen fertility treatments are imposed perpendicularly across the tillage systems to non-legume crops within each rotation. Three crop rotations are utilized in this study with each phase of the rotation occurring every year. Rotation 1 is wheat/sunflower/barley/soybean. 2 is wheat/soybean/corn/field pea. 3 is wheat/corn/soybean/canola. The large size allows for adequate sampling area for data collection of the numerous parameters without confounding data.

Results

The 2010 growing season started out with great moisture provided by fall rains and ample snow melt and was characterized by near normal precipitation for April thru June, (about an inch below average precipitation for each of July and August, and about 2.4 inches above normal for September). The end result was a growing season with near normal total precipitation, although the distribution was abnormal. Temperatures were significantly higher in April and remained slightly above normal for the rest of the growing season.

Roundup Ready soybean seed was planted on May 18 and harvested September 27. Soybean seedlings were sampled one month after seeding to rate treatments for root diseases. The preliminary findings of this one year of data suggest a significant reduction in seedling root diseases in no-till, at 76.6% incidence, compared to the tilled systems, at 94.2% and 95.3% incidence. An additional reduction was seen following barley in a rotation, at 82.2% incidence, compared to corn and wheat at 90.6% and 95.3% respectively. The combined effect put the incidence of root diseases in no-till after barley at 69.7% incidence compared to after corn and wheat in no-till at 78.0% and 88.0% incidence respectively. However, the severity associated with the levels of incidence reported was quite low averaging a 1.9 on a scale from 0-10 with 0 being clean and not infected and 10 being completely infected causing death of the plant. Plant tissue tests for crops following soybean did not provide conclusive results for N content between the 0 and 50 pounds of additional N treatments. Soybean yields ranged from 35.8 to 46.4 bu/acre across all rotations, (prior nitrogen fertility treatments), and tillage systems. Tillage system did not have a significant impact on soybean yield based on the 38.8 to 42.0 bu/acre yields achieved in this trial when averaged across previous crops and prior fertility treatments. Barley, corn and wheat were all found to be not significantly different and acceptable previous crops for soybean based on the 38.7 to 41.9 bu/acre yields achieved in this trial when averaged across tillage systems and prior fertility treatments. Composted feedlot manure is a favorable alternative fertilizer source for crops grown prior to soybean production (reducing fertilizer costs). It did not significantly increase soybean yield as it did in 2009 but it did again increase protein content by 0.5 to 32.8% and this year oil content was significantly reduced by 0.6 to 21.9%. With yields achieved and a price of $10.30 a bu straight off the combine all tillage systems, previous crops, previous fertility treatments, and all combinations were quite profitable, (with net income ranging from $183.16 to $292.36). Net income takes into account tillage, seeding, chemical, seed, combining, and overhead costs on the expenses side and yield and price on the income side.

Conclusions

Tillage system did not impact soybean yield so reducing tillage is an economically viable way to decrease soybean input costs by $8 to $15 per acre if conditions allow. Barley, corn and wheat were all found to be acceptable previous crops for soybean based on yields achieved in this study. Composted feedlot manure is a favorable alternative fertilizer source for crops grown prior to soybean production by reducing fertilizer costs.

Impact of Rag1 Aphid Resistant Soybeans on Binodoxys communis (Hymenoptera: Braconidae), a Parasitoid of Soybean Aphid (Hemiptera: Aphididae)

Principal Investigator & Co-Investigators: Dr. Janet Knodel (PI), Kiran Ghising (graduate student), Dr. Jason Harmon, Patrick Beauzay, and Dr. Deirdre Prischmann-Voldseth, Department of Entomology, School of Natural Resource Sciences, NDSU. Cooperators: Dr. Burton Johnson and Dr. Ted Helms, Department of Plant Sciences, NDSU

Abstract

Multiple strategies are being developed to assist in the pest management of the soybean aphid, *Aphis glycines* Matsumura. However, there has been little research thus far to determine how such strategies may influence each other, thereby complicating their potential effectiveness. A susceptible soybean (*Glycine max* L.) variety without the Rag1 gene and a near isogenic resistant soybean variety with the Rag1 gene were evaluated in the laboratory for their effects on the fitness of the soybean aphid parasitoid, *Binodoxys communis* (Gahan). The presence or absence of the *Rag1* gene was verified by quantifying soybean aphid growth rates and PCR of leaf tissue using the Satt 435 marker.

To test for fitness effects, parasitoids were allowed to attack soybean aphids on either a susceptible or resistant plant for 24h and then aphids were kept on the same plant throughout parasitoid development. Parasitoid fitness was measured by mummy and adult parasitoid production, adult parasitoid emergence, development time, and adult size. Parasitoids that attacked soybean aphids on susceptible plants produced more mummies, more adult parasitoids, and had a higher emergence rate compared to those on resistant plants. Although the total number of adult parasitoids that emerged from resistant plants was low, these parasitoids took one day longer and were smaller compared to those from susceptible plants.

This study suggests that biological control by *B. communis* may be compromised when host plant resistance is widely utilized for pest management of soybean aphids.

Soybean aphid alate

Rag1 susceptible leaf cropped

Parasitiod & Parasitized Aphid Mummies

Impact of Nitrogen on Soybean Aphid Densities and Parasitization By *Binodoxys Communis*
SBARE Grant with Match Provided by the NDSC

Principal Investigators: Dr. Deirdre A. Prischmann-Voldseth, NDSU Entomology Dept. and Dr. R. Jay Goos, NDSU Soil Science Dept., Graduate Student: Samantha Brunner

Soybean aphid densities are influenced by nitrogenous compounds present within plant phloem, primarily amino acids. Soybeans can obtain nitrogen (N) from fertilizers and mineral soil N (i.e. nitrate) and from N-fixation (i.e. ureides). The amount of nitrate in the soil can influence the degree of nodulation and N-fixation by symbiotic root microorganisms (rhizobia), and in turn affect the amount and identity of amino acids within plant tissues. In year one, the main objective of this project was to determine how the source of N (from fertilization or N-fixation) impacts densities of pest soybean aphids. Year two will focus on *Binodoxys communis*. We used four levels of nitrogen (0, 25, 50 and 100 mg N/pot) and two levels of *Bradyrhizobium japonicum* inoculation [no rhizobia and with (+) rhizobia: N-DURE, INTX Microbials]. Plants were infested with soybean aphids (Fig. 1) and densities of adults and immatures assessed after three and nine days.

Treatments did not impact adult aphid establishment on plants (Fig. 2). Inoculating plants with rhizobia had a positive impact on immature development (as assessed by the appearance of new adults), and total densities of immatures. This effect diminished on plants at high N rates with fewer/ smaller nodules where N-fixation rates were likely lower. The similarity between no and + rhizobia treatments at higher N rates was expected, as increasing N decreases nodulation and N-fixation.

It seems that positive impacts of rhizobia on immature densities was primarily because there were more adults producing offspring, (although there was a slight positive impact on reproduction of individual aphids). Overall, the presence of N-fixing rhizobia had a stronger impact on soybean aphids than nitrate N, and the 25mgN rate seemed the most favorable for aphid development and reproduction. Plant growth stage and the length of aphid infestation (i.e. longer than 9d) may influence these results. We are currently conducting additional experiments investigating treatment effects on plants lacking aphids, and how adding a soil pasteurization treatment affects aphid responses.

Figure 1.

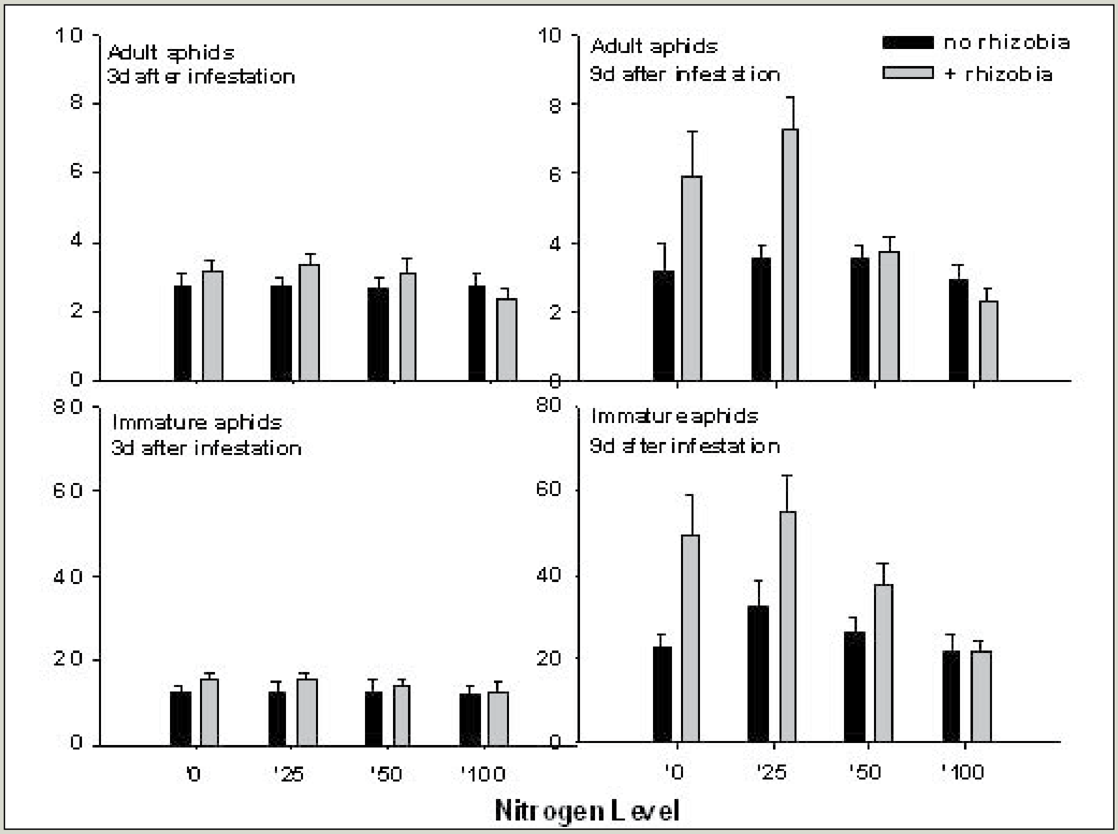


Figure 2.

Screening Soybean Varieties for Resistance to Iron Deficiency Chlorosis

Principal Investigator: Dr. R. Jay Goos, Soil Science Department, NDSU

Many North Dakota soils have calcium carbonate (“lime”) in the topsoil. Lime in the topsoil is commonly found in low, wet soils. Such soils have a high water table in the spring. Alkaline water moves upwards from the water table into the topsoil. When plant roots dry out soil in the summer, lime is left behind. Sometimes these soils are saline, too. Calcium carbonate is, for most crops, a benign component of the soil. For example, wheat, sunflowers, sugarbeets and barley all grow well in lime-containing (calcareous) soils. Soybeans, however, can have a difficult time growing on such soils. The high pH, and bicarbonate in the soil water, can induce iron deficiency chlorosis (IDC) in soybeans. IDC injures the younger tissues of the plant, causing yellowing, stunting, and reduced yield.

The most effective control measure for IDC is the selection of a resistant variety. In this project, we evaluated the IDC resistance of more than 500 glyphosate-resistant varieties, glufosinate-resistant varieties, conventional varieties, and NDSU breeding lines. Studies were conducted at five locations in eastern North Dakota. Chlorosis was rated at the 2-3 trifoliolate stage, and at the 5-6 trifoliolate stage.

As in past years, a wide range of chlorosis resistance was found. Varieties with high levels of resistance are available, but most varieties are not resistant. Farmers need to exercise significant care in selecting varieties for fields with a history of producing IDC in soybeans. Our web site lists complete results of our trials: www.yellowsoybeans.com

The importance of variety selection is shown in the following pictures. A resistant variety was treated with 3 lb/A of FeEDDHA, an iron fertilizer. There was some improved growth with the use of the fertilizer, but the plants were mostly green with or without the use of the iron fertilizer. A very susceptible variety was also treated with 3 lb/A of FeEDDHA fertilizer. The growth was improved by use of the fertilizer, but the use of the iron fertilizer could not fully alleviate the deficiency.

Iron fertilizers like FeEDDHA can be very helpful for situations where variety selection alone is not enough to overcome IDC.

Soybean Viruses in North Dakota

Principal Investigator: Dr. Berlin D. Nelson, Plant Pathology, NDSU

The objective of this project was to conduct an intensive survey for soybean viruses in North Dakota over two seasons and analyze samples for known soybean viruses. In August 2009 and 2010, soybean leaf samples were collected from 196 and 200 soybean fields, respectively, in 25 counties (Barnes, Bottineau, Burleigh, Cass, Cavalier, Foster, Grand Forks, Griggs, Kidder, LaMoure, Logan, McHenry, McIntosh, McLean, Nelson, Pembina, Ransom, Richland, Rolette, Sargent, Steele, Stutsman, Towner, Traill and Wells) in the eastern half of North Dakota (east of the Missouri River). Transects were made through each field and leaves were collected from 20 plants in each field. Sap from each leaf collection was extracted and tested for viruses using Triple Antibody Sandwich ELISA tests. In 2009 samples were tested for soybean mosaic (SMV) and bean pod mottle (BPMV) virus. In 2010, samples were tested for SMV, BPMV and Alfalfa Mosaic Virus (AMV). The results of the ELISA tests were as follows. In 2009, SMV and BPMV were detected in 17 fields each. In four fields both viruses were detected in the same sample. In 2010, SMV was detected in 13 fields, PBMV in 12 fields and AMV in eight fields. More than one virus was found in two of the fields in 2010. During the survey, there was little evidence of bean leaf beetle (vector of BPMV) activity in fields but aphids were observed in numerous fields. None of the fields sampled exhibited any obvious virus symptoms or damage from viruses. All samples of sap were sent to Dr. Les Domier, Plant Virologist with the USDA in Urbana, IL, where he used a quantitative molecular technique called Real Time Antibody-Capture-Reverse Transcription-PCR, to test for the following other soybean viruses: Soybean dwarf virus (SbDV), Tobacco ringspot virus (TRSV), Tobacco streak virus (TSV), Soybean yellow mottle mosaic virus (SYMMV), and Soybean Vein Necrosis Virus (SVNV). Results from the real time PCR assay showed that none of the sap samples from North Dakota were positive for any of these five viruses. Dr. Domier confirmed the presence of AMV in our samples from 2010 using this same technique. This is the first report of AMV in soybean in North Dakota. At the present time there is no evidence of serious problems with virus diseases in soybean in North Dakota. But, as bean leaf beetle activity increases, monitoring for BPMV levels could be justified. Because BPMV can cause seed discoloration (in addition to yield reduction), this virus could have a major effect on the value of food-grade soybean. As yet we have not heard of, or observed, any soybean seed discoloration in North Dakota that appears to be due to virus.

Soy-Resins Applied to Fiber-Reinforced Composites

Principal Investigator: Dr. Dennis P. Wiesenborn, Department of Agricultural & Biosystems Engineering, NDSU. Co-Investigators: Dr. Chad A. Ulven, Department of Mechanical Engineering, NDSU; Dr. Zhigang Chen, Center for Nanoscale Science and Engineering, NDSU; Dr. Judith D. Espinoza-Perez, Department of Agricultural and Biosystems Engineering, NDSU

The need for decreased petroleum dependence and an increased environmental awareness has prompted the research and development of renewable alternative products. Many government sponsored programs, (for example BioPreferred), promote the development and application of bio-products. Vegetable oils are a renewable source of building blocks for polymers, providing an alternative to petroleum-based polymers. Vegetable oils can be modified to produce different types of resins such as epoxidized vegetable oils.

Our previous research optimized the process for epoxidizing vegetable oil, and characterized the thermal-mechanical properties of composites containing 30 to 40% epoxidized oil in blends with a petroleum-based epoxy resin. The curing of those resins requires addition of a chemical hardener, and alternative hardeners might yield improved performance. Therefore, the objective in the past year has been to improve thermal and mechanical performance of soy-composites by comparing the effect of different hardeners. Selection of a hardener which produces a soy-composite with a high thermal and mechanical performance is desirable in order to compete with composites containing solely petroleum-based resins.

Of the amine hardeners evaluated, one hardener stood out as having superior thermal performance: PACM. Glass transition temperature (T_g) is an excellent measure of thermal performance, and PACM-hardened resins exhibited a high T_g of 100^0C. A higher T_g indicates better resistance of the material to high temperatures. PACM was subsequently used to harden composite samples containing 30% soy-based epoxy. The thermal and mechanical characterization of those samples showed that the PACM-soy composite is suitable for applications where temperature is a critical factor.

By achieving this objective, we are demonstrating that soy oil-based resins are suitable for high-value applications, thereby helping to create a new market for soybeans, fostering new business opportunities in the North Central U.S., and lessening our nation's dependence on imported petroleum.

Improving Soy Food Quality for Enhancing Health

Principal Investigator: Dr. Sam K. C. Chang, Cereal and Food Sciences, NDSU

We have three objectives:

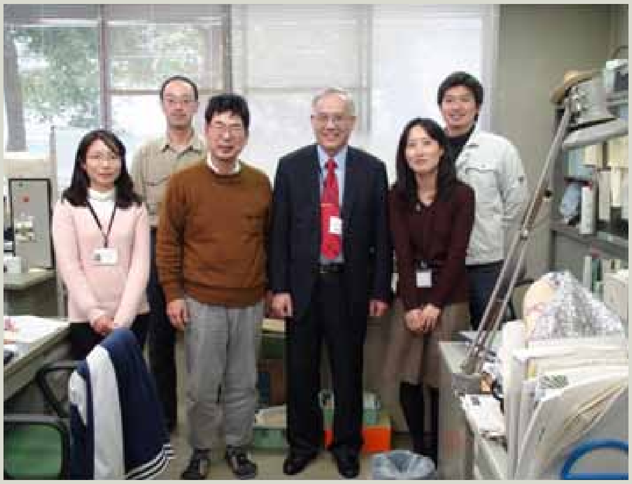
(1) Improving of soymilk quality by investigating the soymilk manufacturing process for eliminating more unwanted beany odor in soymilk;

(2) Investigating on anticancer effect of soy foods using human tumor cell cultures; and

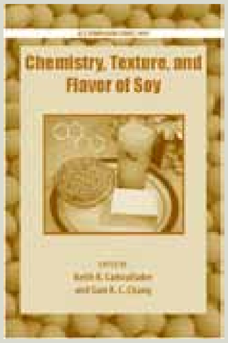
(3) Identifying of the compounds that may be responsible for the biochemical mechanisms for cancer prevention. To achieve the goals, we designed seven processing methods to search for the best extraction and grinding methods that could optimize production yield, reduce beany odor and eliminate trypsin inhibitors, and retain the highest levels of antioxidant capacity of soybeans in soymilk.

The following bullet points summarize our achievements.

- Soymilk protein recoveries were the highest by a processing method using residue-washed water to extract proteins from freshly soaked soybeans, followed by a method that combined treatments with washed water and soaked water for extraction.
- Most beany odor can be eliminated by a combination of hot-grinding and vacuum treatments, which would be the best for commercialization.
- Hot-grinding destroyed undesirable enzymes and therefore reduced the oxidation of unsaturated fatty acids.
- Hot grinding also resulted in greater elimination of total trypsin inhibitors, while retaining more good-nature Bowman-Birk inhibitors, which may inhibit cancer formation.
- The extraction methods using a combination treatment using residue-washed water and soaked water retained the most phenolic substances and total isoflavones in cooked soymilk; retained the highest antioxidant capacity and the highest anti-prostate cancer ability in the cell culture systems.
- Black soybeans produced soymilk, which exhibited higher total phenolic content, higher antioxidant and higher anti-tumor capability than yellow soybeans of the Prosoy variety.
- Soybeans contained not only isoflavones, but also a series of phenolic substances, among which condensed tannins have the highest antioxidant capacity.
- The extracts of soy yogurt and natto have anti-prostate cancer ability. The natto beans had a better effect in reducing prostate cancer cells in the cell culture systems.
- We analyzed for Dr. Ted Helms the quality of several natto experimental lines and several soybean sprout lines. Some of the lines have potential for future releases.
- I gave a lecture on how to select the best soybeans for making soy foods in a Soyatech Soy Innovations-South Africa Conference in Cape Town.
- I gave two lectures on quality characteristics of food-grade soybeans to two groups of soybean buyers from Korea and Indonesia.



Dr. Chang visited Japan's National Food Soybean Research Institute in Feb 2011.



Dr. Chang and Dr. Cadwallader (Illinois) co-published a book on soy.

- I gave a series of invited lectures in Tokyo on soybean biochemistry, and science related to the manufacturing of soymilk, tofu and natto. The advantages of northern grown soybeans were conveyed to the users.
- I have co-published a book with the University of Illinois-Urbana Champaign on 'Chemistry, Texture and Flavor of Soy' in 2011. This book is the first of its kind ever published in the United States and is a great reference book for soy food research.
- We have presented seven meeting papers and published two journal articles. One article titled "Changes of soybean quality during storage as related to soymilk and tofu making" has been recognized by the U.S. Food Science Society as the most cited article published in the Journal of Food Science.

In short, we have exceeded our goals in improving food and nutritional quality of soymilk by designing improved processing technologies. The results have a broad impact to the soy food industry for improving soy food quality for enhancing health. Thanks to the Council for its continuous support of our research program. Requests for our presentations or publications indicated above can be made by sending an e-mail to kow.chang@ndsu.edu.

Novel Soybean Oil-Based Polymers

Dr. Bret Chisholm (PI), Samim Alam, Harjyoti Kalita, and Anurad Jayasooriya
Department of Coatings & Polymeric Materials, Center for Nanoscale Science & Engineering, Materials & Nanotechnology, and the Department of Veterinary and Microbiological Sciences, NDSU

Graduate student, Samim Alam, holding a vial of the novel polymer derived from soybean oil.

Soybean oil (SBO) has considerable utility as a biorenewable chemical for the development of new materials such as surface coatings, plastics, and composites. The utility of SBO is largely based on the unsaturation in the fatty acid portion of the oil. This unsaturation allows for the oil to be transformed (i.e. “cured”) from a liquid to a solid by triggering an appropriate chemical reaction. Both the final properties of the cured material and the rate of cure depend on the number of unsaturated groups per molecule. Compared to many petroleum-based raw materials, the number of unsaturated groups per molecule for SBO is relatively low, resulting in unacceptable properties and unacceptably low cure speed for many applications.

We developed a method for dramatically increasing the number of unsaturated groups per molecule by converting SBO to a novel polymer. This novel polymer is being referred to as the polyvinylether of soybean oil fatty acids (polyVESFA). SBO, on average, possesses 4.5 unsaturated groups per molecule, while polyVESFA can possess hundreds to thousands of unsaturated groups per molecule. The number of unsaturated groups can be controlled through the polymerization process. PolyVESFA has been formulated into a wide variety of coating systems using different mechanisms of cure. In every case, coatings based on polyVESFA cured much faster than analogs based on SBO. For example, for air-dry coating systems, use of polyVESFA in place of SBO reduced drying/cure-time by a factor of 4 to 6.5. For epoxy-amine cure coating systems, the use of polyVESFA reduced cure time by more than an order of magnitude.

Similarly, for radiation-cure coating systems, polyVESFA provided significantly faster cure and better mechanical properties than SBO-based analogs. For the coatings industry, cure speed is critical since it directly impacts production rates of coated articles and energy costs. Faster cure rates translate to higher production rates and lower energy costs.

Based on the results of this project, it appears that polyVESFA, (which is derived from SBO), has tremendous commercial potential and will open new market opportunities for soybeans. A patent application has been filed on this technology and three conference presentations have been made. At present, two major chemical manufactures have expressed interest in this technology.

In addition, a publication based on this technology received the “Best Paper” award from the American Coatings Association.

Integrating Plant Resistance and Natural Enemies for Soybean Aphid Control

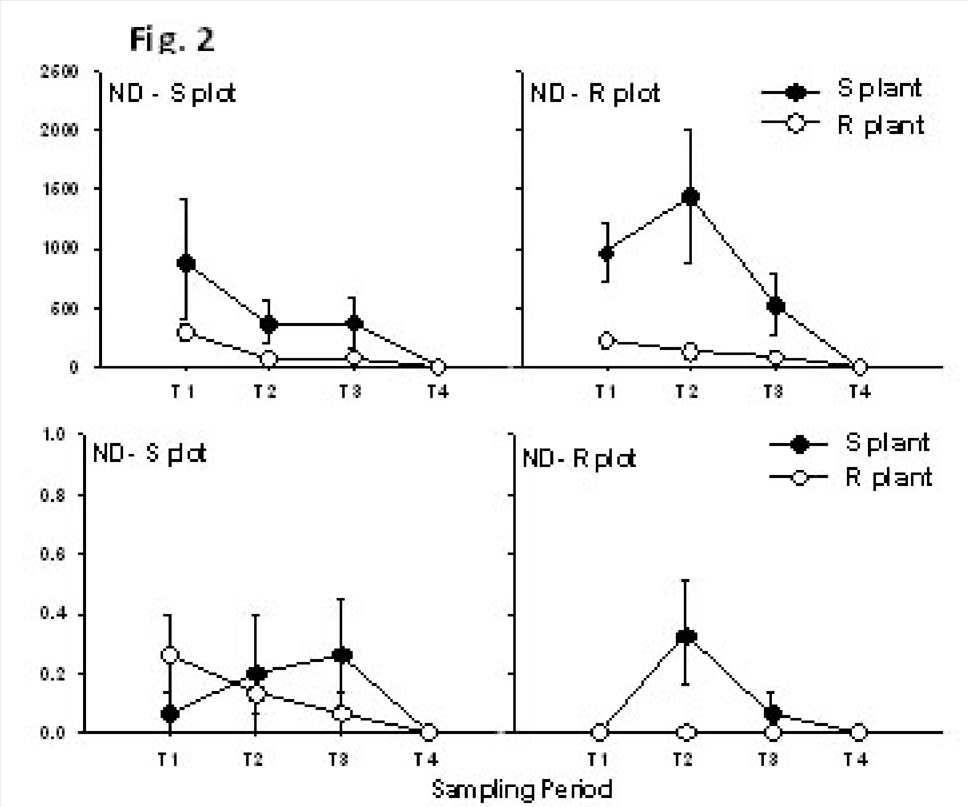
Principal Investigators: Dr. Deirdre A. Prischmann-Voldseth and Dr. Jason P. Harmon, NDSU Entomology Dept., Co-Investigator: Dr. Janet J. Knodel, NDSU Entomology Dept., Cooperating Producer: Mark Askegaard

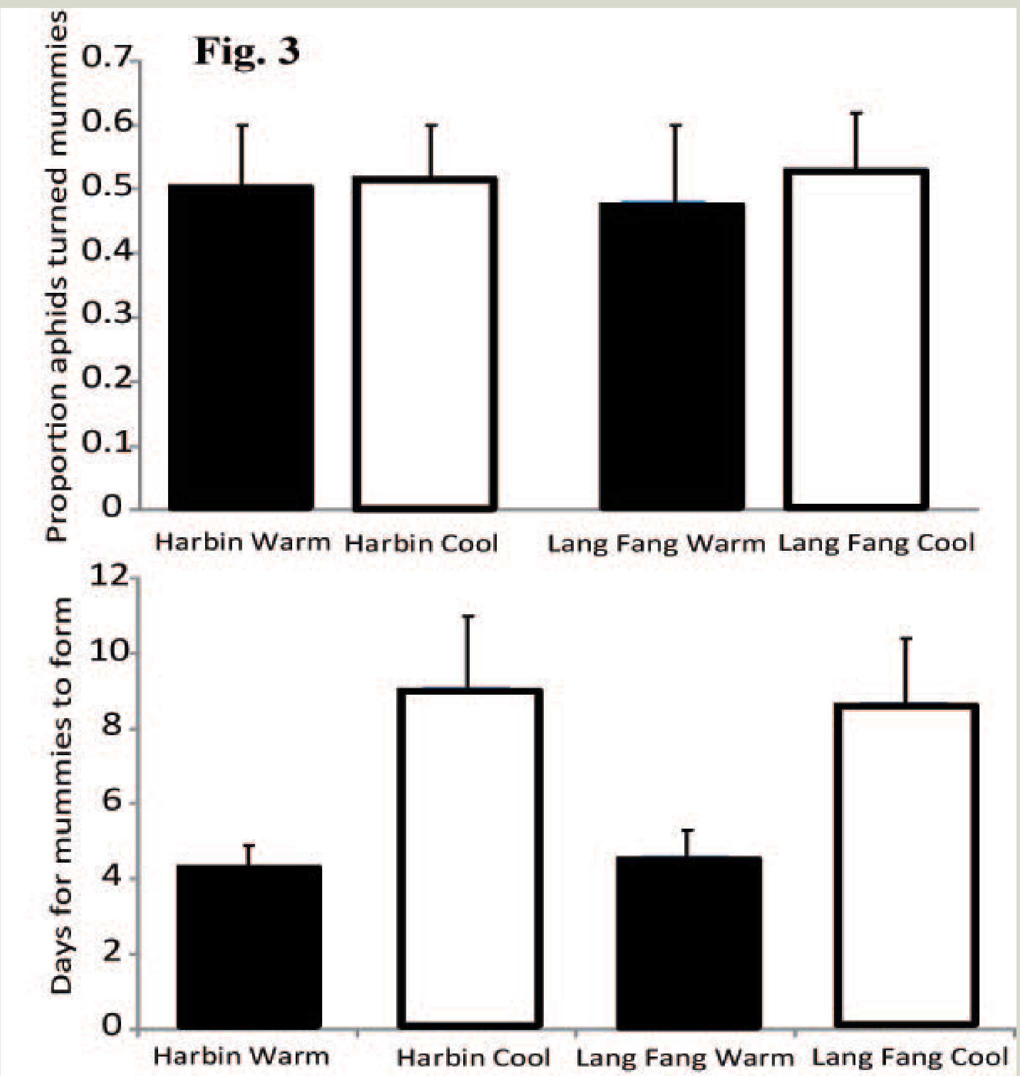
The invasion of soybean aphids in the Midwest caused a dramatic change in farming practices and a need to develop sustainable integrated pest management (IPM) programs. We are interested in integrating multiple pest control tactics and exploring how environmental factors impact these prolific pests in North Dakota.

Natural enemies (predators and parasitoids) can be key players in regulating densities of pest aphids. But, it is unclear how effective they will be in North Dakota, especially when resistant varieties are used. Our previous research showed that natural enemies were having a greater relative impact on soybean aphids in susceptible versus resistant varieties. In 2010, we investigated whether this was due to differences in natural enemy movement (immigration) or reproduction in the two different environments. Replicated quarter-acre plots of susceptible and resistant (*Rag1*) soybeans were established in Prosper, ND. Sentinel plants of the opposing soybean variety were then planted in each plot. High aphid densities were created on experimental plants within each plot (n = 5 home plants and n = 5 sentinel plants) by adding aphids and caging plants for two weeks (Fig. 1). After aphid populations built up, cages were removed and aphid and predator densities were documented every three days (T1-4; Fig. 2). We focused on ladybeetles as a representative predator. Initially, aphid densities on caged plants were higher on infested susceptible (S) plants than infested resistant (R) plants (*i.e.* S plants represented a more intense aphid 'hot spot;' Fig. 2). Ladybeetles were more abundant in S plots and had a stronger response to infested S plants, (which was likely a function of higher aphid densities on those plants; Fig. 3). But, it did not appear that plant identity per se (S or R) affected the rate of aphid decline. This may be because natural enemies other than ladybeetles fed on aphids on R plants. There was a brief lag in aphid declines in R plots, which could have been due to an initial paucity of natural enemies in R plots. This effect may be exacerbated when dealing with a larger geographical area (*i.e.* within agricultural fields).

Figure 1

Binodoxys communis, a soybean aphid parasitoid native to China, is currently being field tested in North Dakota. We are working with two strains of this natural enemy (Harbin and Lang Fang) that originate from two different geographical areas - Harbin from a more northerly latitude. Since these *B. communis* strains are from regions with different climatic conditions, each strain may be better at controlling aphids at different temperatures. Therefore, we investigated how each strain responds to temperatures relevant to North Dakota. This may help determine an optimal strategy for releasing and establishing B. communis for soybean aphid control in North Dakota. We tested how many parasitoids developed on aphids kept at either 60°F (15.5°C) (cool) or 80°F (26.7°C) (warm). These





temperatures correspond to the coolest average temperature and the warmest average temperature recorded in Fargo, ND over a one week period in July or August over the last 10 years. We performed the experiment with mated female parasitoids of each strain given 25 soybean aphids. We measured how effective the parasitoids were at producing "mummies" (parasitized aphids that are about to become new adult wasps) and how long it took these new mummies to form. Our results showed the temperature had very little effect on parasitoid production for either strain (Fig. 3). However, temperature did have a large effect on how long it took for parasitoids to develop in to mummies (Fig. 3).

Parasitoids in the cool took about four days longer to develop in to mummies than when they were in the warm, and this difference was consistent for both strains of parasitoid. These results suggest that both strains are equally effective at these average temperatures. Different results may occur if we exposed them to particularly hot or cold temperatures (daytime highs and lows) as opposed to averages. Or, it may be that there is little local adaptation in terms of activity at different summer temperatures.

By influencing development time, our results also suggest that temperature could be an important factor in determining how well *Binodoxys* controls soybean aphid.

Breeding of Improved General Use Cultivars and Germplasm

Principal Investigators: Dr. Ted Helms Department of Sciences, NDSU; Dr. Berlin Nelson, Department of Pathology, NDSU; and Dr. R. Jay Goos, Department of Soil Science, NDSU

This research had three broad objectives which included: i) breeding non-GMO cultivars; ii) evaluating molecular markers to breed for iron-deficiency chlorosis tolerance; iii) test private company varieties for yield under various conditions to aid growers in variety selection.

Breeding non-GMO cultivars

Advanced lines are screened for phytophthora root rot and SCN-resistance by Dr. Berlin Nelson. Dr. Jay Goos evaluates advanced lines for tolerance. The breeding effort is a team approach. In the 2011 growing season, 272 advanced lines are being evaluated for yield at multiple locations. Fourteen advanced lines yielded between 2-3 bu/A more than Sheyenne or Ashtabula and the first steps of the seed increase process will be initiated for those lines in the 2011 growing season. These 14 lines have shown good lodging resistance and phytophthora root rot resistance. Some of these lines also are resistant to SCN. I anticipate having one-half acre seed increases of several of these lines in Chile, South America in the winter of 2011-2012. This will speed of the seed increase process by one year.

A new small-seeded specialty soybean was approved for release in March of 2011. This variety is intended for the natto and sprout markets to provide value-added products in our region. The variety was designated as ND1100S. A second small-seeded line was approved for seed increase and possible release as a named cultivar in March, 2012.

Breeding Roundup Ready® One Cultivars

I made crosses in the summer of 2010 to start a new program of developing RR1 cultivars at NDSU. In July 2011, I made a lot more crosses to incorporate Roundup resistance into high-yielding NDSU experimental lines. The ND Soybean Council approved a three-year grant that included money to lease a small-plot combine and hire a third full-time project technician. The combine is in the process of being built by the manufacturer and the new technician has been hired. Breeding is a long process. I anticipate that the first RR1 types could be released in 2017 or 2018. The goal is for farmers to be able to save their own RR1 seed and replant it the next year. The rumor is that in 2015 farmers will be able to save their own RR1 seed and plant it.

Test Private Company Varieties for Yield under Various Conditions

I test private company varieties at multiple locations. This data is available on the NDSU web site: http://www.ag.ndsu.edu/varietytrials/soybean/barley/variety-trials/soybean/fargo-main-station.

RESEARCH FINANCIAL REPORT 2010-2011

Fuels, Chemicals and Polymers from Cracked Soybean Oil (Seames)	$ 80,000.00
Biological Control and Aphid Resistant Cultivars (Knodel/Harmon)	$ 38,823.11
Screening Soybean Varieties for Resistance to Iron Deficiency Chlorosis (Goos)	$ 38,734.71
Durable Soy-Based Thiol-ene and Thiol-urethane Thermoset Coatings (Webster)	$ 39,791.00
Identifying Intensive Management Practices to Increase Soybean Net Returns (Endres/Kandel)	$ 12,600.00
Integrating Plant Resistance and Natural Enemies for Soybean Aphid Control (Prischmann-Voldseth)	$ 49,446.00
Impact of Nitrogen on Soybean Aphid Denisities and Parasitation on Binodoxy's Cummunis (Prischmann-Voldseth)	$ 3,437.00
Impact of Tillage System and Previous Crop on Root Rots and Soybean Performance (Aberle)	$ 6,850.00
Control of Soybean Diseases (Nelson)	$ 50,294.25
Effects of Soil Type on Soybean Cyst Nemotode (Nelson)	$ 13,950.00
Soybean Viruses in North Dakota (Nelson)	$ 13,620.00
New Iron Fertilizers by Incorporating EDDHA/EDTA into Polymer Maromolecules (Voronov/Goos)	$ 29,950.00
Impact and Control of Sclerotinia Stem Rot on Soybean Production (Schatz/Markell)	$ 14,200.00
Improving Soyfood Quality for Enhancing Health (Chang)	$ 50,000.00
Soybean Oil Applied to the Fabrication of Light-Weight Panels to Shield Agricultural Machinery and Vehicles (Wiesenborn)	$ 15,669.62
Whole - Field Comparison of Soybean Production Using Strip Till, Conventional Till, and No -Till Grown on Wheat and Corn Stubble (Nowatzki/Bora)	$ 7,436.00
General Breeding of Improved General Use Cultivars and Germplasm (Helms)	$250,000.00
Determining Soybean Variety Response to Tile Drainage (Kandel)	$ 17,000.00
Novel Soybean Oil-Based Polymers (Chisolm)	$ 65,555.59
Controlling Volunteer RR Canola & Evaulating the Micro-Rate Concept on Soybeans (Zollinger)	$ 4,050.00
Capturing Value from Real World Soybean Production Practices (Metzger)	$ 5,695.94
Minnesota Soybean Growers Association's Amino Acid Study	$ 19,662.52
U.S. Soybean Export Council's High Value U.S. IP Food Soybean Research Project	$ 15,829.58
NDSU Greenhouse Sponsorship	$750,000.00
Research Combine Sponsorship (Kandel)	$ 40,000.00
North Central Soybean Research Program	$150,000.00
Research Committee/Consulting Services/Administrative Costs	$ 58,197.95
TOTAL RESEARCH EXPENSES	$1,840,793.28

FY 2011 Research Committee

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- **Claude Richard, Fargo**
- **Tyler Speich, Milnor**
- **Scott Gauslow, Colfax**
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North Dakota Soybean Council
Our World Is Growing.

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