Multistate Regional Research Project
S1010: Dynamic Soybean Pest Management
For Evolving Agricultural Technologies
and Cropping Systems

Annual Report in 2003
(October 1, 2002 – September 30, 2003)

Project Duration: October 1, 2002 – September 30, 2007

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ANNUAL REPORT
(Period Covered: 10-01-2002 to 09-30-2003)
COOPERATIVE REGIONAL PROJECT S1010
Multistate Research Project
“Dynamic Soybean Pest Management for Evolving Agricultural
Technologies and Cropping Systems”
(from S-281)
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PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS
**Progress of Work and Principal Accomplishments:**

**Objective 1:** Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

**GA:** Pest arthropod populations were similar in conventional and Round-Up Ready systems of weed management.

An early maturing variety of edible soybeans (Midori Giant) escaped damaging populations of stink bugs and caterpillars.

Soybean aphid (SBA) was detected in Georgia for the second year in a row.

Twenty-eight varieties of soybeans were screened for resistance to stink bugs and Lepidoptera pests. Varieties exhibited a large range of susceptibility to these pests.

Fire ants in soybeans were controlled with Amdro and Lorsban; however, fewer spiders were collected in plots treated with these insecticides.

Warrior, Scout, Capture, Demon and Orthene were effective against soybean looper.

**IN:** A preliminary threshold of 250 SBA/plant up to R4 was established.

Planting date and plant age did not appear to have an impact on SBA density.

SBA outbreaks occurred 1-2 weeks after outbreaks in more northern states; thus, SBA moves from north to south. SBA overwintered in northern Indiana. *Rhamnus cathartica*, *R. alnifolia*, and *R. lanceolata* were shown to be overwintering hosts of SBA. Several species of Rhamnaceae supported fall migrants (gynoparae), but only *R. cathartica* and *R. alnifolia* supported the egg-laying generation (oviparae) of SBA.

In the field, initial colonies of SBA are patchy and consist of nymphs. Eventually, SBA colonize entire fields and achieve a more uniform distribution.

A model of SBA population dynamics is being developed.

**KS:** Resistance to SBA is being investigated using a visual rating scale using KS 4202 as the “sentry” variety. Antibiosis tests revealed three varieties with significantly reduced aphid reproduction.

*Dectes texanus* has shifted from sunflowers to soybeans. *D. texanus* on both hosts are conspecific, but sunflower is a better host than soybean.

**LA:** Did not find SBA in 2003.
NE:  SBA gradually spread throughout the eastern half of NE in 2003. Most damaging populations were found in northeastern NE. This colonization pattern was similar to 2002 but more fields were treated in 2003 than 2002. Milder temperatures in 2003 may have accounted for higher populations in 2003.

Two out of four studies showed about a 10 bu/acre yield increase in SBA-treated plots compared to untreated plots.

Soybean defoliation reduced early-season crop tolerance to weeds.

ND:  SBA was found on buckthorn in the fall of 2003 at Moorhead, MN on the MN/ND border. SBA was found in highest abundance on late reproductive stage soybeans in 2003.

SBA initially colonized the edge of soybean fields near shelterbelts; populations gradually became uniformly distributed in the field. Recommendation: scout field borders near shelterbelts first in early July to detect initial colonization by aphids.

In a greenhouse test, MN0302 and Dynagro 3072 generated high populations of SBA but exhibited low damage. SBA became established on thiamethoxam-treated (applied to seed) plots 3 weeks later than on untreated plots. ND participated in the common experimental protocol for refining the SBA economic threshold. Karate Z was applied at R2, R3, R4 and R5. Aphid infestation was not high enough to obtain meaningful data.

OH:  The threshold for SBA is 250-300/plant with increasing populations. In validation studies, in all cases where aphid populations midwest the threshold, yield losses occurred. Lorsban at 2 pt/acre gave excellent control of SBA; data suggest Lorsban has contact and fumigant action.

CEAs and consultants reported yield increases of 5-15 bu/acre in fields treated for SBA. Proper management entails weekly sampling beginning at R2 and treating when populations reach 250-300 SBA/plant.

In an insecticide screening trial, Furadan at 8 oz/acre and Lorsban at 24 oz/acre provided the best control of SBA.

In narrow row soybeans, skip row soybean planting is encouraged to avoid running over soybeans with spray equipment (treating for SBA).

Heavy slug defoliation occurred soon after emergence when weather turned unseasonably cool. A $500,000 program funded by USDA-NCRS EQIP has been established and will make monies available to growers to sample and treat for slugs.

TN:  Evaluated soybean cultivars for resistance to Dectes stem borer; for early MGV cultivars, Delta King was most damaged; least damaged was FFR. For late MGV cultivars, Dectes damage was less than for early MGV cultivars.
The pyrethroids, Asansa XL [0.05 lb (AI)/acre], Baythroid [0.03-0.044 lb (AI)/acre], Fury [0.05 lb (AI)/acre] and Karate Z [0.03 lb (AI)/acre] performed well against green stink bug. Lorsban [1 lb (AI)/acre] was least effective.

**TX:** Populations of stink bugs were compared on MGIV, V, VI and VII soybeans planted in mid-April and late May. Basically, stink bugs, primarily southern green stink bug, built-up to damaging levels on MGIV soybeans planted early. However, for the late May planting date, stink bug populations did not exceed threshold levels on MGV and VI and VII soybeans. Planting MGV or VI soybeans in May/June may avoid damaging stink bug populations and allow early harvest before cool, wet weather occurs.

**VA:** SBA was found in soybean fields in 10 counties; however, populations did not approach damaging levels. Educational programs were conducted to alert clientele of this potentially devastating insect pest.

Based on the Corn Earworm Advisory, corn earworm (CEW) problems on soybeans were predicted to be less in 2003 compared to 2002, and in fact, they were. About 60% of VA soybean acreage was treated for CEW in 2002; only 17% was treated in 2003. The % of soybean acres treated in August was well correlated with predictions based on a survey of field corn in July. Field-collected CEW moths from around the soybean-producing area of VA were subjected to varying rates of cypermethrin. No evidence of pyrethroid resistance was detected. However, field collected CEW moths reared from larvae collected around the soybean-producing area of VA did exhibit low levels of resistance. Growers were warned and encouraged to employ non-pyrethroid insecticides. Steward 1.25 SC at 4.6 and 6.7 oz/acre, Tracer 4SC at 2 oz/acre, Mustang Max at 2.8 and 4.0 oz/acre, Larvin at 10 oz/acre and Karate Z at 1.6 oz/acre provided at least 90% control of CEW.

**WI:** In field experiments, late-planted soybeans produced higher SBA populations than early planted soybeans.

Results of experiments show that the economic threshold for SBA is 500/plant at R1. At R2/3, the threshold increases to 1000/plant. The best time to apply an insecticide for SBA is R/2. SBA was detected earlier on early- rather than late-planted soybeans. SBA tend to congregate in the uppermost nodes during June and early July after which their spatial distribution is less clumped.

Adapted germplasm also was screened for SBA; populations ranged from 1000 to 2500 per plant which suggests that resistance to SBA can be incorporated into adapted germplasm.
Objective 2:
Define insect-vector ecology and virus-disease relationships and develop management strategies.

ND: Aphid-transmitted viruses were not detected in ND.

WI: Soybean dwarf virus was detected in soybeans in five counties in WI in 2003.

Alfalfa mosaic virus (AMV) and soybean mosaic virus (SMV) were the most prevalent viruses infecting soybeans in 2003.

Soybean germplasm was evaluated for reaction to AMV, SMV and bean pod mottle virus; differences among varieties for yield and grain quality were evident. This information was given to breeders for use in their programs.

Objective 3:
Biological control of the soybean aphid in North America.

IN: Harmonia axyridis is a common predator of SBA.

Little parasitism occurs but fungal disease epidemics are common. Other predators are damselflies, flower flies and lacewing larvae.

The major predator of SBA is Orius insidiosus. O. insidiosus populations were associated with thrips populations. Thrips may be sustaining O. insidiosus populations for later SBA predation. Hypothesis: O. insidiosus keep in check locally overwintering SBA but are unable to impact large migrant populations entering IN from the north.

KY: The predatory harvestman, Phalangium opilio, is a common predator of CEW eggs and also feeds on SBA. This predator only feeds at night. Also, CEW eggs are a better host diet than SBA.

USDA/ARS Michigan: In cooperation with State Experiment Station scientists, the USDA PPQ Invasive Pests Management Laboratory in Niles, MI screened and evaluated exotic natural enemies of the SBA, modeled natural enemy impacts on SBA, conducted foreign exploration for SBA natural enemies and studied the interaction of predators and parasitoids on SBA biological control. Also, this facility reared the Wyoming strain of an established aphid parasitoid, Aphelinus albipodus (shipped 76,000 to MN and 447,000 to WI).

WI: In 2003, SBA was severe in southern WI. A. albipodus was released in 2002 and became established in 2003. Lady beetles are the most significant predator of SBA in WI.

SBA natural enemy complex is diversifying following the recent introduction of this pest.
**Objective 4:**
Apply geospatial and precision technologies to advance pest management in soybeans.

**LA:** The drop cloth and light meter methods (measures light interception) of determining when to treat for defoliating insects gave similar results; both methods triggered an insecticide application within several days of one another.

- Results confirm that light measurements using hand-held light meters can accurately predict when insecticide application is warranted.
- Use of vegetation indices generated by remote sensing correlated well to light interception and leaf area index (LAI) measurements. Thus, remote sensing shows promise as an accurate method of determining when to apply insecticide.

**VA:** Varieties and planting dates were manipulated to achieve various LAIs of field-grown soybeans. Infrared images of these plots were taken from a fixed-wing aircraft at three different altitudes. NDVI (normalized difference vegetation index) values were calculated from the infrared images. Results show a significant linear relationship between LAI and NDVI.

**Usefulness of Findings:**

Significant progress was made towards determining the current distribution of the SBA and predicting its future spread. This information is being used by participating states to alert stakeholders to the potential damage of this introduced pest. Pro-active IPM programs are being developed in all states where the SBA is a threat. Soybean entomologists in the northcentral, midwestern and eastern states have embarked on aggressive programs to determine SBA response to various cultural practices (e.g., planting date relative to maturity group) and varietal selection. These scientists also are screening germplasm for resistance to the SBA as well as diseases caused by viruses. Data have been given to cooperating plant breeders to incorporate into their programs.

Crucial biological information on the SBA was generated in 2003. For instance, overwintering relationships with buckthorn (*Rhamnus* spp.) were elucidated and applied to predict future damaging populations of SBA. In general, the SBA initially colonizes field margins, then spreads throughout fields to produce a relative uniform distribution. Populations can double in 2-3 days, so farmers must scout fields frequently and carefully. An economic threshold of approximately 250-500 SBA/plant already is being utilized by soybean farmers saving them millions of dollars annually in yield losses and reducing unnecessary pesticide applications. Assume an average of 5 bushel/acre yield gain from proper use of these economic thresholds over 10% of the soybean acreage in IL, IN, IA, MN, OH and WI, and assume a price of $9/bushel for soybeans, then this research has the potential to generate $225 million annually!

Insecticides, such as thiamethoxam seed treatments, are being screened for efficacy against SBA. Results of these screening studies are being used in conjunction with economic thresholds to effectively control SBA.
Aggressive biological control programs involving native and exotic natural enemies of SBA are being conducted. Parasitoids have been released and establishment is being monitored. Foreign exploration in Asia is being conducted and promising exotic natural enemies are being evaluated. Results of these activities will be incorporated into SBA-IPM programs resulting in reduced environmental disruption caused by insecticides.

Useful management information for stink bugs, Lepidoptera defoliators, *Dectes texanus*, CEW and slugs was generated. For instance, a new soybean production method is being evaluated on the Gulf Coast where stink bugs are problematic on MGIV soybeans planted in mid-April. The new method targets MGV and VI soybeans planted in mid-May to early June. Preliminary data indicate that this method may avoid stink bug damage, produce high yields and quality and allow harvesting before the onset of inclement weather.

Excellent progress was made in applying geospatial and remote sensing techniques to estimating soybean defoliation to trigger control tactics and to pinpoint other problem areas in soybean fields. For instance, use of vegetation indices generated by remote sensing correlated well to light interception and LAI measurements. Also, LAI and NDVI values calculated from infrared images taken from an aircraft were correlated significantly. These novel techniques can be used to accurately monitor soybean fields for pest damage which will allow farmers to more accurately time control tactics and to apply pesticides to only those areas of fields needing attention.

**Work Planned:**

Spread of the SBA will be monitored by all states. Investigations of SBA biology, population dynamics, damage, management and virus/vector relationships will be continued and expanded. Biological control efforts aimed at the SBA will be intensified including foreign exploration for exotic natural enemies. The goal is to achieve SBA-IPM programs for each affected state.

Management of other pests, such as stink bugs, Lepidoptera defoliators and pod-feeders, slugs and *D. texanus*, will be researched and data extended to stakeholders. For instance, in the east, the Corn Earworm Advisory will be continued to alert soybean farmers of potential damage based on CEW damage in corn. This program is highly successful and is being fine-tuned and more widely adopted. In the midwest where slugs damage seedling soybeans, a $500,000 grant will be available to farmers from 2004-2006 to help them sample and treat for slugs. Along the Gulf Coast, stink bug populations, damage, yield and seed quality will be compared on MGIV-VII soybean varieties in an effort to develop an improved soybean production system which minimizes stink bug problems and maximizes yield and seed quality.
PUBLICATIONS (BY STATE)
Publications: (by State)

Georgia


Indiana


**Kentucky**


**Louisiana**


**Nebraska**


**Ohio**


**Virginia**

Malone, S., D. A. Herbert, Jr., and S. Pheasant. Determining adoption of integrated pest management practices by grains farmers in Virginia. J. of Extension (Accepted for publication, Jan. 2004)
APPROVAL
October 1, 2002

Executive Director T. J. Helms
Southern Agricultural Experiment Station Directors
Mississippi State University, P.O. Box 9656
Mississippi State, Mississippi 39762

Dear Director Helms:

The Executive Directors on behalf of the Regional Directors Association have
RECOMMENDED APPROVAL of MRF project **S-1010 Dynamic Soybean Pest Management**
for **Evolving Agricultural Technologies and Cropping Systems** for funding beginning October

CSREES concurs with the recommendation of the Executive Directors and has APPROVED
this project. A copy of the approved MRF project outline will be available to all participating
stations and agencies via the National Information Management and Support System.

Sincerely,

Cheryl J. Oros
Director, Planning and Accountability

cc:
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REPORTS (BY STATE)
2003 Georgia Annual Report

PROJECT:  S-1010, Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

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PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS

Objective 1. Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

Studies on the population dynamics of the velvetbean caterpillar (VBC) stink bugs (SB) soybean loopers, threecornered alfalfa hoppers, and other arthropods on soybeans produced in a Roundup Ready system and a conventional system was conducted in 2003. Soybean variety (Roundup Ready vs. conventional) had little impact on the insect species observed. In particular, economic threshold levels of VBC and SB were attained in both cropping systems in 2003.

Initial research on the vegetable soybean system (Edamame) in south Georgia has documented that this commodity can be efficiently produced utilizing most of the soybean culture that is currently being recommended. An early-maturing variety, Midori Giant, can be harvested around 60 days after planting. This variety, when planted from early April to mid-May, escapes most insect-induced crop injury caused by stink bugs and caterpillars. Other, later-maturing varieties, i.e., Bellesoy, Green Lion, and MoJo Green, do have economically damaging infestations of soybean insect pests, but these pests can be effectively managed through the judicious use of insecticides.

Soybean aphids were observed on soybean a second year at the UGA Georgia Mountain Research & Education Center at Blairsville, GA. Only 3 total aphids were observed in all plots on 11 July. By 13 August, aphids were common in all three soybean varieties planted, H5233 (R2-R4 growth stage), DP6680 (R3), and H7242 (R2). Two weeks later, 29 August, aphid densities ranged from 0 to 12 per 10 trifoliolates. This is the highest aphid density observed in either 2002 (first year detected) or 2003. By 24 September, less than 10 total aphids were observed and all three soybean varieties were at R7 growth stage. In 2002, all soybeans were mowed and harrowed by late August; whereas in 2003, the soybean plots were allowed to mature naturally. Although aphid populations are low in northern Georgia, there presence is cause for concern about possible future pest outbreaks in the state’s soybean crop.

Objectives 2, 3, and 4.

No work conducted in 2003
Other Soybean Entomology Research Projects.

Twenty-eight soybean varieties and breeding lines were selected from the initial 68 entries (2001 & 2002 trials) for advanced screening for stink bug and lepidopteran resistance. In the advanced study, stink bug damaged kernels ranged from 2.9 to 18.2% in a year with moderate stink bug population densities and % defoliation (primarily VBC but some loopers) ranged from 15 to 55% under moderate to heavy caterpillar populations.

In a red imported fire ant suppression study, fire ant captures in pitfall traps were significantly lower in the Amdro and Amdro + Lorsban plots compared to untreated plots. Spiders, primarily Lycosidae, were also more abundant in the untreated plots, while the earwig *Labidura riparia* was more abundant in the treated plots.

Five insecticide trials were conducted in Georgia soybeans in 2003. Orthene, Capture, Denim, Warrior, Scout Xra, Lannate, Tracer, S-1812, Karate, Asana, Pounce, and Penncap M were effective on VBC. Warrior, Scout, Capture, Denim, and Orthene were effective on SBL. Orthene, Capture, Warrior, Scout, Asana, Karate, and Penncap M were effective on stink bugs.

**Usefulness of findings:** Having a better understanding of the impact of the herbicide tolerant soybean production system on arthropod communities will aid in refining the soybean IPM program as this technology advances. It appears that the vegetable soybean production system can provide an efficient alternative crop for producers looking for new ways to improve the profitability of their farming operation. Ag Economics are currently developing vegetable soybean crop budgets and exploring marketing options for Georgia producers. The soybean aphid is now established in north Georgia, and this pest will continue to be monitored for abundance and damage potential. Georgia growers and Extension Agents have been alerted to the potential pest status that this new and invasive arthropod might attain. Several soybean breeding lines have been identified with substantial resistance to stink bugs and/or velvetbean caterpillars. These lines will provide genetic material for future crosses and back crosses, hopefully resulting in the release of resistant varieties. Several new insecticides look promising as alternative controls for soybean insect pests. Some are now labeled for use on soybean and others are pursuing registration and labeling.

**Worked Planned for 2004:**

Research is planned to continue monitoring for the invasive soybean aphid and to assess population densities and spread throughout the state. Studies will continue on examining the entomological and economical risks associated with the vegetable soybean production system, the herbicide tolerant soybean system, host plant resistance, and alternative pesticide recommendations.
Project: S-1010, Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

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Purdue University cooperates on S-1010 on objective 1 ["Ecology and management of insect pests (soybean aphid)"] and objective 3 ['Biological control of soybean aphid']. Below we present results by objective, plans for future research, and a list publications from these efforts.

Objective 1: SBA Damage & Threshold

• A 5-acre research plot was established in Tippecanoe County at Purdue University Agronomy Farm and subdivided into 20 plots, each 8 rows by 60' long and each plot assigned to one of 5 threshold treatments. Pesticide (Lorsban) was applied at 1200 cumulative aphid days (cad), 1500 cad, and 3000 cad, in treatments 1, 2 and 3 respectively. Treatments 4 and 5 received no pesticides. Initial analysis shows no correlation between aphid levels and yield. However considerable replicate variation (due to intense rainfall in July) may be obscuring relationships. Detailed yield component data are still being analyzed. Data have been combined with recent efforts of University of Minnesota and Michigan State scientists to help develop the provisional SBA threshold of 250 aphids/plant (up to R-4 stage), a higher, as yet determined threshold R4-R5 stages, and a no treatment recommendation for beans >R6.

• In related research we established 20 one-half acre plots with 4 different planting dates. Each plot was sampled weekly to determine aphid abundance, thrips number (see below), and the presence of predators. Aphid abundances were high in all plots, with levels reaching 3-4 thousand aphids a plant during peak aphid infestation. The aphid infestation followed an interesting pattern, with early season populations remaining quite small. The aphid population only seemed to explode after a large influx of alate aphids. These alates appeared 1-2 weeks after large blooms of alate aphids were observed in northern states (MI, WI) and are thought to have immigrated from the north. Data are still under analysis, but preliminary results suggest no difference in aphid abundance between the four planting dates.

• We also conducted clip-cage experiments to measure individual aphid growth rates on differentially aged, and staged plants. In these experiments we measured the intrinsic growth rate of aphids on the plants in the field. Contrary to expectations, aphids performed equally well on plants of all ages (before plant senescence). This data, together with the data from the planting date experiment suggest that planting date, and therefore the age/stage of soybean plants upon aphid immigration into the field, does not directly play a role in aphid dynamics.
**Objective 1: Soybean aphid overwintering**

- Soybean aphid was found to overwinter in 4 counties in northern Indiana (Kosciusko, Fulton, LaGrange, and Tippecanoe). Measurement of overwintering success in Tippecanoe County found no survival in unprotected locations, suggesting that while aphids can survive the winter in Indiana, they do so at very low levels.
- A choice test using 11 putative primary hosts has shown three species of Rhamnaceae to be suitable hosts for development to the overwintering egg generation: *Rhamnus cathartica*, *R. alnifolia*, and *R. lanceolata*. This is the first reporting of the overwintering suitability of *R. alnifolia* and *R. lanceolata*.
- A fall survey in northern Indiana found "pre-overwintering" forms (e.g., oviparae) on both *R. cathartica* and *R. alnifolia*. Aphids were also found on *R. frangula*, but data from our host-testing studies suggest that these aphids will not produce the overwintering (egg) form on this host plant. We will re-visit fall-sampled sites to confirm overwintering success.
- To complement the choice test, a non-choice host test experiment was conducted in the laboratory. The findings confirm that although several species of Rhamnaceae are able to support survival of the fall migrants (gynoparae), only *R. cathartica* and *R. alnifolia* support maturation of the egg-laying generation (oviparae). Specimens of *R. lanceolata* were not available for inclusion in this study. Analyses of reproduction and survival on various primary hosts is on-going.

**Objective 1: Soybean aphid dynamics**

We are addressing this component of Objective 1 via statewide sampling of soybean fields and simulation modeling of SBA dynamics.

**Sampling** - Our efforts included season-long sampling of 22 fields throughout the state and one time visits of other fields during the SBA outbreak (8 to 25 August). Our first finding of aphids in Indiana soybeans occurred on 11 June 2003 - some three to four weeks earlier than that had been observed in 2001 and 2002. Statewide sampling revealed economically important populations (=250 SBA/plant) common in the northern one third of the state, sporadic in the middle third and relatively rare (although "hot spots did occur) in the southern one (Figure 1). In season-long samples we noted that SBA populations characteristically colonize soybean fields. As the aphid initially colonizes a soybean field, its distribution is highly patchy with single scattered plants with small colonies consisting of early instar nymphs and no adults. Winged migrants that had fed for a short time, deposited a few nymphs and then moved on in search of another host plant presumably produce these small colonies. Later, the field becomes uniformly infested, but at low densities of aphids. Outbreak levels (e.g., hundreds per plant) occur after the field is saturated with these initial aphid colonies. Analysis of aphid impact on soybean production is on-going. At this point in time, no consistent pattern of agronomic factors (e.g., planting date, variety, group) and aphid dynamics has been noted.
Modeling --- We are currently developing a simulation model of field-level population dynamics of the soybean aphid and its dominant predator, Orius insidiosus. The model is composed of linked sub-models describing soybean development, aphid population dynamics, and predator functional and numerical response. Brief details of the sub-models are as follows:

1. Aphid population growth: Aphid survival, development and reproduction rate are temperature-dependent throughout the soybean growing season, with late season decline driven by plant senescence. Daily mean temperatures are input from average historical temperature data for Tippecanoe County, and daily population growth parameters are based on temperature-dependent fecundity and survivorship data reported by McCornack et al. (in review, pers. comm.). Aphid population growth is independent of soybean V-stage, as our field studies have shown no consistent effect of plant stage on aphid intrinsic growth rate. Initial colonization rate and timing are based on field data obtained in 2001-2003.

2. Predator population dynamics: Predation by O. insidiosus on aphids is a function of aphid density, which in turn depends on aphid abundance and plant leaf area. We have preliminary data on predator functional response (Rutledge, unpub. data), and will collect numerical (reproductive) response data in laboratory studies of predators fed varying densities of aphids. Behavioral response is not explicitly included in this non-spatial model. Soybean plant growth is independent of aphid and predator densities, but predator dynamics are coupled with prey dynamics, with predators imposing a daily mortality on aphids based on their functional and (numerical) responses.

The model will generate predictions of peak aphid densities and intrinsic growth rate. We will use a published crop growth model [SOYGRO] to "grow soybeans" for needed plant and yield components. Validation studies will use 2004 field. We also plan to explore the spatial dynamics of this system by developing a spatially-explicit analog of the current, non-spatial model. This model will incorporate spatial patterns of aphid invasion into a field as well as the behavioral numerical response of predators.

Objective 2: Natural enemies

Exotic natural enemies -- Our previous (to S-1010) efforts included 2 seasons (2001-2002) conducting foreign explorations in Japan and collaborating with similar efforts in China (via USDA & UMN) and Korea (USDA). In the current reporting period, we did not conduct research on "exotic natural enemies as we do not have the quarantine facilities necessary for study. We remain keen to collaborate in the SBA classical biological control efforts and will continue collaborations with groups evaluating the potential of select natural enemies for release against the SBA in the near future.

Endemic natural enemies -- The impact and ecology of endemic natural enemies were intensively studied in a field in Tippecanoe County and extensively examined using data from the statewide sampling effort (above). As in past years, the predominate natural enemy was Orius insidiosus, although other predators, particularly Harmonia axyridis were abundant later in the season. There was little evidence of parasitism but fungal disease epidemics were relatively common. Orius insidiosus, was the most commonly observed predator in the field before aphid populations exploded. After high aphid levels were established ladybeetles, primarily H. axyridis, were the most frequently seen predator. Other abundant predators were flower flies, damselbugs and lacewing larvae. O. insidiosus levels were spatially and temporally correlated with thrips. The close association of O. insidiosus and thrips, along with the presence of O. insidiosus early in the field, leads us to believe that thrips may be sustaining O. insidiosus in the field, which in turn allows them to suppress aphid population growth and prevent outbreaks. Currently, we are hypothesizing that O. insidiosus are suppressing locally overwintering aphids, but were unable to contain the rapid growth of population levels resulting from the influx of northern-produced late aphids.
In other research we have done:
• Laboratory studies of predation by *O. insidiosus* showed that the predators could suppress populations of soybean aphid successfully over time and over a wide range of aphid numbers and density. We intend to examine the role of thrips in the ability of *O. insidiosus* to suppress aphid numbers over time.
• Field studies on the ability of *O. insidiosus* to suppress aphid populations were conducted in field cages. These experiments showed that *O. insidiosus* could at times suppress aphid populations but that in general the density of aphids was too low in the cages for the predators to impact the aphid population. We will continue these experiments next year with different densities of aphids.

**Activities planned for 2004:**
• Analyses of soybean yield-aphid dynamics as part of threshold studies.
• Analyses of aphid dynamics to aid in sampling efforts and modeling work.
• Continue research on *O. insidiosus* predation, concentrating on the role of alternative prey and the predator's life history characteristics.
• Publication of findings relating to predation, host plants and aphid dynamics.
• Conduct insecticide efficacy studies
2003 Kansas Annual Report

PROJECT: S1010, Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

COOPERATING AGENCIES AND PRINCIPAL LEADERS: University of Kansas

Progress Report: The major component of this project is the development of soybean resistance to the soybean aphid. We are in the process of developing a protocol for a visual screening technique in which feeding damage will be assessed. We are in the process of developing a 1-5 (1 least damage, 5 most severe damage) rating scale to assess visual damage to plants. Included will be a determination of how many aphids are required to elicit severe damage in a susceptible entry in a reasonable period of time. When tests are conducted with this technique, KS 4202 will be the "sentry" and an experiment will be terminated when KS 4202 has progressed to a rating of 5. Fifteen plants will be used for each entry, and the 10 healthiest plants will be infested.

For antibiosis measurements, 6 aphids are placed on each plant at the V1 stage. Twenty-two entries have been assessed. Three reduced reproduction significantly. One supported a significant increase in reproduction over the susceptible check currently being used, KS 4202.

Sympatric divergence is thought to be common in phytophagous insects that undergo host shifts. When a host shift occurs, the subpopulation is undergoing an adaptive peak shift in traversing from one fitness peak (the natal host) to a different fitness peak (the alternative host). Although many cases of sympatric divergence are known, few systems in early stages of a host shift have been studied; little information on the genetic changes that occur during early sympatric divergence and adaptive peak shift is therefore available. Theory predicts that subpopulations on the alternative host have a lower fitness relative to those on the natal host. In addition, specific criteria for assessing whether a host shift has led to host race formation have been described. Our objective is to study the consequences of a host shift by Dectes texanus (Coleoptera: Cerambycidae). It has been historically a pest of cultivated sunflowers; in the late 1960s, a host shift to soybeans has occurred, where it now causes significant damage. This host shift represents a major event because it involves plants of diverse families. Our specific aims are: estimate the host fidelity and oviposition preference of D. texanus from sunflowers and soybeans; measure the fitness of D. texanus on sunflowers and soybeans, and quantify the allele frequencies of subpopulations from soybeans and sunflowers. To date, we have undertaken preliminary studies on mating compatibility, DNA sequence analysis, fitness on soybeans and sunflowers, and allele frequencies using microsatellites. Our data indicated D. texanus on soybeans and sunflowers are conspecific based on mating studies and DNA sequence analysis; as predicted, D. texanus on soybeans have a lower fitness relative to those on sunflowers as measured by pupal weight, pupal emergence, and mating success; both subpopulations prefer to oviposit on sunflower as expected during early stages of host race formation; there are measurable allele frequency differences among contemporaneous subpopulations on sunflowers and soybeans suggesting sympatric divergence. When completed these studies will be of great interest to evolutionary biology because no systems in early stages of sympatric divergence and adaptive peak shift have been studied in detail. The results are also of significance to U.S. agriculture because depending on whether D. texanus on sunflowers and soybeans are isolated or semi-isolated subpopulations or a panmictic population, different approaches to management of this insect on the two crops are required.

Impact: Improving soybean aphid resistance will reduce pesticide costs and pesticide load in the environment, and improve yields where aphid pressure exists.

Publications: None so far.
Project: S-1010, Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

State: Kentucky

Progress of Work, Principle Accomplishments, and Usefulness of Findings:

Our work on this project during 2003 was limited to Sub-objective 3b.

In our earlier studies the predatory harvestman, *Phalangium opilio*, was the second or third most frequently observed predator of corn earworm eggs in Kentucky soybean fields (second to nabids and sometimes third to bigeyed bugs). This opilionid predator also was observed feeding on the soybean aphid, *Aphis glycines*. In all cases, feeding by this predator was observed only at night. In a laboratory study during 2003, we compared the reproductive performance of *P. opilio* on three diets: corn earworm eggs (monotypic diet), soybean aphids (monotypic diet), and a combination of those two prey (mixed diet). Predators were reared on a standard laboratory diet until the beginning of the penultimate nympha1 instar, at which time they were switched to one of the three treatment diets. They remained on the randomly assigned treatment diet until adult females died. A monotypic diet of soybean aphids yielded higher mortality during the final nympha1 instar, smaller adult body size, and lower fecundity compared to the other diets. A monotypic or mixed diet containing soybean aphids caused a longer pre-ovipositional period and smaller clutch sizes than a monotypic diet of corn earworm eggs. The soybean aphid adversely affects the reproductive biology of this predator. These findings contribute to our understanding of how natural enemies respond to the exotic pest species, *A. glycines*. 
S-1010 Progress Report for Louisiana

Matthew Baur and David Boethel, Department of Entomology, and Jim Board, Department of Agronomy

Objective 1. Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

We were unable to find soybean aphid in the state in 2003.

Objective 2. Define insect-vector ecology and virus-disease relationships and develop management strategies.

No work done.

3. Biological control of the soybean aphid in North America.

No work done.

4. Apply geospatial and precision technologies to advance pest management in soybeans.

Objective 4.1) Develop criteria for insecticide application based on remote sensing technology (digital aerial photography).

We compared methods of monitoring insect populations to determine when insecticides should be applied. The two methods that were compared were the drop cloth technique to determine population levels and the light interception technique using a light meter to determine defoliation. Both the light meter and the digital aerial photograph are used to determine percent light interception by soybean canopies. We compared the measures of light interception and vegetation index (determined from digital aerial photography) to measure how closely these two estimates of light interception were related.

The test site comprised 0.72 hectares of land on a Commerce silt loam soil (fine-silty, mixed nonacid, thermic Aeric Fluvaquent) with tile drainage and irrigation if needed. Seed were planted on 0.91m row spacing. Recommended cultural practices were followed to assure optimal canopy growth and yield. Fertilizer and lime were applied prior to planting according to soil test recommendations. Plants were irrigated whenever soil moisture content fell to 50% of field capacity. The study was planted on raised beds to reduce the threat of waterlogging. Weed, diseases, and unwanted insects were controlled by recommended application of pesticides.

Infestations of velvetbean caterpillar were assured by spraying permethrin in mid to late June when the plants were in the late vegetative stages (V10-V12) to eliminate predators. In July, August and September, plots were surrounded with phermone baits to attract adult males. Boarder rows were stocked with late instar caterpillars (about 5,000) during July.
We used the RCBD experimental design with six replications in a split plot arrangement. Experimental units consist of 24 contiguous rows giving a plot size of 21.8 X 6.1 m or 133 m$^2$. The main plot factors were the two soybean varieties H4998RR (Maturity Group IV) and A5902 (Maturity Group V). Selection was based on the different growth habits shown for the two varieties. H4998RR is an indeterminate variety meaning that main stem growth continues between first flowering and the start of seed filling, whereas A5902 is determinate that stops main stem growth shortly after first flowering. Both cultivars are Roundup Ready. The split plot factors were methods of determining when insecticides should be applied. Our treatments included: 1) no insect control, 2) control of velvetbean caterpillar when the population reached ET as determined by drop cloth sampling, and 3) control of velvetbean caterpillar when light interception fell to 95% during the early and mid seed filling (i.e., the initial 2/3 of the seed filling period).

Velvetbean caterpillar populations exceeded economic thresholds (8 worms of ½ inch or longer per row ft) in the last week of August and the first week of September, however those populations immigrated into the fields and substantial (1/3 to 1/2 ET) caterpillar populations were apparent by the end of July. Both the drop cloth method and the light meter method triggered insecticide applications within several days of one-another. Significant differences in defoliation were evident among plots and in the worst plots (the controls) defoliation exceeded 30%.

The strength (represented by R$^2$) of the relationship between light interception (determined by hand-held light meters) and the vegetation indices from aerial photography ranged from 0.3095 [between light interception (LI) and green normalized difference vegetation index (GNDVI)] to 0.4746 [between LI and simple ratio (SR)]. R$^2$ was 0.4627 between LI and NDVI (shown below).

These results confirm that light measurements using hand held light meters can accurately predict when insecticide application is warranted (as demonstrated by Board and Boethel 2001), but do little to support the contention that digital aerial photography can be used to measure light interception when defoliation is caused by insects.
Objective 4.2) Develop models based on ground based collections of reflectance spectra and canopy light attenuation curves from soybean fields using handheld radiometers and ceptometers. Models then will incorporate leaf angle distributions to arrive at estimates of leaf area based on the light penetration.

We have collected only limited reflectance spectra and light attenuation data for soybean fields and examples of this information are shown below.

We are currently working with the BOREAS TE-18 GeoSAIL Canopy Reflectance Model to examine the interaction between incident light and soybean leaf canopy and determine the effects of solar zenith angle, angle of view, object variables such as leaf angle.

Objective 4.3) Determine the relationship of remotely sensed vegetative indices, leaf area index, and soybean yield.
The test site and experimental design was identical to that described in 4.1. The split plot factors were again levels of defoliation, but in this experiment, leaf area and light interception differences were created within each variety by manual defoliation which maintained inter row gaps of 0” (control), 8”, 14”, and 22” throughout the growing season. Light interception and leaf area index were determined on all treatments near the temporal midpoint of the seed filling period (early September). Concomitantly, a digital aerial photograph of the field site was taken by Emerge Corporation on September 6, 2003.

Data in Table 1 show that SR, NDVI, and GNDVI closely tracked the gradient in leaf area index and light interception shown by the treatments. For example, light interception of H4998RR fell from the control level of 94% to 78% for the 8” gap, then to 74% for the 14” gap, and finally to 60% for the 22” gap. This light interception gradient resulted from a decline in leaf area index from the 4.34 control level to 3.83 at the 8” gap, 3.73 for the 14” gap, and then to 3.58 at the 22” gap. These decreases in light interception and leaf area index were closely reflected in declining levels of SR, NDVI, and GNDVI. All vegetation indices showed C.V.’s much smaller than for light interception and leaf area index, demonstrating that they would have greater stability and accuracy as criteria for insecticide application. Results for A5902 were similar to H4998RR except not as many statistically significant differences occurred. This probably was due to the more narrow range for light interception shown for A5902 vs. H4998RR.

The efficacy of using vegetation indices to track leaf area index and light interception is also shown by correlation analyses within each variety. For H4998RR, NDVI was strongly tied to light interception ($r^2 = 0.96$, $P<0.05$) (shown below) and leaf area index ($r^2 = 0.99$, $P<0.01$). Almost identical relationships were shown for GNDVI vs. leaf area index and light interception and for SR vs. leaf area index and light interception. For A5902, light interception was not
significantly correlated with any vegetation index; however, all vegetation indices showed almost perfect correlations with leaf area index.

Table 1. Relationship between on-site recordings of light interception (LI) and leaf area index (LAI) with vegetation indices (SR=simple ratio; NDVI=normalized difference vegetation index; GNDVI=green normalized difference vegetation index) determined by digital aerial photography.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Defoliation treatment</th>
<th>LI</th>
<th>LAI</th>
<th>SR</th>
<th>NDVI</th>
<th>GNDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H4998RR</td>
<td>Control</td>
<td>94</td>
<td>4.34</td>
<td>2.285</td>
<td>0.389</td>
<td>0.202</td>
</tr>
<tr>
<td></td>
<td>8” gap</td>
<td>78*</td>
<td>3.83</td>
<td>2.227*</td>
<td>0.377*</td>
<td>0.197*</td>
</tr>
<tr>
<td></td>
<td>14” gap</td>
<td>74*</td>
<td>3.73</td>
<td>2.218*</td>
<td>0.374*</td>
<td>0.196*</td>
</tr>
<tr>
<td></td>
<td>22” gap</td>
<td>60*</td>
<td>3.58</td>
<td>2.19*</td>
<td>0.369*</td>
<td>0.193*</td>
</tr>
<tr>
<td>AG5902</td>
<td>Control</td>
<td>89</td>
<td>5.15</td>
<td>2.412</td>
<td>0.412</td>
<td>0.216</td>
</tr>
<tr>
<td></td>
<td>8” gap</td>
<td>82</td>
<td>4.43</td>
<td>2.39</td>
<td>0.406</td>
<td>0.213</td>
</tr>
<tr>
<td></td>
<td>14” gap</td>
<td>72*</td>
<td>4.63</td>
<td>2.396</td>
<td>0.408</td>
<td>0.214</td>
</tr>
<tr>
<td></td>
<td>22” gap</td>
<td>66*</td>
<td>3.31*</td>
<td>2.332*</td>
<td>0.396*</td>
<td>0.206*</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td>8.0</td>
<td>0.79</td>
<td>0.053</td>
<td>0.0098</td>
<td>0.0045</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td></td>
<td>8.9</td>
<td>16.2</td>
<td>1.9</td>
<td>2.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

* Indicates treatment mean is significantly less than control at the 0.05 probability level according to LSD.

**Light Interection (LI) VS Normalized Difference Vegetation Index (NDVI) for H4998RR**

\[
y = 1612.5x - 531.8 \\
R^2 = 0.9601 \\
r = 0.979 \\
df = 2 \\
s = 0.05
\]
Progress of Work, Principle Accomplishments, and Usefulness of Findings:

Objective 3:

The USDA Plant Protection and Quarantine (PPQ), Invasive Pests Management Laboratory in Niles, Michigan (Niles Lab) worked cooperatively with regional partners for a second year to implement the initial stages of a biological control program to manage the soybean aphid (SBA). In 2003 we directed PPQ project funds ($150,000) to support cooperative agreements on critical topics, as follows:

1) Screening and Evaluating Exotic Natural Enemies of the Soybean Aphid by George Heimpel, David Ragsdale, Zhishan Wu (University of Minnesota), and David Voegtlin (University of Illinois)
2) Modeling Natural Enemy Impacts on Soybean Aphid by Robert O’Neil (Purdue University)
3) Foreign Exploration, Quarantine and Screening of Soybean Aphid Natural Enemies by Keith Hopper, Kathryn Musig, Jay Donahue, Michael McMahon, and Larry Ertle (USDA Agricultural Research Service, Newark, DE)
4) Interaction of Predators and Parasitoids in Soybean Aphid Biological Control by Doug Landis, Alejandro Costamagna, M. O’Neal, Mike Brewer, and Takuji Noma (Michigan State University)

In addition, the Niles Lab reared the Wyoming strain of an established aphid parasitoid (Aphelinus albipodus Hyatt & Fatima) for field evaluation by state cooperators, shipping 76,000 parasitoids to Minnesota and 447,000 to Wisconsin researchers. We also provided over 247,000 soybean aphids (Aphis glycines) to researchers in Indiana, Michigan, New Jersey, and Pennsylvania.

The Niles Lab is currently rearing a supplemental colony of Lysiphlebus testaceipes, a native aphid parasitoid collected from soybean fields in Michigan, for Michigan State University researchers. For example, Mike Brewer will be using the parasitoids for laboratory exposure tests to determine the relative host preference of these parasitoids between soybean aphid and other aphid species that are commonly present in Michigan.
S1010 Annual Summary of Activities during 2003 – Nebraska

T.E. Hunt & L.G. Higley

Objective 1a. Soybean Aphid Mgt.

In June, extremely low numbers of aphids were found in Nemaha, Cass, Saunders, Douglas, and Burt counties (a few aphids per field, one field out of approximately 10 with aphids). Aphids were found primarily in fields near wooded river bottoms along the eastern border of Nebraska. Buckthorn, an overwintering host of the aphid, was found in wooded river bottoms throughout the eastern half of Nebraska. Buckthorn surveys indicate the majority of buckthorn in Nebraska is along rivers such as the Elkhorn, Missouri, Blue and not minor streams. In mid-July, soybean aphid infestations began to be reported from northeast Nebraska. By late July soybean aphids could be found in all soybean production areas of Nebraska (eastern half of Nebraska), with almost all economically damaging populations being in the northeast portion of the state. Populations peaked in mid-August (see graph below). Peak populations in the northeast ranged from less than 100 aphids/plant to approximately 5000 aphids/plant (field averages). Most infested fields in the northeast had low to moderate populations.

The pattern of soybean aphid colonization in 2003 was similar to 2002. Very few aphids were found until mid-July, with more fields per county infested in the northeast corner of the state. Mid-July colonization coincided with summer storm patterns having high northeast winds. However, population levels were much higher in 2003. In 2002 there were only two reports of fields being treated for soybean aphid. In 2003 many fields were treated in northeast Nebraska, although it is likely that many did not require treatment or were treated after economic damage had been done. A possible explanation for higher numbers in 2003 may be that in 2003 temperatures in the second half of July through the first week of August were unseasonably mild (high 60s to low 80s), which favors soybean aphid reproduction. In 2002 temperatures were high during this period.
In general, if aphid populations reached thresholds in July or early August, it appears that farmers benefited from treatment. If treatment occurred in mid August, benefit was variable and depended on aphid population size, population dynamics, and predator levels (primarily lady beetles). Late August treatments likely resulted in no benefit, as aphid populations naturally declined.

**Summary of yield trials**

1) An efficacy trial in which populations were slow to develop. Populations peaked at about 150 to 250 aphids per plant in most plots in mid August. Treatments were applied when plants were at R3 on Aug 7. Populations were about 50 aphids per plant. No significant difference in yields.

2) A study where the field population averaged 1,215 aphids/plant on Aug 15 when aphids were treated with Warrior full rate (dryland beans). Field average (outside treated plots) went to an average of 2,483 aphids/plant on Aug 21, but rapidly declined after that – less that 100/plant on Aug 29. RESULTS: Untreated plot ave. 35 bu/ac. Treated plot ave. 35 bu/ac. No difference.

3) A study where the field population averaged 3,958 aphids/plant on Aug 15 when aphids were treated with Warrior full rate (dryland beans). Field average (outside treated plots) went to an average of 1,833 aphids/plant on Aug 21, then declined to 705/plant on Aug 29. RESULTS: Untreated plot ave. 26 bu/ac. Treated plot ave. 33 bu/ac. Seven bu difference.

4) A study in irrigated and non-irrigated beans (see graph above). Treatment was on Aug 17 (Warrior again) when irrigated average was about 950/plant and non-irrigated average was about 700 per plant. Plots peaked about Aug 20 at about 1064/plant (irrigated) and 962/plant (non-irrigated) RESULTS: Untreated irrigated ave. 35 bu/ac. Treated irrigated ave. 45.9 bu/ac. 10.9 bu difference in irrigated. Untreated non-irrigated ave. 32.6 bu/ac. Treated non-irrigated ave. 44.4 bu/ac. 11.8 bu/ac difference in non-irrigated.

**Objective 1b. Validate Bean Leaf Beetle Management Strategies**

Weekly sampling of bean leaf beetle populations in five northeast Nebraska soybean fields indicated that spring populations of bean leaf beetles (overwintered adults) were low, as were F1 populations. Sampled fields did not reach economic thresholds for spring or F1 beetles, nor were there validated reports of economic populations in other Nebraska soybean fields. F2 beetle population peaks were lower F1 beetle population peaks. F2 beetles began to emerge the first week of September when soybeans were at stage R6. They did not reach economic thresholds. Beetle numbers were relatively low across the state.

Spring 2003 samples of bean leaf beetle overwintering habitat were much lower than the spring of 2002, but similar in pattern. Few to no beetles were found in smooth brome grass field edges, and about equal numbers were found in wooded leaf litter and soybean stubble. Spring populations were generally low across the state. Low numbers of spring BLB was in large part because of low numbers of F2 beetles the previous fall.
2002 – Density of live BLB/1sq meter.

<table>
<thead>
<tr>
<th>Location</th>
<th>November</th>
<th>Late March/Early April</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean stubble</td>
<td>Wood lot leaf litter</td>
</tr>
<tr>
<td>Echtenkamp</td>
<td>13.2</td>
<td>12</td>
</tr>
<tr>
<td>Haskell</td>
<td>5.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Woodward</td>
<td>5.9</td>
<td>6.7</td>
</tr>
</tbody>
</table>

2003 – Density of live BLB/1sq meter.

<table>
<thead>
<tr>
<th>Location</th>
<th>November</th>
<th>Late March</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean stubble</td>
<td>Wood lot leaf litter</td>
</tr>
<tr>
<td>Echtenkamp</td>
<td>1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Haskell</td>
<td>0.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Woodward</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Objective 1c. Management Strategies Under Evolving Cropping Systems.

A study was initiated to: 1) determine the period during in which weeds must be controlled to prevent yield losses in narrow row soybeans (CPWC); 2) determine the effects of early season insect defoliation on the CPWC; 3) develop weed management recommendations that consider the CPWC and early season insect defoliation; and 4) integrate the results into soybean management tools that can be disseminated to farmers through traditional and Web-based technologies.

Preliminary results indicate that soybean defoliation reduces early-season crop tolerance to weeds. Soybean under defoliation stress is less tolerant to early-season weed presence requiring earlier weed management (up to 13 days) than in healthy soybean. These preliminary results indicate that insect defoliation should be considered when planning and conducting weed management in soybeans.
S-1010 Project Objectives:

Objective 1. **Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems**


**Buckthorn (Rhamnus spp.)**

In spring and fall of 2002 and 2003, buckthorn (*Rhamnus cathartica*) plants from 13 different locations in three eastern counties of North Dakota were scouted regularly for the presence of soybean aphid eggs, spring generations, and fall sexual forms. Soybean aphid were finally found on buckthorn in the fall of 2003 at a Moorhead, Minnesota site.

No soybean aphids or eggs were found on any of the buckthorn plants at any of the in the three counties in the fall of 2001 or 2002 in North Dakota. No aphids were found on buckthorn in the spring of 2002 or 2003. However, in the fall of 2003, soybean aphid were found on common buckthorn growing in Moorhead, Minnesota. A shelterbelt with numerous mature buckthorn was scouted for aphids. None of the large, mature buckthorn had aphids present on foliage. But, young saplings, 12" to 24" in height, were found with large populations of aphids. Plants had only 5 to 10 leaves, with each leaf infested with only few to several hundred aphids. When found, all colonies appeared to be nymphs. Unfortunately, upon returning the next week to document the progress of the population, very few aphids were found due to large numbers of multi-colored Asian lady beetles feeding on the aphids. One egg was found. Plants were marked with surveyor flags for future reference. A check of these plants the first week of January found that the saplings had been destroyed by rabbit and/or deer browsing the shelterbelt. Some of the infested plants were returned to the lab prior to the arrival of lady beetles. In the lab, males from a lab colony were provided to the female oviparae and eggs were laid on the young plants.

Berries were collected from five species of buckthorn, including *Rhamnus dauberica*, for use in a planned host and overwintering study for 2004-2005. Seeds are currently being cold treated. Germination will be attempted in about one month. Plants will be reared in the greenhouse for later use.

**Soybean (Glycine max)**

In both 2002 and 2003, two 80+ acre commercial soybean fields were surveyed weekly for soybean aphid. The fields were located in Casselton and Harwood, ND. The fields were geo-referenced with 92-96 samples sites mapped across the field (grid sampling layout). The geo-reference points were used weekly to record aphid populations observed on leaflets. Variables recorded included total aphids recorded by nymphs, wingless adults, and winged adults, key predators, presence of disease, and location of aphids on the plant. Surveys continued until plants began to defoliate at the end of August to the first two weeks of September.
Seasonal Variation of Population

Aphids were detected for the first time in early July at all locations on late vegetative stage soybeans. The first population peak was observed around July 22 at all locations, both years, on R2-R3 stage soybeans. After this very minor peak, populations per trifoliate decreased but started populations became more uniformly distributed in the field. The second, and greatest population peak was observed in late August to early September on late reproductive stage soybeans (R5-R7). Populations in 2002 did not reach the same levels as were observed in 2003. Field surveys the third week of August were prevented due to rainfall. Measurable rainfall in 2002 occurred on 12 days of August, with the greatest rain events being 0.2" on 8/01, 8/08, and 8/11; 0.4" on 8/16; and 0.3" on 8/31 for a total of 1.75". There were seven days of rain recorded in 2003, but all but one were less than 0.2"; 0.3" was received on 8/25. Total rainfall in August 2003 was 0.96".

Within-field distribution of soybean aphid

In 2002, aphids were detected for the first time in early July on late vegetative stage soybeans on the shelterbelt side of the field at both locations. After this, the aphid populations increased and spread in the field. The first soybean aphid population peak was observed in late July at R2-R3 stage soybean plants and within two weeks of this population peak, the aphids were almost uniformly distributed through the field, though at below threshold numbers. Aphid populations increased rapidly by late August to early September, at the R6-R8 stages, to give the highest population peak of the season. After this, aphid populations started decreasing rapidly due to winged aphid development and out migration from the fields. Aphid populations had declined to a level of insignificance by mid September.

A similar pattern was observed in 2003. First detections were near shelterbelts and field edges. Populations in August began increasing a little earlier and were peaking at R5. In one of the production fields, the population began to decline shortly thereafter. In the second, the populations remained high. In this field, the foliage was greener longer.

Some general observations that may be important for our region, with our large fields and open areas, include the likelihood that shelterbelts influenced site of initial colonization. It appeared that after 3 to 4 weeks of first aphid detection, aphids were observed throughout the field, though below currently recognized economically significant populations. The greatest numbers of aphids in the July peak were associated with the sites of first colonization. Recommendations for field surveys include the suggestion of scouting these border areas beginning in early July to detect the initial colonization of aphids.

Evaluate currently available soybean varieties from the northern production area for possible tolerance/resistance to the soybean aphid.

Greenhouse Study: A varietal screening program was set up to screen forty “00”, and forty “0” soybean varieties for identifying natural resistance and/or tolerance in the commonly grown Northern soybean varieties. The study was conducted under controlled conditions in a rearing room at 25°C with a photoperiod of 16:8 (L:D) using 10" x 20" x 3.25" 36-celled plastic flats(with cell size of 2.2" x 2" x 3.25") set up as a Randomized Complete Block with sampling. Four plants of eight test varieties and a susceptible check row were planted in each flat which was replicated three times. Five apterous adult aphids were introduced per plant at the VC stage. Aphid counts were taken on the plant stems, on the leaf-undersides and on the leaf tops after one and two weeks of aphid introduction. Plant damage was recorded after two weeks on a 1-4 scale. The aphid counts were also assigned a value on a 1-4 scale. An index was calculated by multiplying the two values together. The index value had a possible range of 1-16.

<table>
<thead>
<tr>
<th>Soybean Aphid Population Rating(SAPR)</th>
<th>Damage Rating (DR) on Soybean Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 aphids</td>
<td>Leaves look perfectly green and plant looks healthy</td>
</tr>
<tr>
<td>26-100 aphids</td>
<td>Some leaves show yellowing</td>
</tr>
<tr>
<td>101-200 aphids</td>
<td>Many leaves show yellowing, some show severe yellowing</td>
</tr>
<tr>
<td>More than 200 aphids</td>
<td>Almost all leaves show severe yellowing Or Cupping Or curling of leaves Or Unusually dwarf plants</td>
</tr>
</tbody>
</table>

Soybean Aphid Index = SAPR x DR
The mean Index Rating for the forty northern, “0” varieties, varied from 2.7 to 11.4. In the majority of the cases, large aphid populations caused significant damage. However, MN0302 and Dynagro 3072 had large aphid populations which did not result in significant damage. Five varieties with small aphid populations displayed significant levels of damage (TR-0808RR, Korada, Thunder 0598, PB-0601RR and Proseed 0069). Generally aphid populations increased rapidly after the first week of infestation. There were some varieties in which populations decreased considerably by the second week (DAC Vision, S00-N7, Proseed 0059, Proseed 0079RR, NT 0505RR, NS0134RR, Proseed 0069 and DSR 0301RR). Damage to these varieties was very significant, with damage ratings ranging from 3.4 to 4. However, the calculated Index was moderate due to low aphid numbers remaining on the plants at two weeks.

The mean Index Rating for the forty southern, “00” varieties, varied from 1.2 to 7.8. In most of the varieties, a high Index was representative of high damage caused by the soybean aphid. Similarly, a low Index represented low damage caused by the aphids.

Field Study: Selected varieties from the controlled screening study were tested in the field to validate the results observed under controlled conditions compared to field situations. The field protocol consisted of 12 selected varieties out of the total 80, representing two varieties each for high-middle-low index scores for both the maturity types. For each selected variety, two treatments were used. The first was an untreated treatment and aphid infestations were allowed to develop without interference. In the second treatment, thiamethoxam (CRUISER 5SC®) treated seed (@30 g a.i. per 100 kg seed) was used to prevent or delay aphid infestation during the season.

Plots were four rows wide and 20 feet long with a 30 inch row spacing. In the untreated plots, soybean aphids from a lab reared colony were seeded in the plots by putting 30 aphids on the underside of leaves of 30 plants in the middle 2 rows at the V1 growth stage. Aphids were sampled in plots weekly, using whole plant counts of 10 randomly selected plants per plot. After the populations increased considerably, only 5 plants were sampled for population counts to cut down on labor. The plots were trimmed to 14 feet before harvest.

Comparisons included yield and yield component analysis among the various treatments with the seed treatment representing the maximum yield potential. Yield component analysis was done measuring variables such as plant height, number of nodes, number of pods, yield and seed weight. Seed quality analysis was done measuring protein and oil percentages.

Results
Aphid populations failed to establish during early vegetative stages of soybeans and aphid introductions were unable to create conditions similar to the controlled study. Aphid populations increased during early reproductive stages with an average of 50 aphids per plant by R4 stage soybeans in untreated plots and by R5 stage soybeans in treated plots. Two varieties with high Aphid Index values (P90B72 and TF-6149RR) had high aphid numbers throughout the sampling period. But they performed differently with respect to seed yields. TF-6149RR performed very poorly but P90B72 unexpectedly yielded quite high.

There were no significant differences between yield, seed weight, number of nodes, pods and protein and oil percentages of treated and untreated treatments. The reason could be the late establishment of aphid populations in the plots after reproductive stages had been reached and yield parameters were determined.

Evaluate the efficacy of insecticides for their ability to effectively control soybean aphid.

No foliar applied efficacy plots were established in North Dakota during the 2003 production season.

The variety screening study did utilize thiamethoxam as a seed treatment to delay or prevent aphid establishment on plants. Aphid infestations, which increased in early August in all plots, became established on the seed treated fields during the first week of August, about three weeks after the untreated plots. For illustration, aphid populations from the variety plots at Prosper, ND are illustrated in figures 7.

Region wide soybean aphid yield-component study for determining an economic threshold.

North Dakota participated in the common experimental protocol for refining the soybean aphid economic threshold. Experimental design was a RCB, we will apply the following "treatments" to allow varying aphid populations to occur. Due to late development of aphid populations, treatments were applied to coincide with reproductive growth stages. Treatments began at R2 (two treatments to keep plots aphid free: 7-28-03 and 8-04-03), R3 (treatments timed with 7-14 days after aphid colonization: 8-04-03), R4 (treatments timed with 14-21 days after aphid colonization: 8-11-03), and R5 (treatments timed with 2-28 days after aphid colonization: 8-21-03). All insecticide treatments were made using lambda-cyhalothrin at 3.2 fl. oz. of product per acre.

Plots were planted on 5-24-03. The variety was Asgrow 0801 (Roundup Ready), the most commonly-grown soybean variety in southeastern North Dakota. Plot size was 4 rows (30” rows) by 60 ft in length. Therefore, plot dimensions were 10 x 60 feet. There was a 10 foot tilled border around each plot. The middle two rows were harvested using a small plot combine for a harvest area of 300
sq ft. Aphids were sampled weekly using whole plant counts of 5-10 randomly selected plants per plot. Yield component analysis measured the variables: plant height, number of nodes, pods per node, seed weight, protein content and oil content. Aphids from a lab reared colony were placed in plots the last week of June, however, no significant establishment was observed.

There were no significant differences in yield, plant height, pods per plant, hundred seed weight, or percent oil. Percent protein was significantly greater for one untreated check compared to the R5 treatment. The general conclusion is that the aphid infestation level was not great enough, nor did they establish early enough to cause significant impact on the variables evaluated.

**Objective 2. Define insect-vector ecology and virus-disease relationships and develop management strategies**

Earlier surveys coordinated by Dr. Berlin Nelson, NDSU soybean plant pathologist, have not detected the presence of the aphid-transmitted viruses. The bean leaf beetle is not common in North Dakota and bean pod mottle virus has not been detected. Bean leaf beetles were detected in fields in September 2003, but at very low incidence.

**Objective 3. Biological control of the soybean aphid in North America.**

No specific activities to report.

**Objective 4. Apply geospatial and precision technologies to advance pest management in soybeans.**

No specific activities to report.
**Project:** Dynamic soybean insect management for emerging agricultural technologies and variable environments

**Principal Leader and Cooperating Agency:**
Ronald B. Hammond, Professor
Department of Entomology
Ohio Agricultural Research & Development Center
The Ohio State University

**PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS**

**Objective 1.** Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

**Sub-objective 1a.** Develop management strategies for the soybean aphid.

*Validation of Current Action Thresholds*
Initially, two locations were planted for this study. One location was at the OARDC near Wooster, OH, in Wayne County, while the second was at the Northwestern Branch of the OARDC near Hoytville, OH, in Wood County. Plots were planted with and without various seed treatments of Cruiser, Poncho, and Gaucho. Our intent was to use the non-seed treatment plots and areas for foliar spray treatments. The soybean variety at both locations was Pioneer 93B67. Planting dates were 28 May and 23 May, respectively. Plot size were 8 rows by 100-150 ft, replicated 4 times, in 30-inch rows. However, weekly sampling indicated few aphids the entire summer. Counts usually were no higher than 5-10 aphids per plant, with less than 10% of the plants infested. Thus, no further efforts were done at these locations. No yields were taken.

A field at the OARDC near Wooster, OH, that was being grown for seed purposes was located and became available for studies. The field was planted on 24 June (note: this is a very late planting) in 15-inch rows. The field was observed to have a large population of soybean aphids in early August. To obtain information to help validate current action thresholds, we decided to use part of this field for this study, albeit no seed treatment plots were available.

We established plots within this field with the intent to spray an insecticide weekly for 3 weeks to establish varying aphid populations. The initial spray was applied on 7 August at the late R2 growth stage. Plots had been established measuring 10 by 50 ft. We used Lorsban as our insecticide of choice at 2 pt/acre. On examining all the plots the following day, it became apparent how well Lorsban worked at causing aphid mortality. Not only were the aphids in the sprayed plots controlled, but also aphids in the surrounding plots were extremely low. The Lorsban spray appeared to have drifted into the surrounding plots. On examining a brochure for Lorsban for control of the soybean aphids, we read, “The fuming action of Lorsban-4E is particularly effective for control of aphids found on the underside of leaves”. Although wind conditions at the time of spraying was extremely low, we believe that environmental conditions at the time of application (very humid) allowed for good “fuming” conditions and allowed the spray or mist to spread into adjacent plots. Aphids in all the plots were basically...
controlled, and no plot ever had aphid populations greater than 100-200 per plant. Nevertheless, we also sprayed another set of plots a second time on 18 August, as well as making an initial spray to another set of plots on that date. Thus, we had 4 treatments: plots sprayed once on 7 Aug, once on 18 Aug, twice on 7 and 18 Aug, and a check. Sampling done after each sprayed indicated almost complete control in the treated plots, with aphid numbers always less than 25 per plant. The non-sprayed areas (keeping in mind the problem with the use of Lorsban), maintained an aphid density between 100-200 per plant; the population never did increase into the 1000s per plant as expected.

Harvest data were taken from these 4 treatments, with the yields ranging from 30.6 to 33.3 bu/acre (Table 1), with the “check” being 32.9. A significant difference was not obtained. (Note: this lack of a yield loss was with aphids between 100-200 per plant). Examining individual plant growth characteristics also showed a lack of significant differences, although numerically the check plots were the shortest with the fewest nodes per plant. However, the number of pods per plant did not follow this same trend. Of interest, an insecticide trial was conducted at the other end of the field (see section below), and the problem with drifting sprays did not occur. In those trials, spraying was also done at our action threshold of 250-300 per plant. While treated plots yield 32.8 to 36.0 bushels per acre, the control averaged 29.0 bu per acre (with aphid densities greater than 1000 per plant). Nodes per plant were similar with the treated plots, while both the nodes and pods per plant in the check from the insecticide treatment trial was 9.9 and 25.2, respectively. Thus, we believe that the Lorsban was effective at preventing a yield loss; however, we cannot directly compare these yields with an un-sprayed treatment were aphid numbers were high from another trial, albeit from the same field.

Table 1. Yield and growth parameters from the study

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield gm/plot</th>
<th>Yield bu/acre</th>
<th>Height (cm)</th>
<th>Nodes/plant</th>
<th>Pods/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed Once on 7 Aug</td>
<td>4823.6</td>
<td>30.6</td>
<td>63.3</td>
<td>11.1</td>
<td>30.7</td>
</tr>
<tr>
<td>Sprayed once on 18 Aug</td>
<td>5042.3</td>
<td>32.0</td>
<td>62.2</td>
<td>11.1</td>
<td>32.8</td>
</tr>
<tr>
<td>Sprayed on 7 and 18 Aug</td>
<td>5245.0</td>
<td>33.3</td>
<td>63.4</td>
<td>11.2</td>
<td>28.4</td>
</tr>
<tr>
<td>Check</td>
<td>5188.3</td>
<td>32.9</td>
<td>60.6</td>
<td>10.9</td>
<td>31.0</td>
</tr>
</tbody>
</table>

Modification of Existing Action Threshold Using Strip Trials

Numerous contacts were made with extension agents and consultants in early summer regarding the establishment of strip trials to determine the impact of the soybean aphid on yield. However, none of the people contacted had success in establishing aphid studies. However, we obtained many reports of either strip trials or treated vs. non-treated areas from across the state from numerous sources. In all cases reported, yield losses occurred in all situations, ranging from 5-15 bu per acre. However, none of the reports are included any levels of aphid infestation prior to, or following treatment. At best, they reported that the insecticide applications were working. Thus, it is impossible to make any recommendations as to possible modifications of the existing action thresholds based on information coming into us from strip trials.

Summary of Action Threshold Validations/Modifications

In Ohio, we recommended weekly sampling beginning at R2 by counting aphids on the plants. Our threshold for taking action was 250-300 aphids per plant and an increasing population. Based on our own observations on from the field, we believe that this action threshold is valid and should remain as such. In the first study, populations that remained between 100-200 did not cause yield losses, nor did we see yield losses in our insecticide trial where the pyrethroids allowed an aphid density to remain between 250-300. In most field situations we observed, we saw the aphid population in non-sprayed area to continue to increase to levels well over 1000 aphids per plant resulting
in yield reductions. In all cases where weekly sampling occurred and spraying was done at the 250-300 level and subsequent populations densities reached the 1000-2000 levels, we observed yield losses.

Thus, we believe the proper management practices should continue to be begin weekly sampling at R2, and as the population density increases to 250-300 per plant, consider treatment. Whether this occurs during the R2-R3 stage or the R4 or early R5 stage might be immaterial.

**Screen cultivars and parental lines for resistance to soybean aphid**

No plot work per se, was done in Ohio towards this objective. However, contact was made with soybean breeders from Ohio State and from Pioneer Hi-Bred, and with the directors of OSIA (Ohio Seed Improvement Association) and OSF (Ohio Seed Foundation) in early summer. The soybean aphid situation was explained to them and the need to observe possible differences among soybean varieties, both within their own plot and field work, and also from their interactions among growers. We had continuous contact with them throughout the summer and then in the fall to see if any observations of any differences among varieties were seen.

Everyone contacted stated that they kept aware of possible differences during the summer, sharing the concern with their workers. However, none of the people saw any differences, all commenting how the soybean aphid populations were basically equal within their fields. In those situations were a field was sprayed, comments were all varieties and/or lines seemed to have equal aphid populations. Unlike with other insect problems on soybeans, we did not hear of varieties appearing to have any impact from growers. In those areas with high populations of aphids, it appeared that all soybean varieties had aphid populations.

**Additional Insecticide Studies**

An insecticide trial was conducted with various insecticides. Six foliage insecticides were tested. Soybeans were planted on 24 Jun. Tests were designed as a RCB with 7 treatments and 4 replications. Plot size was 10 ft (8 rows on 15 in centers) by 50 ft. Insecticides were applied using a bicycle sprayer with a 10 ft boom with 6 spray nozzles on 7 Aug. Spray nozzles were TeeJet 80015 spaced at 20 in, spray pressure at 40 psi, and spray output at 31.1 gpa. Soybeans were in growth stage late R2 (flowering). Pre-treatment sampling indicated approximately 250-300 SA per plant across the plots, which is considered our current action threshold. Post-treatment samples were taken a 4, 11, and 18 DAT by estimating the number of aphids on 3 plants per plot. Observations were also taken on the level of honeydew and sooty mold, two symptoms of the presence of soybean aphid. Aphid data were transformed prior to analyses by square root of \(x + 0.5\). All data were analyzed with ANOVA and means separated using LSD. Yield data were taken by harvesting a section 5 ft by 50 ft from the middle of each plot.

All insecticides reduced the numbers of soybean aphids per plant. Furadan and Lorsban provided the best control throughout the sampling period. The pyrethroids, while providing control, did not achieve the level of aphid reduction provided by the other materials. These populations remained between the 250-300 aphids per plant level. Of the pyrethroids, Warrior generally had the lowest populations. The only plots relatively clean of honeydew and sooty mold were the Furadan and Lorsban treatments. All the pyrethroid-treated plots had some sooty mold and honeydew present, albeit much less than the check plots. However, all treatments prevented a yield loss, including the aforementioned pyrethroid treatments. (Note: the lack of yield for the pyrethroids was when the population remained at the action threshold and did not continue to increase). Observations indicated that there were no apparent differences between the treatments with the date of harvest maturity. At harvest, there were no differences in plant height, although numerically, the check plants were smaller. There were lesser nodes per plant and pods per plant in the check compared to the treated plots.
### Soybean aphid per plant

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate oz/acre</th>
<th>4 DAT</th>
<th>11 DAT</th>
<th>18 DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asana</td>
<td>7.7</td>
<td>333.0 b</td>
<td>225.0 b</td>
<td>216.0 bc</td>
</tr>
<tr>
<td>Mustang Max</td>
<td>3.5</td>
<td>267.0 bc</td>
<td>141.0 c</td>
<td>287.0 b</td>
</tr>
<tr>
<td>Baythroid</td>
<td>2.4</td>
<td>178.0 cd</td>
<td>115.0 c</td>
<td>227.0 bc</td>
</tr>
<tr>
<td>Warrior</td>
<td>2.56</td>
<td>125.0 d</td>
<td>140.0 c</td>
<td>156.0 c</td>
</tr>
<tr>
<td>Furadan</td>
<td>8.0</td>
<td>10.0 e</td>
<td>35.0 d</td>
<td>58.0 d</td>
</tr>
<tr>
<td>Lorsban</td>
<td>24.0</td>
<td>10.0 e</td>
<td>34.0 d</td>
<td>58.0 d</td>
</tr>
<tr>
<td>Check</td>
<td>--</td>
<td>870.0 a</td>
<td>1208.0 a</td>
<td>1050.0 a</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different (LSD, P = 0.05).

### Yield, Height, Nodes/Plant, Pods/Plant

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate oz/acre</th>
<th>Yield gm/plot</th>
<th>Yield bu/acre</th>
<th>Height (cm)</th>
<th>Nodes/Plant</th>
<th>Pods/Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asana</td>
<td>7.7</td>
<td>5518.6 ab</td>
<td>35.1</td>
<td>64.7</td>
<td>11.2 a</td>
<td>30.9 a</td>
</tr>
<tr>
<td>Mustang Max</td>
<td>3.5</td>
<td>5372.8 ab</td>
<td>34.1</td>
<td>62.8</td>
<td>11.3 a</td>
<td>32.1 a</td>
</tr>
<tr>
<td>Baythroid</td>
<td>2.4</td>
<td>5154.8 b</td>
<td>32.8</td>
<td>64.5</td>
<td>11.1 a</td>
<td>30.4 a</td>
</tr>
<tr>
<td>Warrior</td>
<td>2.56</td>
<td>5661.1 a</td>
<td>36.0</td>
<td>62.9</td>
<td>10.6 ab</td>
<td>29.1 a</td>
</tr>
<tr>
<td>Furadan</td>
<td>8.0</td>
<td>5404.8 ab</td>
<td>34.3</td>
<td>64.6</td>
<td>10.5 ab</td>
<td>29.0 a</td>
</tr>
<tr>
<td>Lorsban</td>
<td>24.0</td>
<td>5269.7 ab</td>
<td>33.4</td>
<td>62.9</td>
<td>10.7 ab</td>
<td>29.0 a</td>
</tr>
<tr>
<td>Check</td>
<td>--</td>
<td>4579.2 c</td>
<td>29.0</td>
<td>61.6</td>
<td>9.9 b</td>
<td>25.2 b</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different (LSD, P = 0.05).

### Other Pertinent Observations

We became aware of growers concerned with using ground application in mid to late summer in narrow-row soybeans because of having to drive over soybeans. This led many to use only aerial application which proved effective. This winter, we are recommending to growers to consider the use of skip-row soybean systems as a way to use ground application in narrow-row soybeans without the necessity of driving down rows. Dr. Jim Beuerlein has written an article on this available at [http://ohioline.osu.edu/agf-fact/0131.html](http://ohioline.osu.edu/agf-fact/0131.html).

### Sub-objective 1b. Validate emerging management strategies for the bean leaf beetle.

Although early season bean leaf beetle populations were high in certain areas of the state, second generation beetles failed to develop. Pod feeding did not occur where expected. Thus, planned experiments were not completed.

### Sub-objective 1c. Develop management strategies for insect pests of soybean under evolving cropping systems.

No work done under this objective.

### Objective 2. Define insect-vector ecology and virus-disease relationships and develop management strategies.

### Sub-objective 2a. Examine relationships between bean pod mottle virus and its primary vector, the bean leaf beetle.
In cooperation with colleagues from Plant Pathology, we initiated studies with soybeans resistant to bean leaf beetle feeding to determine if insect resistant soybeans, HC95-15MB and HC95-24MB, could prevent the spread of bean pod mottle virus in the field. Earlier studies suggested a decrease in virus spread in these resistant lines. Field plots were located in two locations in Ohio. Plants in the middle of the plots were inoculated with virus in early summer and the spread of virus was monitored throughout. Insect feeding was rated in the plots during the same time periods. However, both locations had relative low populations of bean leaf beetles. Data are currently being analyzed. The study will be repeated in 2004.

Sub-objective 2b. Examine the potential for soybean aphid to be an effective vector of soybean mosaic virus, and whether the virus is increasing in incidence in the major soybean growing areas of the U.S.

Observations were taken during the summer on the occurrence of virus symptoms in plots and fields with aphid populations. These observations included keeping a watch on the development of green stem syndrome. No symptoms were ever observed in these plants. The only field with significant green stem syndrome was a field with an early heavy density of bean leaf beetles.

Objective 3. Biological control of the soybean aphid in North America.

No specific work done by Ohio. However, early summer sampling indicated numerous lady beetle larvae in the fields. Larvae, brought back to the laboratory to be identified, were mostly 7-spotted lady beetles. During the early to mid summer time period, few if any multicolored Asian lady beetles were found. However, the multicolored Asian lady beetles began showing up in heavy numbers in all soybean fields by mid-August. At first, larvae were mostly present; thereafter, adult multicolored Asian lady beetles began appearing. The large numbers of these beetles resulted in great concern in grape fields following soybean maturity, and then to homeowners in October. However, during the summer months, the appearance of these large numbers of lady beetles did not appear to have a large impact on the aphid population at that time. In none of the fields being sample did aphid density dramatically decrease until either we saw an emigration of winged aphids or plant maturity.

Objective 4. Apply geospatial and precision technologies to advance pest management in soybeans.

No work done under this objective.

Additional studies related to S-281

We continued to monitor slug populations in soybeans. Following a very good early-spring planting season and having most fields planted by the first week in May, slug eggs hatched at the normal time in early to mid May. However, the weather turned cool and wet, and crop growth became essentially non-exisistant. Numerous corn and soybean fields, while emerging quite well, experienced heavy slug defoliation throughout May and June. Numerous fields were treated with molluscicide bait. A large group of researchers, extension, growers, and government workers continue to meet to discuss the growing problem. A USDA-NCRS EQIP (Environmental Quality Incentives Program) has been established in six Ohio counties for slug management. This $500,000 program will make monies available to growers over a three year period to sampling and treat for slugs. I am the resource person for this program.
EVALUATION OF SOYBEAN CULTIVARS FOR RESISTANCE TO DECTES STEM BORER

Soybean cultivars in Maturity Groups III, IV and V with herbicide tolerance (Roundup Ready) were planted at the West Tennessee Experiment Station on June 5, 2003. Plots were single rows replicated three times in a randomized complete block design. Plots were planted no-till and managed as a commercial planting. Dectes damage ratings were made beginning Sept 25 in the MG III and IV lines and concluded in the MG V lines on Dec 2.

In the MG III and MG IV early varieties, no Dectes-damaged plants were found. It is possible that when the beetles emerge in late June and July that they are able to determine that the plants would be unsuitable as a host and avoid them. Further studies on maturity groups would be necessary to document oviposition preferences of the beetles.

In the MG IV late varieties, Dectes damage ranged from 0.3 to 6.3 damaged plants per plot (Table 1). However, there were no statistically significant differences among varieties.

Twenty-two MG V Early RR soybean varieties averaged 0.7 to 15.3 damaged plants per plot (Table 2). Delta King was most damaged, but was not significantly different from Asgrow, Steyer and USG. Least damaged in the group was FFR which did not differ significantly from 15 other varieties in the MG V Early group.

Eighteen MG V Late RR soybean varieties had less damage than most of the MG V Early varieties with the number of damaged plants ranging from 0.3 to 3.7 (Table 3). The damage differences among these varieties were not significant.

At the Milan Experiment Station, the same varieties were planted, but no Dectes damage was observed at that location.
Table 1. Dectes damaged plants in MG IV Late soybean varieties at Jackson, TN. 2003.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Description</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>Armor</td>
<td>47-G7 (RR)</td>
<td>1.0 a</td>
</tr>
<tr>
<td>29</td>
<td>Asgrow</td>
<td>AG 4603 (RR)</td>
<td>0.7 a</td>
</tr>
<tr>
<td>30</td>
<td>D &amp; PL</td>
<td>DP 4724 RR</td>
<td>0.7 a</td>
</tr>
<tr>
<td>31</td>
<td>Delta King</td>
<td>DK 4763 RR</td>
<td>3.7 a</td>
</tr>
<tr>
<td>32</td>
<td>Delta King</td>
<td>DK 4967 RR</td>
<td>0.7 a</td>
</tr>
<tr>
<td>33</td>
<td>FFR</td>
<td>4891 RR</td>
<td>0.3 a</td>
</tr>
<tr>
<td>34</td>
<td>FFR</td>
<td>4922 RR</td>
<td>0.7 a</td>
</tr>
<tr>
<td>35</td>
<td>Hornbeck</td>
<td>HBK R 4920 (RR)</td>
<td>1.3 a</td>
</tr>
<tr>
<td>36</td>
<td>Hornbeck</td>
<td>HBK R 4922 (RR)</td>
<td>1.3 a</td>
</tr>
<tr>
<td>37</td>
<td>Merschman</td>
<td>Dallas</td>
<td>1.7 a</td>
</tr>
<tr>
<td>38</td>
<td>Morsoy</td>
<td>RT 4809 (RR)</td>
<td>4.3 a</td>
</tr>
<tr>
<td>39</td>
<td>Pioneer</td>
<td>94 B 73 (RR)</td>
<td>5.7 a</td>
</tr>
<tr>
<td>40</td>
<td>Pioneer</td>
<td>94 B 74 (RR)</td>
<td>6.3 a</td>
</tr>
<tr>
<td>41</td>
<td>USG</td>
<td>7499n RR</td>
<td>3.0 a</td>
</tr>
</tbody>
</table>
Table 2. Dectes damaged plants in MG V Early soybean varieties. Jackson, TN. 2003.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>Asgrow AG 5301 (RR)</td>
<td>a-d</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Asgrow AG 5501 (RR)</td>
<td>3 ef</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Croplan RC 5252</td>
<td>5.7 def</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>D &amp; PL DP 5414 RR</td>
<td>3 ef</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Dekalb DKB 53-51 (RR)</td>
<td>4.3 ef</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Delta King DK 5366 RR</td>
<td>2 ef</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Delta King DK 5465 RR</td>
<td>4.3 ef</td>
<td></td>
</tr>
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<td>49</td>
<td>Delta King DK 5561 RR</td>
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<td>50</td>
<td>DynaGro DG 3535</td>
<td>2 ef</td>
<td></td>
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<td>51</td>
<td>FFR 5225 RR</td>
<td>4.7 ef</td>
<td></td>
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<td>52</td>
<td>FFR 5485 (RR)</td>
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<td></td>
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<tr>
<td>53</td>
<td>Golden Harvest H 5183 RR</td>
<td>2 ef</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>N. K. S 52-U3</td>
<td>1.3 f</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>N. K. S 50-N3</td>
<td>7.7 b-e</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Pioneer 95 B 42 (RR)</td>
<td>5 ef</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Pioneer 95 B 32 (RR)</td>
<td>6.3 c-f</td>
<td></td>
</tr>
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<td>60</td>
<td>Progeny 5250 RR</td>
<td>7.7 b-e</td>
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<tr>
<td>61</td>
<td>Steyer 5300</td>
<td>12.7 ab</td>
<td></td>
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<td>62</td>
<td>Terral TV 54 R 11 (RR)</td>
<td>1.7 ef</td>
<td></td>
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<tr>
<td>63</td>
<td>USG 510n RR</td>
<td>4.3 ef</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>USG 7522n RR</td>
<td>12 abc</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Vigoro V 52 N3 RR</td>
<td>3.3 ef</td>
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</table>

LSD (P=.05) 5.2
Standard Deviation 3.15
CV 57.66
Bartlett's X2 23.884
P(Bartlett's X2) 0.299

Replicate F 5.143
Replicate Prob(F) 0.01
Treatment F 5.011
Treatment Prob(F) 0.0001
Table 3. Dectes damaged plants in MG V Late soybean varieties. Jackson, TN. 2003.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td>Armor</td>
<td>56-J6 (RR)</td>
<td>1 ab</td>
</tr>
<tr>
<td>67</td>
<td>Asgrow</td>
<td>AG 5605 (RR)</td>
<td>1.7 ab</td>
</tr>
<tr>
<td>68</td>
<td>Asgrow</td>
<td>AG 5701 (RR)</td>
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<tr>
<td>69</td>
<td>Asgrow</td>
<td>AG 5903 (RR)</td>
<td>1 ab</td>
</tr>
<tr>
<td>70</td>
<td>D &amp; PL</td>
<td>DP 5634 RR</td>
<td>0.7 b</td>
</tr>
<tr>
<td>71</td>
<td>D &amp; PL</td>
<td>DP 5915 RR</td>
<td>0.7 b</td>
</tr>
<tr>
<td>72</td>
<td>Dekalb</td>
<td>DKB 57-51 (RR)</td>
<td>3 ab</td>
</tr>
<tr>
<td>73</td>
<td>Delta King</td>
<td>DK 5661 RR</td>
<td>0.3 b</td>
</tr>
<tr>
<td>74</td>
<td>Delta King</td>
<td>DK 5668 RR</td>
<td>0.7 b</td>
</tr>
<tr>
<td>75</td>
<td>Delta King</td>
<td>DK 5767 RR</td>
<td>1.3 ab</td>
</tr>
<tr>
<td>76</td>
<td>Dyna-Gro</td>
<td>3562 (RR)</td>
<td>1 ab</td>
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<td>77</td>
<td>Hornbeck</td>
<td>HBK R 5620 (RR)</td>
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<tr>
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<td>N. K.</td>
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<td>79</td>
<td>Progeny</td>
<td>5660 RR</td>
<td>1.7 ab</td>
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<tr>
<td>80</td>
<td>Terral</td>
<td>TVX 56 R1 B2 (R)</td>
<td>2 ab</td>
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<tr>
<td>81</td>
<td>Terral</td>
<td>TVX 58 R1 V2 (R)</td>
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<td>82</td>
<td>USG</td>
<td>570</td>
<td>0.3 b</td>
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<tr>
<td>83</td>
<td>Vigoro</td>
<td>V 562 N RR</td>
<td>2.7 ab</td>
</tr>
</tbody>
</table>

LSD (P=.05) 2.39
Standard Deviation 1.44
CV 109.19
Bartlett's X2 25.125
P(Bartlett's X2) 0.092
Replicate F 13.082
Replicate Prob(F) 0.0001
Treatment F 1.36
Treatment Prob(F) 0.217
Seven insecticide treatments were evaluated for control of stink bugs in soybean at the West Tennessee Experiment Station. Treatments were applied August 20 at the rate of 8.23 gallons per acre to soybeans in the pod fill stage with a 12.7 ft spray boom suspended from an IH 660 highboy. Treatments were replicated three times in a randomized complete block design. Plots were 12.7 ft by 50 ft long. Three drop-cloth samples 3 ft in length were taken in each plot on August 25. A 25 sweep sample was also taken in each plot on August 25.

The stink bug population was primarily green stink bug. Green stink bug numbers in sweep samples (Table 4) were significantly reduced by the pyrethroid treatments compared to the untreated, but the number in Lorsban- and Sevin-treated plots did not differ from the untreated. Green stink bug nymphal numbers were reduced in all treated plots except the Sevin plot compared to the untreated. Brown stink bug adult and nymphal numbers did not differ among treatments or the untreated control. The drop cloth samples did not separate treatment effects as well as sweep samples (Table 5). Green stink bug adult numbers differed significantly among treatments and Lorsban was the least effective treatment, but none of the treatments except Lorsban differed significantly from the untreated control. Green stink bug nymphal numbers differed among treatments and were significantly lower in all except Baythroid 0.03 lb ai/a-, Lorsban-, and Sevin-treated plots compared to the untreated.

Table 4. Efficacy of insecticides against stink bugs collected by sweep net 5 days DAT. Jackson, TN. 2003.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (lb ai/A)</th>
<th>Stink bugs per 25 sweeps</th>
<th>Green stink bugs</th>
<th>Brown stink bugs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adult</td>
<td>Nymph</td>
</tr>
<tr>
<td>Asana XL</td>
<td>0.66 EC</td>
<td>0.0 c 3.3 b 0.3 a 1.7 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baythroid</td>
<td>2 EC</td>
<td>0.7 c 1.7 b 0.0 a 0.0 a</td>
<td></td>
<td></td>
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<tr>
<td>Baythroid</td>
<td>2 EC 0.044</td>
<td>0.0 c 1.0 b 0.3 a 0.3 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fury</td>
<td>1.5 EC 0.05</td>
<td>0.3 c 1.0 b 0.3 a 0.0 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karate Z</td>
<td>2.08 EC 0.03</td>
<td>0.3 c 2.3 b 1.0 a 0.3 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lorsban XLR</td>
<td>4 EC 1</td>
<td>4.7 a 5.3 b 2.3 a 0.7 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sevin XLR</td>
<td>4 EC 1</td>
<td>2.0 bc 13.0 a 1.7 a 0.3 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td></td>
<td>3.3 ab 19.3 a 2.0 a 0.0 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (P=.05)</td>
<td></td>
<td>2.38 2.12 7.51 1.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td></td>
<td>95.73 121.25 72.94 205.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment Prob(F)</td>
<td></td>
<td>0.0051 0.0008 0.2095 0.3328</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Six insecticide treatments were evaluated for control of the Dectes stem borer on soybean at the West Tennessee Experiment Station. Treatments were replicated three times in a randomized complete block design. Treatments were applied with a two-row backpack sprayer in 16.7 gallons of spray per acre on July 18. Two sleeve cages were placed over plants in each plot and pulled down so that the upper portion of the plants (to be enclosed within the sleeve cage) would be sprayed. To determine the initial efficacy, three field-collected beetles were placed in each cage following the application of insecticides to the plants. The number of live and dead beetles was counted 3 and 7 days after treatment (DAT) on July 21 and 25. To determine the residual efficacy of the treatments, the cages were again infested 7 DAT (July 25) and counts made of live and dead beetles 3 days later (July 28).

Percent mortality data are reported in Table 6. Due to the variability of the data, there were no significant differences among treatments and none was different from the untreated control at any of the three evaluations. In the first evaluation (3 DAT), all the pyrethroid treatments except Asana had mortalities above 80% while the untreated had <20% mortality. The mortality in the Sevin-treated plot was 42%. At 7 DAT, 100% mortality was observed in three of the treatments (Baythroid at two rates and Karate). Mortality in the untreated had risen to 78%, indicating that the beetles do not survive extended periods when caged on the soybean plants. Although beetles caged for three days one week after treatment on untreated plants died at the rate of 53%, highest mortality was observed in Karate-treated plots and lowest mortality was observed in the Asana-treated plots which was similar to that observed at the 7 DAT reading. From these data, it appears that initial mortality may be higher from pyrethroid insecticides compared to the carbamate insecticide, Sevin. The data do not indicate that we might expect good residual mortality from the pyrethroid applications. In addition to expanding these studies, large plots need to be sprayed when beetles first appear in the field to determine the value of the treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate Lb ai/a</th>
<th>% Mortality 3 DAT</th>
<th>% Mortality 7 DAT</th>
<th>% Mortality 10 DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asana XL 0.66EC</td>
<td>0.05</td>
<td>66.6a</td>
<td>74.8a</td>
<td>27.8b</td>
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<tr>
<td>Baythroid 2EC</td>
<td>0.03</td>
<td>91.8a</td>
<td>100.0a</td>
<td>41.5b</td>
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<tr>
<td>Baythroid 2EC</td>
<td>0.044</td>
<td>80.6a</td>
<td>100.0a</td>
<td>58.3ab</td>
</tr>
<tr>
<td>Fury 1.5 EC</td>
<td>0.05</td>
<td>84.8a</td>
<td>66.7a</td>
<td>72.2ab</td>
</tr>
<tr>
<td>Karate Z 2.08EC</td>
<td>0.03</td>
<td>83.3a</td>
<td>100.0a</td>
<td>89.0a</td>
</tr>
<tr>
<td>Sevin XLR</td>
<td>1.0</td>
<td>41.7a</td>
<td>58.3a</td>
<td>50.2ab</td>
</tr>
<tr>
<td>Untreated</td>
<td></td>
<td>19.5a</td>
<td>77.7a</td>
<td>52.8ab</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not differ significantly (P=.05, Duncan’s New MRT)

EARLY SOYBEAN PRODUCTION SYSTEMS

Early soybean production systems were evaluated at the Milan Experiment Station in 2003. Group III (DK 3964 RR) and IV (A4403) soybeans were planted on April 23 and again on May 14. Samples were taken every two weeks to determine the seasonal occurrence and abundance of pest and beneficial species in the two planting dates and the two maturity groups. Samples are presently being evaluated.

PEST ABUNDANCE IN MULTICROP SYSTEMS

Conventional and Bt corn and cotton and soybeans were planted on two planting dates and monitored for pest activity throughout the season. Of particular interest were stink bugs, corn earworms and European corn borers as well as beneficial arthropods. Data from these 8-row plots are currently being analyzed.
Project: Dynamic soybean insect management for emerging agricultural technologies and variable environments

Principal Leader and Cooperating Agency:

M.O. ‘Mo’ Way, Associate Professor
Department of Entomology
Texas A&M University
Agricultural Research and Extension Center

Progress of Work And Principal Accomplishments:

Objective 1: Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

Introduction

On the Upper Gulf Coast of Texas, MGIV soybeans are planted early (approximately mid-April) and harvested early to avoid drought conditions during late summer when late MG soybeans are in the critical pod fill stages. However, MGIV soybeans usually are attacked severely by stink bugs [southern green stink bug (SGSB), Nezara viridula; green stink bug (GSB), Acrosternum hilare; and brown stink bug (BSB), Euschistus servus] during pod fill. Late MG soybeans (VIIs and VIIIs) are planted later (mid-May to mid-June) and harvested later in the fall. However, late MG soybeans can suffer from drought conditions during pod fill, be exposed to inclement weather during the fall causing seed deterioration and harvesting problems and often are attacked by damaging populations of defoliating Lepidoptera [velvetbean caterpillar (VBC), Anticarsia gemmatalis; green cloverworm (GCW), Plathypena scabra; and soybean looper (SL), Pseudoplusia includens]. Perhaps MGV and/or VI soybeans planted at the proper time can avoid both severe stink bug and Lepidoptera pressure and produce satisfactory yields with good seed quality. Thus, the objective of this study was to monitor insect populations and damage and compare yields and seed quality among MG IV-VII soybeans planted early and late.

Materials and Methods

The study was conducted at the TAMU Agricultural Research and Extension Center at Beaumont in 2003. The study consisted of two identical experiments - two planting dates (mid April and late May). Each experiment was designed as a split plot with Maturity Group as main plots and treated or untreated for insects as sub-plots. The varieties and their Maturity Groups were: 1) RA 452, MGIV; 2) S56-D7, MGV; 3) S64-J1, MGVI; and 4) S73-Z5, MGVII. Insect-treated plots were sprayed multiple times with Orthene 90S at 1 lb/acre. Spray applications were made with a two-person spray rig equipped with 13 nozzles (tip size = 80015, 50 mesh screens) and pressurized with CO₂ (20-30 psi). Spray width was 21.7 ft and final spray volume was 12.3 gpa. Plot size was 43 ft x 8 rows (30 inches between rows). Treatments in each experiment were replicated four times.
Early planting experiment

Plots were planted 14 Apr at approximately 8-10 seeds per foot of row. On 17 Apr, plots were sprayed with a tractor-drawn spray rig. The spray was a tank-mix of First Rate at 0.75 oz/acre and Dual Magnum at 1 pt/acre. Final spray volume was 35 gpa. On 20 Apr, soybeans emerged through Bernard-Morey fine sandy loam soil. On 21 May, plots were furrow-irrigated due to drought conditions in April and May. Escaped weeds were controlled by cultivation and a post-directed spray (using a hand-held sprayer) of Poast at 1.5 pt/acre, Basagran at 1.5 pt/acre, Blazer at 1 pt/acre and Latron AG-98 at 2 pt/100 gal spray on 3 Jun. Arthropods were sampled by taking 20 consecutive sweeps of a 15 inch diameter sweep net in each plot on the dates in Table 1A. The contents of each sweep net sample were placed in a plastic bag which was frozen. At a later date, bags were thawed and the contents identified and counted. On the same dates arthropods were sampled, soybean growth stage for each variety also was noted and recorded. In addition, Table 1A shows the dates when Orthene 90S was sprayed on treated plots. The middle four rows of each plot were harvested at maturity (see Table 1A for harvest dates) with a small plot combine. Yields were adjusted to 13% moisture. Seed from each plot was rated for quality using a 1-5 visual scale (1 = excellent, 5 = very poor). Bushel weight also was recorded for each plot. Immediately prior to harvest, pod and plant height were measured for each plot. Insect count data were transformed using $\sqrt{x} + 0.5$ and all data analyzed by ANOVA and LSD.

Late planting experiment

Plots were planted 30 May at approximately 8-10 seeds per foot of row. On 3 Jun, plots were sprayed with a tractor-drawn spray rig. The spray was a tank-mix of First Rate at 0.75 oz/acre, Dual Magnum at 2 pt/acre and Glyphomax Plus at 2 pt/acre. Final spray volume was 35 gpa. On 4 Jun, soybeans emerged through Bernard-Morey fine silt loam soil. Escaped weeds were controlled by cultivation. Arthropods were sampled as in the early planting experiment. Table 1B shows when all plots were sampled for insects, when treated plots were sprayed with Orthene 90S and when stage of growth was recorded. All other materials and methods were the same as in the early planting experiment.

Results

Early planting experiment

SL, VBC and GCW populations were too low in the experiment for meaningful analysis. However, populations of phytophagous stink bugs (nymphs and adults) - primarily SGSB - were significantly higher in MGIV than MGV and VI soybeans (Tables 16A and 16B). Across sub plots, stink bug populations were significantly higher in MGIV than MGV or VI soybeans on 27 Jun (R5 for MGIV soybeans), 7 Jul (R5 for MGIV soybeans), 17 Jul (R6 for MGIV soybeans) and 29 Jul (R6/7 for MGIV soybeans) (Tables 1A and 16B). Populations of stink bugs were highest on MGV and VI soybeans on 19 Aug when MGV soybeans were R7 and MGVI soybeans were R6 (Tables 1A and 16B). Data suggest that stink bug populations were higher and more problematic on MGIV than MGV and VI soybeans, given an early planting date (14 Apr). Also, higher stink bug populations persisted on MGIV soybeans much longer than on MGV and VI soybeans. Perhaps, stink bug population dynamics are more geared towards MGIV than V and VI soybeans on the Upper Gulf Coast, given an early planting date. Although stink bug populations were lower on MGV and VI than IV soybeans, yields of V and VI soybeans were relatively low (Table 2A). Across sub plots, MGIV soybeans yielded 31.3 bu/acre while MGV and VI soybeans yielded only 18.1 and 14.2 bu/acre, respectively (Table 2B). Perhaps, on the Upper Gulf Coast, a later planting date would be more conducive to higher yields of MGV and VI soybeans and
not attract high populations of stink bugs. Thus, in 2004 an experiment is planned to investigate planting dates (late April, mid May and late May) and stink bug populations on MGV and VI soybeans. The Entomology Project hopes to show that MGV and VI soybeans on the Upper Gulf Coast can produce acceptable yields with minimal stink bug pressure. In addition, MGV and VI soybeans can be harvested earlier than MGVII and VIII soybeans which permits harvesting operations during more favorable weather. All other arthropod populations were too low for meaningful analysis.

**Late planting experiment**

SL, VBC and GCW populations were too low for meaningful analysis. Stink bug populations were relatively low throughout the experiment except on 19 Aug when phytophagous stink bug populations were significantly higher on MGIV and V soybeans than on MGVI and VII soybeans (Tables 39A and 39B). On this date, MGIV and V soybeans were R6 and R5, respectively (Table 1B). All other arthropod populations were too low for meaningful analysis. Across sub plots, yields were significantly higher for MGVII than MGIV-VI soybeans (Table 2B). However, the late maturity date (29 Oct), 4 to 6 weeks later than the MGV and VI maturity dates in the early planting experiment (Table 2A) often coincides with the onset of inclement weather on the Upper Gulf Coast.
Table 1A. Soybean maturity group/planting date vs. insects, early planting date (April 14). Beaumont, TX. 2003

<table>
<thead>
<tr>
<th>Date of 20 sweeps</th>
<th>MGIV RA 452</th>
<th>MGV S56-D7</th>
<th>MGVI S64-J1</th>
<th>MGVII S73-Z5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun 7 (no sweeps)</td>
<td>R3</td>
<td>R2</td>
<td>R2</td>
<td>R2</td>
</tr>
<tr>
<td>Jun 13</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun 17</td>
<td>R4</td>
<td>R4</td>
<td>R3</td>
<td>R2/3</td>
</tr>
<tr>
<td>Jun 27</td>
<td>R5</td>
<td>R4/5</td>
<td>R4</td>
<td>R3</td>
</tr>
<tr>
<td>Jun 30</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 7</td>
<td>R5</td>
<td>R5</td>
<td>R4</td>
<td>R4</td>
</tr>
<tr>
<td>Jul 17</td>
<td>R6</td>
<td>R6</td>
<td>R5</td>
<td>R5</td>
</tr>
<tr>
<td>Jul 18</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul 29</td>
<td>R6/7</td>
<td>R6</td>
<td>R5</td>
<td>R5</td>
</tr>
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<td>Jul 30</td>
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<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
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<td></td>
</tr>
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<td>Aug 19</td>
<td>R8</td>
<td>R7</td>
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<td>R5</td>
</tr>
<tr>
<td>Aug 21</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
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<td></td>
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</tr>
<tr>
<td>Aug 29</td>
<td>H&lt;sup&gt;a&lt;/sup&gt;</td>
<td>R7</td>
<td>R6</td>
<td>R5/6</td>
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<tr>
<td>Sep 5</td>
<td></td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
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<td>Sep 11</td>
<td>H</td>
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<td>R7</td>
<td>R6</td>
</tr>
<tr>
<td>Sep 23</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep 25</td>
<td>H</td>
<td>H</td>
<td>R8</td>
<td>R7</td>
</tr>
</tbody>
</table>

<sup>a</sup> Plots previously harvested, MGIV (RA 452) harvested Aug 20, MGV (S56-D7) harvested Sep 18. MGV (S64-J1) harvested on Sep 30. MGVII (S73-Z5 harvested on Nov 3.
Table 1B. Soybean maturity group/planting date vs. insects, late planting date (May 30). Beaumont, TX. 2003

<table>
<thead>
<tr>
<th>Date of 20 sweeps</th>
<th>MGIV RA 452</th>
<th>MGV S56-D7</th>
<th>MGVI S64-J1</th>
<th>MGVII S73-Z5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul 29</td>
<td>R2/3</td>
<td>R2</td>
<td>R2</td>
<td>R2</td>
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<td>Jul 30</td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug 8</td>
<td>R3</td>
<td>R3</td>
<td>R2</td>
<td>R2</td>
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<td>Aug 19</td>
<td>R6</td>
<td>R5</td>
<td>R5</td>
<td>R4</td>
</tr>
<tr>
<td>Aug 21</td>
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<td></td>
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<tr>
<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
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<td>R5</td>
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<tr>
<td>Sep 5</td>
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<td></td>
<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
<td></td>
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<td>R5</td>
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<td>Applied 1.0 lb Orthene 90S on all TREATED plots</td>
<td></td>
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</tr>
<tr>
<td>Sep 25</td>
<td>R7</td>
<td>R7</td>
<td>R6</td>
<td>R6</td>
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<tr>
<td>Oct 14</td>
<td>H&lt;sup&gt;a&lt;/sup&gt;</td>
<td>R7</td>
<td>R7</td>
<td>R7</td>
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</tbody>
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<sup>a</sup> Plots previously harvested, MGIV (RA 452) harvested Oct 7. MGVII (S73-Z5) harvested on Oct 24. MGV (S56-D7) and MGVI (S64-J1) harvested on Nov 3.
Table 2A. Agronomic and yield data, soybean maturity group/planting date vs. insects.\textsuperscript{a}
Beaumont, TX. 2003

<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity group</th>
<th>Treatment</th>
<th>Plant ht. (in.)</th>
<th>Pod ht. (in.)</th>
<th>Mature date</th>
<th>Bushel wt. (lb/bu)</th>
<th>Seed qual. (1-5)</th>
<th>Yield (bu/A)</th>
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</thead>
<tbody>
<tr>
<td>RA 452</td>
<td>IV</td>
<td>Treated</td>
<td>26</td>
<td>1</td>
<td>Aug 15</td>
<td>59.6</td>
<td>2.5</td>
<td>37.4</td>
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<td>26</td>
<td>1</td>
<td>Aug 21</td>
<td>57.4</td>
<td>3.8</td>
<td>25.2</td>
</tr>
<tr>
<td>S56-D7</td>
<td>V</td>
<td>Treated</td>
<td>14</td>
<td>0</td>
<td>Sep 12</td>
<td>45.8</td>
<td>5.0</td>
<td>19.5</td>
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<td></td>
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<td>13</td>
<td>0</td>
<td>Sep 18</td>
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<td>16.6</td>
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<td>VI</td>
<td>Treated</td>
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<td>Sep 27</td>
<td>49.4</td>
<td>4.5</td>
<td>13.9</td>
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<td></td>
<td>Untreated</td>
<td>17</td>
<td>1</td>
<td>Oct 5</td>
<td>49.8</td>
<td>4.5</td>
<td>14.4</td>
</tr>
<tr>
<td>S73-Z5</td>
<td>VII</td>
<td>Treated</td>
<td>13</td>
<td>0</td>
<td>Nov 3</td>
<td>51.5</td>
<td>4.5</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Untreated</td>
<td>13</td>
<td>0</td>
<td>Nov 3</td>
<td>47.4</td>
<td>4.8</td>
<td>5.3</td>
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</table>

\textit{Early planting date (April 14)}

<table>
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<th>Variety</th>
<th>Maturity group</th>
<th>Treatment</th>
<th>Plant ht. (in.)</th>
<th>Pod ht. (in.)</th>
<th>Mature date</th>
<th>Bushel wt. (lb/bu)</th>
<th>Seed qual. (1-5)</th>
<th>Yield (bu/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA 452</td>
<td>IV</td>
<td>Treated</td>
<td>45</td>
<td>8</td>
<td>Oct 8</td>
<td>58.3</td>
<td>3.3</td>
<td>22.7</td>
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<td>Untreated</td>
<td>45</td>
<td>8</td>
<td>Oct 17</td>
<td>53.3</td>
<td>4.3</td>
<td>17.2</td>
</tr>
<tr>
<td>S56-D7</td>
<td>V</td>
<td>Treated</td>
<td>36</td>
<td>6</td>
<td>Nov 12</td>
<td>53.4</td>
<td>3.9</td>
<td>23.4</td>
</tr>
<tr>
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<td></td>
<td>Untreated</td>
<td>37</td>
<td>6</td>
<td>Nov 18</td>
<td>53.5</td>
<td>4.3</td>
<td>10.8</td>
</tr>
<tr>
<td>S64-J1</td>
<td>VI</td>
<td>Treated</td>
<td>43</td>
<td>7</td>
<td>Nov 12</td>
<td>57.0</td>
<td>3.0</td>
<td>25.5</td>
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<td></td>
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<td>6</td>
<td>Nov 18</td>
<td>56.7</td>
<td>3.5</td>
<td>10.6</td>
</tr>
<tr>
<td>S73-Z5</td>
<td>VII</td>
<td>Treated</td>
<td>41</td>
<td>7</td>
<td>Oct 27</td>
<td>59.8</td>
<td>2.8</td>
<td>26.0</td>
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<tr>
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<td>Untreated</td>
<td>41</td>
<td>7</td>
<td>Oct 30</td>
<td>59.2</td>
<td>3.0</td>
<td>26.0</td>
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</table>

\textit{Late planting date (May 30)}

\textsuperscript{a}See Table 2B for statistical analysis of agronomic and yield data, early and late planting date.
<table>
<thead>
<tr>
<th>Plant ht. (in.)</th>
<th>Pod ht. (in.)</th>
<th>Mature date</th>
<th>Bushel wt. (lb/bu)</th>
<th>Seed qual. (1-5)</th>
<th>Yield (bu/A)</th>
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</thead>
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<tr>
<td><strong>Early planting date (April 14)&lt;sup&gt;a&lt;/sup&gt;</strong></td>
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<tr>
<td><strong>Main plot effects:</strong></td>
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<td></td>
</tr>
<tr>
<td>IV 25.8a</td>
<td>1a</td>
<td>Aug 18d</td>
<td>58.5a</td>
<td>3.1c</td>
<td>31.3a</td>
</tr>
<tr>
<td>V 13.4c</td>
<td>0b</td>
<td>Sep 15c</td>
<td>45.3c</td>
<td>5.0a</td>
<td>18.1b</td>
</tr>
<tr>
<td>VI 17.3b</td>
<td>1a</td>
<td>Oct 1b</td>
<td>49.6b</td>
<td>4.5b</td>
<td>14.2c</td>
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<tr>
<td>VII 13.1c</td>
<td>0b</td>
<td>Nov 3a</td>
<td>49.4b</td>
<td>4.6b</td>
<td>5.4d</td>
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<td><strong>Subplot effects:</strong></td>
<td></td>
<td></td>
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<td>T</td>
<td>17.5</td>
<td>0.5</td>
<td>Sep</td>
<td>51.6a</td>
<td>4.1b</td>
</tr>
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<td>U</td>
<td>17.3</td>
<td>0.5</td>
<td>Sep 27a</td>
<td>49.8b</td>
<td>4.5a</td>
</tr>
<tr>
<td><strong>Interactions:</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mp x sp</td>
<td>ns</td>
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<td>sig</td>
<td>sig</td>
<td>sig</td>
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<tr>
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<td>ns</td>
<td>&lt;0.0001</td>
<td>0.0044</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

| **Late planting date (May 30)<sup>a</sup>** |
| **Main plot effects:** | | | | | |
| IV 44.8a | 8.0a | Oct 13c | 55.8b | 3.8b | 20.0b |
| V 36.4c | 6.3c | Nov 15a | 53.5c | 4.1a | 17.1c |
| VI 41.6b | 6.1c | Nov 15a | 56.9b | 3.3c | 18.0bc |
| VII 40.6b | 7.0b | Oct 29b | 59.5a | 2.9d | 26.0a |
| **Subplot effects:** | | | | | |
| T | 41.1 | 6.9 | Oct 30b | 57.1a | 3.2b | 24.4a |
| U | 40.6 | 6.8 | Nov 5a | 55.7b | 3.8a | 16.2b |
| **Interactions:** | | | | | |
| mp x sp | ns | ns | sig | sig | sig |
| **P value:** | 0.4341 | 0.4123 | 0.0159 | 0.0152 | 0.0007 | <0.0001 |

<sup>a</sup>Means in a column followed by the same or no letter are not significantly different at the 5% level (ANOVA, LSD).
Table 16A. Total phytophagous stink bugs (nymphs + adults) data for soybean maturity group/planting date vs. insects. Beaumont, TX. 2003

<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity group</th>
<th>Treatment</th>
<th>Jun 17</th>
<th>Jun 27</th>
<th>Jul 7</th>
<th>Jul 17</th>
<th>Jul 29</th>
<th>Aug 19</th>
<th>Aug 29</th>
<th>Sep 11</th>
<th>Sep 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA 452</td>
<td>IV</td>
<td>Treated</td>
<td>3.0</td>
<td>3.8</td>
<td>0.3</td>
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<td>3.0</td>
<td>5.0</td>
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<td>H</td>
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<td>S56-D7</td>
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<td>Treated</td>
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<td>0.5</td>
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<td>H</td>
<td>H</td>
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<td>S64-J1</td>
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<td>S73-Z5</td>
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</tr>
</tbody>
</table>

a See Table 16B for statistical analysis of total phytophagous stink bugs (nymphs + adults) data.
b H = plots previously harvested.

Table 16B. Statistical analysis of total phytophagous stink bugs (nymphs + adults) data from Table 16A. Beaumont, TX. 2003

<table>
<thead>
<tr>
<th></th>
<th>Jun 17</th>
<th>Jun 27</th>
<th>Jul 7</th>
<th>Jul 17</th>
<th>Jul 29</th>
<th>Aug 19</th>
<th>Aug 29</th>
<th>Sep 11</th>
<th>Sep 25</th>
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<td>6.8</td>
<td>1.0</td>
<td>1.1</td>
<td>0.4</td>
</tr>
<tr>
<td>U</td>
<td>1.4</td>
<td>1.1</td>
<td>1.3a</td>
<td>1.9</td>
<td>5.8a</td>
<td>4.8</td>
<td>1.6</td>
<td>1.6</td>
<td>2.8</td>
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</table>

Interaction: mp x sp ns ns sig ns sig ns ns ns ns
P value: 0.2773 0.4957 0.0078 0.5408 0.0047 0.5996 0.9005 0.2746 0.8252

a Means in a column followed by the same or no letter are not significantly different at the 5% level (ANOVA, LSD).
b H = plots previously harvested.
Table 39A. Phytophagous stink bug (nymphs + adults) data for soybean maturity group/planting
date vs. insects. Beaumont, TX. 2003

<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity group</th>
<th>Treatment</th>
<th>Jul 29</th>
<th>Aug 8</th>
<th>Aug 19</th>
<th>Aug 29</th>
<th>Sep 11</th>
<th>Sep 25</th>
<th>Oct 14</th>
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<tbody>
<tr>
<td>RA 452</td>
<td>IV Treated</td>
<td></td>
<td>1.3</td>
<td>0</td>
<td>5.3</td>
<td>0.5</td>
<td>3.3</td>
<td>0.3</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td></td>
<td>0</td>
<td>2.3</td>
<td>11.0</td>
<td>0.5</td>
<td>3.5</td>
<td>1.8</td>
<td>H</td>
</tr>
<tr>
<td>S56-D7</td>
<td>V Treated</td>
<td></td>
<td>1.5</td>
<td>1.3</td>
<td>3.5</td>
<td>0.5</td>
<td>0.3</td>
<td>1.3</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td></td>
<td>0.8</td>
<td>0.3</td>
<td>7.8</td>
<td>0.5</td>
<td>5.0</td>
<td>3.0</td>
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</tr>
<tr>
<td>S64-J1</td>
<td>VI Treated</td>
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<td>0</td>
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<td>0</td>
<td>0.3</td>
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</tr>
<tr>
<td></td>
<td>Untreated</td>
<td></td>
<td>0.3</td>
<td>0</td>
<td>1.0</td>
<td>1.8</td>
<td>7.0</td>
<td>3.8</td>
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<tr>
<td>S73-Z5</td>
<td>VII Treated</td>
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<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Untreated</td>
<td></td>
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<td>0</td>
<td>0.8</td>
<td>0.3</td>
<td>1.8</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Late planting date (May 30)

0 no. phytophagous stink bug (nymphs + adults)/20 sweeps

a See Table 39B for statistical analysis of phytophagous stink bug (nymphs + adults) data.

b H = plots previously harvested.

Table 39B. Statistical analysis for phytophagous stink bug (nymphs + adults) data from Table 39A. Beaumont, TX. 2003

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>effects:</td>
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<tr>
<td></td>
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<td>0.8</td>
<td>5.6a</td>
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<td>2.1</td>
</tr>
<tr>
<td></td>
<td>VI</td>
<td>0.3</td>
<td>0</td>
<td>1.1b</td>
<td>0.4</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>1.3</td>
<td>0.1</td>
<td>0.6b</td>
<td>0.1</td>
<td>0.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>

|                |        |       |        |        |        |        |
| Subplot effects:| T      | 1.1   | 0.4    | 2.6b   | 0.3    | 0.9b   | 0.4b   |
|                | U      | 0.5   | 0.6    | 5.1a   | 0.5    | 4.3a   | 3.0a   |

| Interactions: | mp x sp | ns    | sig   | ns    | ns    | ns    | ns    |
| P value:      |         | 0.7328| 0.0182| 0.1572| 0.4940| 0.4593| 0.6816| 0.2840|

Means in a column followed by the same or no letter are not significantly different at the 5% level (ANOVA, LSD).

b H = plots previously harvested.
Usefulness of Findings:

This study could have important economic and environmental implications for Upper Gulf Coast soybean producers. Of course, we will repeat the study in 2004 with modifications in order to pinpoint the best time to plant MGV/VI soybeans on the Upper Gulf Coast. We believe we can show that MGV/VI soybeans can produce acceptable yields, avoid damaging insect pest problems and be harvested before the onset of inclement weather. If our research results continue to confirm our hypotheses, a new system of producing soybeans on the Upper Gulf Coast could emerge. About 150,000 acres of soybeans are produced annually on the Upper Gulf Coast. Our research results could reduce soybean pesticide use by one application a season ($10/acre = $1.5 million annual savings) and increase yields 3 bu/acre due to better harvest time and reduced pest damage ($7/bu=$21/acre=$3.2 million annual revenue increase).

Future plans:

We plan to continue the study in 2004 but we will modify the experiment by using better adapted MGV and VI varieties, target better planting dates (late April to late May), and improve the experimental design.

Publications:

No publications reported in 2003.
Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

COOPERATING AGENCIES AND PRINCIPAL INVESTIGATORS: D. A. Herbert, Jr.¹ (Leader - Entomologist), S. Malone¹ (Research Specialist), and D. L. Holshouser² (Cooperator - Soybean Specialist)  
Departments of Entomology¹, and Crop and Soil Environmental Sciences², Virginia Tech, Tidewater Agricultural Research and Extension Center, 6321 Holland Road, Suffolk, VA 23437

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1 (AR, GA, IA, IL, IN, KS, KY, LA, MI, MS, ND, NE, OH, TN, TX, VA, WI, and USDA (MO)):

Sub-objective 1a. Develop management strategies for the soybean aphid.

Because of the small numbers found in the previous two seasons, and the late occurrence (late August – early September), soybean aphid was not considered to be a major threat to Virginia soybean. Therefore, only a minor effort was expended on soybean aphid surveys in summer 2003. Unfortunately, it was the wrong decision, as soybean aphid invaded areas as close as Delaware in July, earlier than ever previously reported, and reached economic levels in several Delaware soybean fields. Although coordinated field surveys were not done in Virginia, soybean aphids were found in fields in ten counties. No economic levels were reported, and no fields were known to have been treated. Considerable time has been spent developing and delivering educational programs based on the newest findings and recommendations from states with active research programs (e.g., Dave Ragsdale, Univ. of Minnesota). A systematic survey is planned for 2004.

Objective 4 (LA, ND, NE, TX, and VA): This objective is to develop criteria for insecticide application based on remote sensing technology (digital aerial photography) that is cheaper and more efficient than the method currently used.

Results of research reported in 2002 indicated that LAI (leaf area index), a measurement that estimates the leaf canopy area, was strongly related to NDVI (normalized difference vegetation index). Infrared images of soybean plots with different cultivars and planting dates were taken at three different altitudes. There was a significant linear relationship between NDVI values and LAI values, with the R-square values ranging from 0.77 to 0.90 for the different altitudes. The project was repeated in 2003. A series of small plots was established to create different leaf canopy levels using different soybean cultivars and planting dates. Infrared images were taken of the plots from a fixed-wing aircraft on several dates and at 3 different altitudes (range: 365.76-975.36 meters). NDVI values were calculated from infrared images. On each image date, LAI values were determined for each plot using the LAI-2000 Plant Canopy Analyzer. LAI values were related to NDVI values using statistical regression procedures. Data analysis is still in progress.
Other Pertinent Activities:

1) Corn earworm advisory: monitoring populations using field corn surveys and blacklight traps.
   A total of 7,400 ears of field corn were randomly sampled for presence of corn earworm in mid to late July, from 148 fields in 29 eastern Virginia counties. Over all areas surveyed, infestation level was 34.2 percent, compared with 73.1 percent in 2002. This relatively low infestation level in field corn indicated that the subsequent infestation in soybean would also be light to moderate. This information was released to growers in weekly advisories that included moth activity information based on a system of 18 blacklight traps located throughout eastern Virginia used to monitor activity and movement of moths from corn fields into soybean and other crops. A post season survey by Virginia Cooperative Extension Agents in 26 of the major soybean growing counties showed that an estimated 58 percent of the state’s soybean acreage was scouted for corn earworm and other insect pests, and that only 17 percent was treated by growers, compared with almost 60 percent treated in 2002. The percentage of soybean acreage treated by growers in August was well correlated with predictions based on the July survey of field corn ($y = 0.98x - 2.9; r-square = 0.64$).

2) Documenting the level of resistance of local corn earworm populations to pyrethroid insecticide.
   Resistance to pyrethroid insecticide was documented using a standardized process that was used in the 2000, 2001 and 2002 resistance-testing program for cotton. We used a series of corn earworm pheromone-baited, mesh, conical moth traps placed in and around fields to capture adult moths. Eight trapping locations were established (Suffolk, Southampton, Prince George/Dinwiddie, New Kent, King and Queen/King William, Essex, Northampton, and Accomack Counties) with 5-10 traps at each location. Traps were operated continuously from June 11 to September 11, with pheromone baits being replaced at about 2-week intervals. Captured moths were placed into 1-quart paper rearing cartons (10 to 30 per carton) with a food supplement (sucrose/water solution), returned to the lab, and kept overnight for observation. The following day, healthy moths were placed individually into glass vials pretreated with 5ug or 10ug of cypermethrin, or an untreated control. After 24 hours, moths were removed and percent dead and alive was determined.

   A total of 3,602 moths were tested over all locations, over the season. About two-thirds (2,395) were challenged with one of the two cypermethrin rates, and about one third (1,207) were placed into untreated control vials. Over all locations and dates, survival of cypermethrin treated moths was low, only 4.2 percent and 1.3 percent at the 5ug and 10ug rates, respectively. These survival rates are similar to those seen in moths previously tested (2000-2002) in the cotton/peanut counties, and are well below critical levels reported for populations tested in some of the major southeastern cotton states.

   We also surveyed the resistance level of corn earworm adults reared from larvae collected from field corn. A total of 579 larvae were collected from corn fields in 20 counties during the mid July survey. In the laboratory, each was placed into a 1-oz cup containing an artificial food source where they fed and developed to the adult stage (moths). These adults were then placed into pre-treated vials (as described above) to determine levels of resistance/survivorship. Results showed that 11.5 percent and 3.7 percent survived the 5ug and 10ug rates, respectively. These elevated survival percentages are of concern and warrant continued monitoring, and possibly encouraging growers to consider shifting to non-pyrethroid insecticide options.

3) To evaluate corn earworm control options in soybean.
   Two field tests comparing product efficacy were established in growers’ soybean fields in Suffolk. Individual plots were 6 feet wide x 40 feet long, replicated 4 times and arranged in a randomized complete block experimental design. Treatments included different rates of Steward 1.25SC, Tracer 4SC, Intrepid, Denim, Larvin, Mustang Max, and Karate Z. Treatments were broadcast with a backpack CO$_2$-powered sprayer calibrated to deliver 14.3 gpa at 18 psi through 8002VS nozzles spaced 18 inches apart on the spray boom. Pre and post treatment corn earworm counts were made using a beat cloth, taking two, 6-foot samples per plot.
Results were analyzed using standard statistical procedures. Although corn earworm populations were low, one test provided reasonable comparisons of product efficacy. At one day after treatment, Steward 1.25SC @ 4.6 and 6.66 oz/acre, Tracer 4SC @ 2.0 oz/acre, Mustang Max @ 2.8 and 4.0 oz/acre, and the high rates of Larvin (10.0 oz/acre) and Karate Z (1.6 oz/acre) provided 90 percent or higher levels of control. Only Intrepid @ 16.0 oz/acre and the low rate of Karate Z (0.96 oz/acre) provided less than 80 percent control.

USEFULNESS OF FINDINGS:

Soybean aphid, *Aphis glycines*, has been present in Virginia soybean since 2001. Up until 2003, populations were never found until late in the season (late August to early September) and were not considered to be an economic threat. However, their earlier than normal July invasion into Delaware, and consequent development into large economic levels, has increased our level of concern. Information being released by other researchers on the preferred temperature range for soybean aphid – the mid 70s to 80s (°F) – also indicates that the level of risk in mid Atlantic states where summertime temperatures rarely reach the mid to high 90s (°F) might also be higher than previously thought. Based on these new insights, a more systematic field survey is being planned for 2004.

Although not completed, research with technologies that utilize NDVI and LAI to improve systems for managing insect pests, and other farming inputs, show promise. In this work, NDVI (normalized difference vegetation index) values, calculated from infrared images of soybean plots, were compared with LAI values for those plots. Results indicated a strong relationship between NDVI and LAI, with NDVI increasing as LAI increased. From these data, we may be able to derive a common regression between LAI and NDVI. If so, we could calibrate, or ground-truth, the curve based on one or 2 LAI measurements in a field, then use infrared images to map out LAIs over the entire field. Knowing the LAI, and therefore the yield potential of a field, is valuable information for growers to improve pest management and other crop input decision-making.

The corn earworm advisory continues to pay benefits to Virginia soybean growers. Pest abundance in field corn has proven to be well related to infestation levels in the subsequent soybean crop. Pest advisories based on this information and weekly updates of corn earworm moth activity encourage growers to scout fields and use economic thresholds to determine the need for insecticide sprays. The 2003 season was a good example where, in response to overall lower levels of corn earworm, growers treated only 19 percent of the acreage, compared with 60 percent in 2002.

Results of monitoring local corn earworm populations for pyrethroid resistance have shown that at least some portion of the population appears to be resistant. These findings are of concern and warrant continued monitoring, and possibly encouraging growers to consider shifting to non-pyrethroid insecticide options.

WORK PLANNED FOR NEXT YEAR:

A coordinated multi county survey for soybean aphid will be implemented. The corn earworm advisory will be continued. A second season of corn earworm pyrethroid resistance monitoring will be conducted. NDVI and LAI objectives will be continued, but only if funding can be secured through competitive grants.
In 2003 a third year of research was conducted to determine the economic threshold and optimal spray timing for control of soybean aphid. Field experiments were established at the Arlington Agricultural Research Station. Early and late-planted soybeans were compared in both experiments.

Late planted soybeans exhibited consistently higher aphid numbers in the two experiments. Results of the economic threshold experiment suggest that spray applications should be made when soybean aphid numbers reach 500 per plant when the plants are at the R1 (early flowering) stage. Once plants reach the R2-R3 (full flowering to early pod) stages the economic threshold should be increased to 1000 or more aphids per plant.

Spray timing studies indicated that the optimal timing of insecticide applications occurs during the R2-R3 stages. Aphid populations can recover from spray applications made prior to these stages, and continue to cause significant feeding damage. Spray applications made at the R4 stage or later may be too late to prevent economic yield loss.

The effects of three planting dates (May 4, May 21, and June 9) on soybean aphid dynamics, and the within-plant distribution of soybean aphids, were investigated in 2003. Soybean aphids were first detected in mid June from plants in the May 4 and 21 plantings, and on July 1 from plants in the June 9 planting. Aphid populations increased rapidly from mid through late July, peaked on August 7, and decreased thereafter until few aphids were found by late August. Some evidence of a planting date effect was detected on July 31, with average aphid densities of 669, 1324, and 1357 aphids per plant for the May 4, May 21, and June 9 plantings, respectively. However, aphid densities in the May 4 planting had increased on August 7 and at that time there were no statistical differences in densities among the three planting dates. Within plants, soybean aphids exhibited the familiar pattern of congregating in the uppermost nodes near the growing point during June and early July. However, from mid July through the remainder of the growing season, more aphids were observed on lower plant nodes.
Soybean aphid infestations in 2003 were generally severe in southern Wisconsin. In 2002, a program was begun to establish the parasitoid *Aphelinus albipodus* in Wisconsin for biological control of soybean aphid, using parasitoids mass reared at the USDA Biological Control Laboratory in Niles, MI. Efforts in 2002 included releases of *A. albipodus* at field sites in Columbia, Dane, and Racine counties. Recoveries of *A. albipodus* near each of these field sites in 2003 indicated successful establishment of the parasitoid. Additional releases of the parasitoid were made in 2003 at two new field sites in Rock and Dane counties. Future monitoring of the now five release sites will be conducted to confirm the continued presence and spread of *A. albipodus* in Wisconsin.

Surveys to characterize the complex of arthropod and pathogen natural enemies of soybean aphid in Wisconsin were continued in 2003. As in both 2001 and 2002, lady beetles were the dominant and likely most important group of aphid predators in Wisconsin soybeans. Additionally, several species of aphid predators/parasitoids, previously rare or absent in soybeans, were substantially more common in 2003. Aphid mortality due to fungal disease, rare in previous years, was also more prevalent and widespread in 2003. Indications are that the aphid natural enemy complex in soybeans may be diversifying following the recent introduction of soybean aphid.

Investigations of Insect-Virus Complex of Soybean
Emily Mueller, David Hogg and Craig Grau

Research has focused on understanding the effect of the soybean aphid, bean leaf beetle and associated viruses on the health and productivity of soybeans; and to formulate management strategies to reduce yield losses associated with this insect-virus complex. *Alfalfa mosaic virus* (AMV) and *Soybean mosaic virus* (SMV) were the most prevalent viruses infecting soybean in 2003. Soybean germplasm was evaluated for reaction to each virus plus *Bean pod mottle virus* (BPMV). Severity of leaf symptoms and mottled seed were used to characterize the reaction type of soybean germplasm to viruses. Soybean lines differed in virus titer in seed and shows promise as a means to characterize soybean germplasm for reaction to BPMV. Soybean varieties differed in seasonal progress of virus-infected plants resulting in differences among varieties for yield and grain quality. Information has been shared with soybean breeders. Data also provides knowledge to develop recommendations for insecticide applications for vector control. The introduction of the soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae), in 2000, has increased the potential of insect transmission of viruses to soybean. In an effort to control this pest along with the spread of viruses, various adapted soybean lines were screened for resistance to aphid colonization and AMV and compared to lines reported to exhibit partial resistance. Throughout the field season, aphid counts and single leaf samples were taken on twenty individual plants in each plot to assess the ability of the soybean aphid to colonize the different lines. Aphid numbers were highly variable across sampling dates, indicating a degree of heterogeneity within Midwestern soybean lines. Peak aphid populations in this experiment ranged from averages as low as 1000, extending as high as 2500 per plant. Results from this study suggest the possibility of selective breeding as a means of managing the soybean aphid. Wisconsin investigators will continue to screen soybean germplasm for resistance to the soybean aphid in controlled and field environments.
Studies were continued to determine the effects of AMV on agronomic performance of soybeans. Six treatments, mechanical inoculation of 0%, 10%, 25%, 50%, 75% and 100% of plants with AMV were replicated eight times. Incidence of AMV-infected plants and foliar symptom ratings were recorded and analyzed seven different times throughout the growing season. Enzyme-linked immunosorbent assays (ELISA) were used to quantify incidence of AMV-infected plants and to detect the presence of other viruses. Treatments in which 0%, 10%, 25%, 50%, 75% and 100% of plants were mechanically inoculated, differences in yield resulted and averaged 58.8, 52.0, 57.8, 57.2, 49.7, and 44.7 bushels per acre, respectively. Foliar symptom ratings scored lower than the actual infected plants, indicating differing levels of plant response to the virus.

The Soybean dwarf virus was detected in soybeans in five Wisconsin counties in 2004. Dwarf was reported in soybean previously in West Virginia. SbDV was initially detected in a survey conducted by the Wisconsin Department of Agriculture by ELISA and confirmed by Les Domier, USDA-ARS, by RT-PCR.

Insect-virus management plans are being developed based on data generated by this project. Resistance to soybean aphids and soybean viruses would lower production costs and stabilize profits from soybean production. Methods to characterize interaction phenotypes of soybean to viruses are being developed and shared with soybean breeders.
MINUTES

The minutes may be reviewed through the following link:
http://www.lgu.umd.edu/project/saes.cfm?trackID=2296
Chair of the technical committee, Ron Hammond, opened the meeting at 8:00 a.m. He asked the attendees to introduce themselves to the group. A list of attendees is attached to the minutes.

For the first order of business, Hammond appointed the two past chairs, Lentz and Boethel, to serve as the Nominating committee to select a chair and a secretary for the annual meeting next year. This year’s secretary, David Hogg, has accepted an administrative position and needs to be replaced. Mo Way, in an email to the chair, volunteered to host next year’s meeting and serve as chair of the technical committee. His proposal to host the meeting and serve as the chair of the technical committee was acceptable to the members present. Lentz volunteered to take the minutes for this year’s meeting.

Hammond mentioned that John Hill, a virologist from Iowa State University, had asked him about meeting jointly with S-1010. This proposal will be pursued further. Administrative Advisor Boethel commended Hammond for his work in getting the project written and in hosting the meeting this year. Although the meeting was originally a Southern regional project, the meeting is now truly a national project and it expected that there will be wider participation. Boethel indicated that the NIMSS reporting form did not have adequate space to fully justify the project. Anna Marie Raspberry, assistant to Southern Director Executive Secretary, Eric Young (Horticulturalist at NCSU) did much to expedite the new project. Boethel suggested that she be sent a letter of commendation. Hammond indicated that he would send a letter of gratitude to her.

Bill Hoffman of CSREES reported on the status of two RFPs, the Pest Management Alternatives and the Integrated Pest Management Program. He reported that there are currently four regional Pest Management Centers (Cornell, Florida, California Davis and Michigan State University). Crop profiles and IPM Strategic Plans were discussed. The centers are established as a source of information in the region. Hoffman indicated that there is now a request out for applications for four-year projects. He indicated that IR-4 continues. CSREES met with EPA and the Land Grant Universities to bring together new ideas. The Plant Diagnostic Network was discussed. It is an effort to nationally detect threats to the U.S. Hubs are located at Cornell, Florida, Michigan State, Kansas State and California Davis with information in the CAPS repository at Purdue.

Hammond asked for a report on other meetings. The soybean breeders met at St. Louis; the Virus Disease group met with the breeders. Syngenta hosted a meeting on seed treatments for soybean. Gaucho, Prescribe (high rate of Gaucho), Poncho and Cruiser were considered. There were two rates of Gaucho with the low rate for secondary pests. The high rate is for bean leaf beetle (BLB) and soybean aphid (SBA) control. Hammond’s assessment is that the seed treatment research needs to proceed. Ragsdale indicated that the resistance to soybean aphid is in MG IV-VII and not in the MG 0-III.

O’Neil commented on the Soybean Aphid Meetings. It appears that environment and native predators are the main factors affecting populations. Ragsdale reported on the damage potential, indicating that a reduction in pod number (pod abortion) is where loss occurs. One variety from Mycogen with a dark hilum under heavy aphid pressure loses the dark hilum.
The 7th World Soybean Research Conference will be held in Brazil 29 Feb-5 March, 2004. Panizzi may be involved.

Hammond mentioned that Hogg had accepted an administrative position in Wisconsin and Herbert had accepted an appointment in Extension administration at VPI. Iowa State University has announced a vacant position in soybean entomology, which will be an applied position. It was mentioned that Hogg would need to be replaced on the technical committee. Bledsoe indicated that C. R. Edwards plans to retire from Purdue at the end of the fiscal year.

O’Neil commented on the Biocontrol work that has been done with the soybean aphid in Asia.

Hammond discussed the termination report of S-281. It is to be submitted within 60 days. A draft of the termination report is contained on pp. 3-20 of the printed report. Hammond requested that changes be made within two weeks. If there are publication changes, those should be submitted also within the two-week period.

**Objective Discussion**

**Objective 1**

**Objective 1a.** NE saw low SBA numbers during 2002. Higley conducted physiological stress studies. SBA reduces photosynthetic rates at low infestation rates. The overwintering host buckthorn is common in the river and creek bottoms. MN found that the minimum temperature for SBA is 45 degrees. SBA reduced pods/node; oil was reduced, seed was 22% larger and the black hilum was not formed on a Mycogen 200 MG II variety. Lorsban and dimethoate gave poor control; Asana and Warrior gave the best control. The threshold reported is 3000 aphid days. SBA does not like hot temperatures. The number of offspring at 77, 81 and 86 degrees was 30, 40 and 10 respectively. Ragsdale thought row spacing impacted populations. Bledsoe (IN) reported a cool, wet spring, which resulted in late planting which possibly, affected SBA numbers. Studies were attempted with little success; plans are to use a split field this year. IN will continue the insecticide work and variety evaluations. O’Neil reported that buckthorn is now leafing. Survival of fundatrices is poor at 29 degrees. He is now looking at buckthorn distributions, even into the south. Predators at low numbers early can impact populations. He is investigating aphid thresholds. In Japan, SBA has low populations and it does reproduce there at high numbers in high temperatures. Helm (IL) reported low numbers in 2002. The suction trap network will monitor populations throughout IL. Hartman of the USDA is conducting HPR work. He has 15-18 lines which show some resistance. These lines have high levels of pubescence. Root-knot nematode resistant lines have SBA resistance. Many have high pubescence. Glogoza (ND) reported yellowing and stunting in the first GPS to identify locations. Shelterbelts are reported to favor aphids. Shelterbelts do not have to have buckthorn present. MN sees SBA higher near shelterbelts. KS first found SBA 20 Aug 2002 (see handout). Research found there was no chlorophyll loss, but Higley found photosynthesis rate was lowered. Cages were not needed for the research since the aphids do not move. Glogoza indicated there could be a major impact, even when SBA is at low numbers. Ragsdale indicated that aphid age might be more impacting.

**Objective 1b.** MN evaluated both the F1 and F2 models. IN validated the overwintering model. ND hopes the F2 generation will be reduced.
Objective 1c. LA evaluated Bt soybean since 1998. The last two years MG V entries have been examined. It gave good control of lepidoptera (soybean looper and velvetbean caterpillar.) GA had similar results. Bledsoe (IN) reported that saturated soils reduce bean leaf beetle and rootworm larvae. On threshold research, MN reported that the SBA populations can double every 2 days. A rating scale does not work. Individuals were referred to results posted on the web. ND picks a trifoliolate near the top for population estimates. They use a rating scale or the trifoliolate leaf.

Objective 2. Hammond (OH) indicated that this objective ties to subobjective 1b. He indicated there was less virus movement in resistant varieties. NE sees infestations of BLB on the first 25% of the early-planted soybeans. IL will evaluate both seed treatments and Warrior for BLB control. IA (Krell) evaluated foliar applications. Bradshaw indicated that the seed treatments plus the foliar spray reduces BLB. Events that affect larval populations include such things as a 10-inch rain in northwest IA that caused the population to crash. Bradshaw feels that the seed treatments will work. IA will continue investigating the effects of pubescence on BLB feeding. Seed treatments will be compared to pyrethroid foliar applications. R. Cloyd of IL was a student at Purdue with Edwards about 5 years ago when he examined trichomes in a series of lines for their impact on BLB feeding. The work was published in the IN Academy of Science proceedings. Bradshaw raised a question of the impact of pyrethroids on beneficials. Boethel asked about the impact of bean pod mottle virus (BPMV) on yield. TN reported the impact of ESPS on BLB numbers. Pitre (MS) continues to investigate BPMV (see report). In a date of planting study, more virus was observed. Early maturity groups planted early were most infested. Row spacing was investigated for virus suppression. It was recommended that an ELISA test be run to determine virus incidence. In MN, Ostlie will work on BLB. A pathologist has surveyed the state in 2001 and found BPMV only on experiment stations.

Objective 3. MN found that after SBA first colonized the field, that within 2 weeks, every plant was infested. The Russian wheat aphid parasite, *Aphelinus albipodus*, was evaluated. The parasite was released into the field at high and low rates. At the high release rate, the lowest number of aphids was collected and at the low rate, aphid numbers were highest. One confounding problem is that the buckthorn aphid may be collected from buckthorn. Voegtlin collected SBA in 12-meter suction traps. O’Neil (IN) will be investigating fly predators in the family Chamaemyiidae. Among the endemic parasites, there are very few mummies. MN reported 5% of the SBA population was affected by pathogens. Very little was found in IN. Predators reported were lady beetles, carabids, *Orius insidiosus*, *Nabis* and *Chrysopa* in MN, MI and IN. O’Neil and Landis will be modeling *Orius*. Two pathogens, *Endora* and *Caneb* look promising.

Objective 4. This objective deals with remote sensing and management of insects looking at NDVI. LA reported that stink bugs were the most abundant pest, with increasing populations of brown stink bug species. Pyrethroid insecticides were not very effective on the brown stink bug species. ND plotted the distribution of SBA over the field 9 July- Sept 2002.

Predominant insects during the 2002 season were reported by state. LA reported that stink bugs, especially the brown stink bugs were most abundant. Pyrethroid insecticides were not too effective. MN reported that SBA was most abundant with 50,000 acres being treated. Spider mites were second in abundance. IN reported that Japanese beetle (JB) and BLB were most prevalent. West Central IN has the JB-BLB infestation. Japanese beetle is very transitory in response to natural control. MS reported that stink bugs were the most prevalent pest, followed by soybean looper (SBL), grasshoppers on no-till and BLB. Soybean podworm was a major pest across the state. TN reported that stink bugs were quite common, followed by SBL and grasshoppers in no-till.

The *Dectes* stem borer is becoming more of a pest since no-till soybeans are so widely planted. MO reported
BLB in early soybean; green stink bug in late-planted soybean and a number of caterpillars (green cloverworm, podworm and woolly bear. IA had BLB very high (450 beetles/50 sweeps) and spider mites. OH again reported that slugs were a major defoliator and SBA was not present. IL had the same JB-BLB problem as IN had. NE had BLB heavy on early beans; followed by grasshoppers and spider mites. ND reported that SBA received the most attention, but grasshoppers were important. Brewer reported *Dectes* in sunflowers. KS reported that *Dectes* was a major problem.

The location of next year’s meeting was discussed. Since Mo Way has volunteered to host the meeting, the group proposed that San Antonio be considered for the March 7-9, 2004. Hammond will check with Way. The nominating committee proposed that Way serve as Chair for next year and that Hunt had consented to serve as Secretary. This proposal was acceptable to the technical committee.

Hammond requested that the group look over the annual report and the publication lists.

Reese mentioned that Kansas State has a website where translations of the Asian literature on SBA is available.

Boethel commented that the group might want to use the longer meeting next year to show more data. The group might also wish to consider an invited speaker, someone who is working in an area related to the project (virologist, etc.). The agenda might also be expanded to consider much of the seed treatment work that is planned for the 2003 season. Boethel and the group extended thanks to Hammond who worked diligently in the project rewrite and in hosting the meeting in Indianapolis. The meeting adjourned at 5:00 p.m.

Gary L. Lentz  
Acting secretary
Monday, March 8, 2004

Chair of the S-1010 technical committee, M.O. Way, opened the meeting at 8:00 a.m. He asked the attendees to introduce themselves. Committee secretary, Tom Hunt, took minutes.

A question concerning S-1010 membership was brought up. Dave Boethel, S-1010 Administrative Advisor, said those interested in membership should contact him. They should have information such as what project objectives that they will work on, etc.

Rick Meyer, CSREES, reported on federal budget and programs. He reported that in the 2004 budget formula funds were about level, but overall there was about a 10% reduction for many programs. He encouraged resubmission of proposals to competitive programs (e.g. RAMP—about 3.4 million dollars available, about 2 proposals will be accepted) as they generally have a high level of success if reviewer suggestions are considered. He also noted that although the Bio-based Pest Management and Biocontrol programs were cut out, an effort was in play to lobby the return of these programs. He suggested writing a letter to Dr. Anna Palmisano, Deputy Administrator for Competitive Programs, indicating gaps in the program offering and requesting reinstatement of the programs. A motion was advanced and passed for S-1010 to draft a letter requesting reinstatement of the Bio-based/Biocontrol programs. M.O. Way volunteered to draft the letter. Dr. Meyer noted how important it was to report outcomes and impact, and contact/lobby policy makers. He also commented on a CSREES 2-month student internship that is designed to get students in contact with policy makers and lobbyists.

Way asked for a report on other meetings. Ron Hammond reported on the recent International Soybean Research Conference held in Brazil. He noted that there was little entomological involvement, and much was devoted to variety and pesticide testing. Ron said that Argentina was active in looking at Bt soybean. He noted that virus control of velvetbean caterpillar was common and there was a plan in the works with Industry to develop methods for large scale rearing of caterpillars for virus production. Today about 43 metric tons a year of velvetbean caterpillars are collected for virus production.

Dave Ragsdale reported on the North Central Soybean Research Project on soybean aphid. Current research and recommendations are reported in a 16-page brochure. Everyone who is a member of a state soybean organization will receive a copy (it will be in soybean Digest). The current threshold is 250 aphids/plant with 80% of the plants with aphids through R4. Contact Dave Wright at NCSRP for copies of the brochure www.planthealth.info. He reported on a December meeting of extension entomologists that came up with a consensus recommendation (above) for soybean aphid. He also reported on other soybean aphid research. Dave also noted that S-1010 soybean aphid researchers met on 3/7 to discus current research.

Bob O’Neil commented on soybean aphid biocontrol. He noted that several trips abroad were made and that there are currently 12 natural enemies of the soy aphid in quarantine. He noted that funding sources for this research were not predictable. A motion was advanced and passed to write a letter to APHIS that expresses this concern. Bob will draft the letter.
It was noted that there is a need to access our respective representatives on legislative appropriation committees.

**Objective Discussion**

Objective 1. Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

GA (McPherson) saw velvetbean caterpillar and stinkbugs at economic levels in 2003. Soybean aphid was found at low levels in north central and northeast GA. Initial research on edamame soybean (vegetable) indicated production of these beans is possible and one variety, Midori Giant, is early and avoids most insect injury. Other later maturity beans also show promise. IL (Voegtlin) discussed the suction trap network. Few soybean aphid were collected this fall (2003), probably because of high levels of *Harmonia*, and Voegtlin tentatively predicts a late start for soybean aphid in 2004. Although two other *Rhamnus* species were identified as hosts of the soybean aphid (*R. alnifolia* and *R. lanceolata*), *R. cathartica* is considered the major host. Voegtlin suggested other states join the suction trap network. Traps cost about $1,200/trap. IN (O’Neil) discussed their contribution to soybean aphid thresholds, aphid overwintering, and aphid population dynamics. Preliminary results indicate no effect of planting date on aphid abundance, nor did the plant age/stage have an effect on the intrinsic growth rate of the aphids. To date, no consistent pattern of agronomic factors and aphid population dynamics has been noted. A soybean aphid simulation model is being developed. KS (Reese and Kambhampati) reported that soybean aphids were at very low numbers but relatively widespread. Progress on developing a protocol for visual screening for resistance to soybean aphid was discussed. Including moisture stress in the protocol was suggested. Kambhampati discussed *Dectes* as an example of the early stages of sympatric divergence borer (presentation given). Several studies were discussed, including those examining host fidelity and oviposition preference of *Dectes texanus*, *D. texanus* fitness on sunflower and soybean, and allele frequencies of subpopulations from soybeans and sunflowers. *D. texanus* on soybean have lower fitness relative to those on sunflowers and individuals reared on both plants prefer to oviposit on sunflower. *D. texanus* is a single species, but there are measurable allele frequency differences between subpopulations on soybean and sunflower, suggesting sympatric divergence. Dave Boethel noted that he has noticed an increase in *Dectes* number the last couple of years. LA (Boethel) reported no soybean aphid in 2003. Dave B. said that Bt genes are now in agronomic soybean lines, but not yet ready for use in U.S. He also noted that the 3rd edition of the Soybean Monograph published by the Agronomy Society is available. MI (DiFonzo) reported on various aphid studies, including seed treatment studies. She noted grub/European chafer problems. Temik is being talked about (among growers) for soybean aphid. VI (Hebert) noted that he saw OP applied in-furrow resulted in increased aphid populations. DiFonzo also reported that 5 out of about 5000 soybean lines tested exhibited some level of resistance to soybean aphid.

Motion to approve minutes from 2003 meeting advanced and passed.

Adjourn for lunch. Re-adjourn at 1:30 for guest speaker

**Guest Speaker**

Dr. Jim Heitholt presented a review of soybean research in Texas. Soybean mean yield of 28 bu/acre. Heitholt noted that there were 3 environments in TX where soybean were grown and there was a need for yield stability, stress tolerance, and increased soybean height. Soybean breeding and several studies examining seeding rate, planting date, and row spacing were discussed.
Objective 1 (continued)

MN (Ragsdale) discussed supercooling points of soybean aphid. Soybean aphids are relatively tolerant to cold temperatures. Egg mortality occurs at -34 degrees C. Oviparae least tolerant (-17 degrees C). At constant temperatures, the optimum temperature for soybean aphid growth and development is 27.7 degrees C. The upper limit is 34.9 degrees C. MO (Clark) reported aphid in all soybean-producing counties. Treatment occurred in the north part of the state. Stink bugs were a problem and bean leaf beetle numbers were average to low. Clark reported *Orius* numbers tracked thrips numbers on soybean. NE (Hunt and Higley) reported bean leaf beetle numbers were relatively low. F2 beetle numbers were about equal or lower than F1 numbers. Significant numbers of beetles overwintered in soybean stubble. Soybean aphids were found in throughout the soybean production region of the state, with highest (economic) numbers in the northeast. In general, infestations began in mid to late July, with population peaks in mid-August. Yield losses of up to 30% were reported. ND (Glogoza) reported late developing populations, with infestations beginning near shelterbelts. OH (Hammond) reported high F1 bean leaf beetle numbers, but low F2 numbers. Slugs are a growing problem, probably relating to an increase in no-till acres. Hammond discussed limitation to slug control in the U.S. Various soybean aphid control studies were discussed. Lorsban was noted as having good “fuming” action. Populations that remained in the 100-200 aphid per plant level showed no yield loss, nor did trials where pyrethroids kept populations at 250-300/plant. Skip-row soybean production is being suggested when using ground application of insecticides. ON (Canada, Schaafsma) reported late aphid problems with yield loss. Noted that slugs are managed in fall with late burndown. TN (Lentz) discussed soybean resistance to *Dectes* stem borer. Lentz brought a dissertation on soybean resistance to *Dectes* stem borer by Louis Gene Richardson, 1975, N.C. State. Some soybean aphids were found. Soybean aphid numbers on green bean appeared to increase. No soybean aphids were found on Kudzu. Other studies on stink bugs were discussed. Most stink bugs were the green stink bug (80%). About 20% were the brown stink bug. TX (Way) noted that methyl parathion was the insecticide of choice on stink bugs, but because of no residual action, additional insect problems could result. A study examining the insect populations, damage, yield, and seed quality across maturity groups IV and VII (late and early planting dates) were discussed. VA (Herbert) reported soybean aphid now found in all soybean growing counties. Aphids were found in late August/early September – probably summer migrants.
Tuesday, March 9, 2004

Nominating Committee (DiFonzo and McPherson) reported that the 2005 secretary/2006 chair is Dave Ragsdale and the 2006 secretary/2007 chair is Chris DiFonzo.

Hammond suggested that for 2005 we extend the official S-1010 meeting to 2 days, starting on Sunday afternoon (about 1:00-2:00) and running to 12:00 noon on Tuesday to accommodate the large research effort directed at the soybean aphid. The committee’s attendance has about doubled over past years. The 2005 meetings will be held in Williamsburg, VA., March 13 to 15. Herbert has generously agreed to help with local arrangements and will need a good head count.

Objective Discussion

Objective 2. Define insect-vector ecology and virus-disease relationships and develop management strategies. (Several studies relating to Objective 2 were discussed under Objective 1)

IA (Rice) discussed bean leaf beetle (BLB)/bean pod mottle virus (BPMV) related studies. Bean leaf beetle is the most consistent pest of soybean in Iowa. Most (and longest) flights were in August (max. continuous = 38 min.; max. total = 169 min.; mean = 9 min.) BPMV was found in Desmodium canadense. Two insecticide sprays are recommended to limit incidence of BPMV, one at soybean emergence and one at the initiation of the F1 population. Late planting dates reduced BLB numbers. MN (Ragsdale) reported that there is one generation of BLB north of I90, 2 generations in the south. Ragsdale also reported that soybean aphid is a vector of several soybean and potato viruses and further notes that searching behavior alone can vector disease. Voegtlin alerted group to watch for the foxglove virus (not here yet, but a vector of soybean dwarf virus, twice the size of the soybean aphid). Warns it is not the same as the U.S foxglove aphid. NE (Hunt) reported on studies on BLB/BPMV conducted in collaboration with Dr. Loren Giesler (Univ. of Nebraska plant pathologist). Results on insecticide treatments (foliar and seed treatments) used to manage BPMV were mixed. Later planting reduced BLB and BPMV incidence. ND (Glogoza) reported the first BLB was found in N.D. in 2003. OH (Hammond) reported that BLB resistant soybean lines exhibited a reduced titer of BPMV and he is examining BLB movement in resistant lines. (VA) Hebert suggested we provide a time slot for a guest speaker on BLB/BPMV, perhaps Sue Tolin (plant pathologist). Hammond suggested John Hill (IA plant pathologist), as he is an S-1010 committee member, PD on a NCSRP project on soybean viruses and vectors, author on a review article on BLB/BPMV, and has worked closely with entomologists (e.g. Pedigo, Krell). ON (Canada, Schaafsma) has observed overwintering BLB and has picked up BPMV.

Objective 3. Biological control of the soybean aphid in North America. (Much on soybean aphid biocontrol was discussed in the Sunday afternoon meeting of soybean aphid workers and under Objective 1).

MN (Ragsdale) discussed Aphelinus albipodus studies (black mummies). Releases were made in 2002, but none were recovered after one year. Some natives are being recruited into the system. Hyperparasitism occurs. More information is needed on the complete lifecycles of parasitoids, particularly on overwintering. Will continue studies and testing new candidates (Niles lab). Hammond noted that Harmonia is a significant pest in Ohio on grapes and in homes – other committee members noted the same. Schaafsma says Harmonia cost the Ontario wine industry millions and some are requesting officials tell soybean growers to spray soybean to control Harmonia. Voetglin suggested that Harmonia may not keep up with aphids during the growing season,
but may clean them up in the fall. IN (Bledsoe) noted sryphid fly outbreaks near soybean aphid infested fields. Boethel asked about interactions between BLB management and soybean aphid control.

VA (Hebert) non-objective 3 discussion. Corn earworm is number one pest in VA and has seen some pyrethroid resistance, but not enough to see field failures. He is recommending growers avoid pyrethroids if possible.

Objective 4. Apply geospatial and precision technologies to advance pest management in soybeans.

VA (Hebert) reported LAI is strongly related to NDVI (normalized difference vegetation index), and that NDVI could be calculated from infrared images taken at 1,300 feet. Suggests that this technology can be used to identify fields at risk.

Meeting adjourned at about 12:00 noon.

Tom Hunt, Secretary
OFFICIAL AND NON-OFFICIAL PARTICIPATION
### S-1010 Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems

#### Official and Non-Official Participation

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MULTISTATE RESEARCH PROJECT PROPOSAL
Multistate Research Project

Project No.: S1010
Title: Dynamic Soybean Pest Management for Evolving Agricultural Technologies and Cropping Systems (from S-281)
Duration: October 2002 to September 30, 2007

Administrative Advisor(s): Boethel, David (LA)

CSREES Reps:

Statement of Issue(s) and Justification:

Soybean pest management is challenged by simultaneous occurrence of biotic (e.g., various insects) and abiotic (e.g., drought) stresses. With new understandings about the physiological basis for yield loss from different stressors, we now have the opportunity to develop better strategies to address combined stressors, which are what most soybean growers experience (Higley 1992). Additionally, the emergence of new soybean production practices, transgenic genotypes, and new insect pests requires research to determine how best to manage insects and other stressors in these systems (Boethel 2002). The potential impact on soybean profitability makes it essential that we begin addressing current and future problems now.

Soybean growers have recently experienced increases in certain insect pest problems and the introduction of a new and potentially significant problem over the past few years. The first situation is the increase in population densities of the bean leaf beetle, Cerotoma trifurcata, and a corresponding rise in the incidence of bean pod mottle virus, a pathogen vectored by the beetle (Rice et al. 2000). This relationship between bean leaf beetle and bean pod mottle virus, previously more common in southern states, is a relative new occurrence in the central and northern United States. The second problem is the recent introduction of the soybean aphid, Aphis glycines (Marking 2001). Soybean growers now are facing widespread use of insecticide over potentially millions of acres of soybean in the upper Midwest and given the native range of this insect, soybeans throughout the United States are at risk of being invaded.

Over the past decade, bean leaf beetle populations have increased to routinely exceed economic thresholds (Rice et al. 2000). Increased soybean acres planted in the Midwest and earlier planting dates are most likely the major factors contributing to the general increase in beetle numbers. The spring colonizing population, which has in the past been a relatively minor concern, is regularly entering fields during seedling emergence and causing great concern to soybean growers. Concurrent with the population increase has been an increase in diseases transmitted by the beetle (particularly bean pod mottle virus) (unpublished data from numerous states). Bean leaf beetle populations have increased dramatically over the past decade, and perhaps is one reason for the increase in bean pod mottle virus. The occurrence of virus-caused symptoms, most notable “green stem syndrome” and mottled seeds, has caused growers great concern. This has been especially true for growers of food grade soybeans where seed appearance is of utmost importance.
Most recently, the discovery of the soybean aphid in the Upper Midwest presents a new challenge to United States soybean production (Marking 2001). The soybean aphid is a recent invader of North American soybean fields. The aphid’s native range is from northern China to Indonesia. In 2000, aphids were found in nine Midwestern states (WI, MI, MN, IL, IN, IA, MS, OH, KY) and by 2001 it expanded into the eastern states of PA, NY, VA, WV and south and west into MO, SD, ND and into Canada (Manitoba and Ontario). Soybean aphids can damage plants by reducing photosynthesis (Higley, personal communication) and reducing pod set by as much as 33% (Ostlie, unpublished data). They can also transmit a number of plant viruses and indirectly affect yield by promoting growth of sooty mold on leaf surfaces. Yield reductions in excess of 16 bu/A have been measured with an average loss in grower strip trials of over 6.2 bu/A (13.9%) in Minnesota in 2001 (Ostlie, unpublished data). In the 2000 field season, the highest reported yield reduction was 13% in one Wisconsin replicated experiment (D. Hogg, unpublished data). Given that the aphid has been in the U.S. for a few years, it probably is overwintering successfully on its primary host, buckthorn. However, it is not known which species of buckthorn or other plants could be serving as a primary host, or the potential range of its overwintering capabilities. We currently do not know the present or future extent of the infestation or whether natural enemies are capable of controlling the soybean aphid.

An additional concern with the soybean aphid, similar to the bean leaf beetle relates to aphid transmission of soybean mosaic virus (Boethel 2002). Aphids that do not colonize soybeans have in the past, transmitted this virus. Transmission of this non-persistent virus is from aphids passing through and probing soybeans in search of a suitable host. Symptoms of soybean mosaic virus are similar to those associated with bean pod mottle virus. Plants can also be infected simultaneously with both viruses that result in severely stunted plants. Soybean diseases caused by viruses are reaching near epiphytotic proportions in many parts of the United States. The two viruses of most concern are bean pod mottle, transmitted by the bean leaf beetle, and soybean mosaic, vectored by aphids. Symptoms are similar, and thus, correct identification is crucial. With the recent discovery of the soybean aphid, which is the first aphid able to colonize soybeans in North America, and one that can transmit soybean mosaic virus, the incidence and impact of this virus may increase substantially. Research is critically needed to understand how to manage soybean aphid to reduce spread of soybean mosaic virus, if this disease becomes more widespread due to the presence of the soybean aphid.

The proposed research on pest sampling and injury assessment by precision agriculture technologies is at the leading edge of IPM research. In the dynamic agricultural environment, diminishing resources (in terms of time and effort) must be directed at significant problems that arise quickly and do not respect property boundaries, county lines, and state or federal districts. Landscape ecology focuses on entire agroecosystems and has won favor in the scientific community because many of the large-scale problems cannot adequately be addressed in small plot experiments or even entire fields. Much scientific effort has focused on small scale and limited factor analyses of ecological communities generally associated with agroecosystems. However, this bottom-up approach has been much maligned in the ecological literature because of its limited scope, and because many of these small-scale factors may become insignificant when viewed at landscape scales. Recently, more support has been given to large-scale, landscape analysis of entire watersheds, ecological communities, and agroecosystems. In agriculture, we have seen tangible results from the landscape perspective including: area-wide
management of such pests as boll weevil, Hessian fly, screwworm, and gypsy moth. Significant problems face producers and scouts in soybean in the future, and at least some of these problems could be addressed using remote sensing technologies. For instance, nutrient deficiencies, drought stress, insect damage, pathogen infestations, and delayed maturity are all significant problems over broad geographic areas. The solutions to these problems require an area-wide view. Under the auspices of previous soybean entomological regional projects, viz., S-255 and S-281, it has been demonstrated that Leaf Area Index (LAI), a measurement of the amount of leaf area per unit area, could be used as an indicator of problem or great-risk soybean fields (Hunt et al. 1999). Yield losses are likely to ensue when LAI values drop below critical levels because of poor stand, drought stress, soil problems, nutrient deficiencies, insect damage, or pathogens. It also has been demonstrated that infrared photography from a fixed-wing aircraft can detect variations in LAI within a field. The aim of this project is to conduct research on remote sensing of soybean fields to determine risks of yield loss, and in this manner, direct management strategies to those areas where yield losses are likely. This research will incorporate new technology including satellite imagery, digital orthographic images or quadrangles (DOQs), geographic information system (GIS) software, and global position systems (GPS) in current management practices and scouting techniques. Distribution of the information via the Internet also will be a component of this effort. There are no technical restraints to conducting the research although the GIS, GPS research proposed will require greater dependence on equipment.

In summary, the proposed research addresses new and evolving pest problems that demand attention by researchers in all soybean-growing regions. The potential impact of these concerns warrants that efforts begin now. Soybean producers, consumers, and other stakeholders will be the beneficiaries of the research. This group of scientists has collaborated in three multi-state projects, and some of the participants are second generation with their major professors being founding members of S-74. The group is comprised of scientists in virtually every soybean producing state. This is particularly important with the recent invasion of the soybean aphid in the Upper Midwest and Northeast United States. There is already a track record of productivity documented by numerous publications, edited books, southern region series bulletins, and stakeholder focused literature. Perhaps the most noteworthy publication is the Handbook of Soybean Insects (Higley and Boethel 1994) published by the Entomology Society of America, the first of a nationally known series. The addition of new states, regions, and researchers into this group truly gives this project a national scope. Joining all soybean workers will allow those new to the project to share in the long-term expertise that currently exists in S-281, along with bringing in new perspectives from areas outside the typical soybean entomology arena.

The research proposed for the replacement for S-281 addresses the following SAAESD priority areas; Goal 1-A,B,&C; Goal 2-A; Goal 4-F.
Related, Current, and Previous Work:

The previous soybean entomology regional project, S-281, addressed three objectives during the five year period it has been in existence. The first objective was to determine the effect of production systems with transgenic and other herbicide-resistant soybeans on insect pests and natural enemies. The research conducted over the first four years of the project revealed that the adoption of herbicide tolerant soybean would not significantly affect the soybean arthropod community (Buckelew et al. 2001; McPherson 2000). Thus, no specific changes in IPM approaches are necessary concerning the adoption of these new production practices. If and when transgenic soybeans resistant to arthropods, i.e., Bt-soybeans, are developed and enter the market, their impact on arthropod communities including non-target species will need to be determined.

The second objective was to determine the impact of early soybean production systems (ESPS) on the population dynamics of pest and beneficial arthropods on soybean. Research has defined which and when certain insect pests should be a problem, and hence the critical periods for monitoring their abundance. Adoption of ESPS can have positive and negative effects on insect management. The early planting dates and early maturing varieties associated with ESPS generally allow for escape from late season migrating lepidopterous pests, such as soybean looper, velvetbean caterpillar, and green cloverworm (Boyd et al. 1997). However, ESPS soybean may be at greater risk to attack by the stinkbug pest guild commonly found in the southern growing regions of the United States (McPherson et al. 2001). The incidence of bean pod mottle virus was higher in ESPS than conventional soybean, undoubtedly associated with larger numbers of the vector, bean leaf beetle, being found in ESPS (Baur et al. 2000).

The final objective of S-281 was to determine the influence of environmental variability, specifically water stress, as soybean responds to insect injury and to develop management tools that account for environmental considerations. Yield responses of soybean subjected to combined stresses from defoliation and drought indicated that the stresses are independent, within the context of a given canopy size (Haile et al. 1998). Economic injury levels and economic thresholds for defoliators on stressed and non-stressed soybeans were developed. Drought stressed soybeans were found to be more susceptible to spider mite problems (Hammond, unpublished data). Although more research is needed, preliminary data suggest that leaf area index (and reduction thereof) can be used to assess the need for management of defoliators (Hunt et al. 1999; Board and Boethel 2001).

Current research related to this proposal concerns the efforts already occurring towards understanding the relationships between the bean leaf beetle and soybean aphid and soybeans. A few states have begun examining the ability to control the overwintering population of bean leaf beetle to limit the occurrence of bean pod mottle virus. Early indications are that a spray following soybean emergence, plus an additional insecticide application in July against the first generation of the insect, offers promise (Krell and Pedigo, unpublished data). The possibility of using this approach by applying a systemic seed treatment is being discussed. This overall approach to management of bean leaf beetle and thus, reducing the incidence of bean leaf beetle is but one objective that needs a regional approach over multiple states.
With the introduction of the soybean aphid into the U.S., most researchers involved in this proposal have begun work towards management of this insect. This ranges from states in the northern soybean production areas where detailed biological studies are being done along with the development of management programs, to more central U.S. states where the aphid occurred for the first time in 2002, to the southern states where monitoring for the soybean aphid will be essential in the coming years. Although it is questionable whether the aphid will become established as a significant pest in the southern states, the potential nevertheless exists. Current efforts against the soybean aphid are under the auspices of NC-502 that was established in October 2000 following the discovery of the aphid in the Midwest. Although a North Central project, it nevertheless had membership and participation from most soybean producing states including those in the south. That project is scheduled to terminate in September 2002 (the same time as the current S-281), at which time regional efforts will be coordinated through this proposed project, the revision of S-281. There are also regional efforts towards biological control of the aphid through NC-125, Biological Control of Arthropods and Weeds, of which numerous participants belong to both groups. Collaborative efforts with this group are expected.

There is also research directed toward soybean viruses through the auspices of a new regional project, NCR-200, Management Strategies to Control Major Soybean Diseases in the North Central Region. That group, however, is a virus-disease oriented project. This proposal will focus on the role vectors play in spreading virus and develop management tactics that focus on proven cultural practices that can mitigate virus spread. Additionally, numerous members of this proposed project are members of that group, and strong collaborative efforts as well as with other plant virologists and pathologists are expected.

Objectives:

Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.
Define insect-vector ecology and virus-disease relationships and develop management strategies.
Biological control of the soybean aphid in North America.
Apply geospatial and precision technologies to advance pest management in soybeans.

Methods:

Participating states by sub-objectives are provided in an attachment.

Objective 1 (AR, GA, IA, IL, IN, KS, KY, LA, MI, MS, ND, NE, OH, TN, TX, VA, WI, and USDA (MO)).

Sub-objective 1a. Develop management strategies for the soybean aphid.

Document distribution and develop standardized sampling protocols. -- Soybean fields throughout the Midwest will be sampled for soybean aphid from early vegetative stages through reproductive stages to improve soybean aphid sampling to produce quantitative estimates. Sampling protocols will be those as presented through the NC Pest Management Center’s Website. Soybean fields elsewhere will be sampled to document continued spread of the soybean
aphid. In areas with aphid build-up, sampling will intensify and as understanding of aphid biology and population dynamics increase, sampling protocols will be optimized for geographic surveys, research needs, and pest management. Suspected soybean aphid overwintering habitat (Rhamnus spp.) and other suspected overwintering hosts also will be sampled and data will be reported on the national database. Locations of Rhamnus populations will be marked with GPS coordinates and referenced to locations of nearby soybean fields. Selected populations of Rhamnus will be monitored to determine key phenological events (e.g., arrival and departure of aphids to/from overwintering, etc.) and aphid densities and survival. The relative risk of aphid invasion into soybean fields will be determined from the spatial relationships between the primary (Rhamnus) and secondary (soybean) host and the aphid dynamics-damage in monitored fields.

Determine soybean response to the soybean aphid. -- Research plots will be established in areas where soybean aphid infestation is expected and opportunistically where aphid populations develop. Plots will receive various insecticide treatments to establish different levels of infestation. Depending on location, physiological responses (e.g., photosynthetic rate, stomatal conductance, transpiration rate) of aphid infested and non-infested soybean will be measured at different infestation levels and plant stages. Preliminary research indicates that photosynthetic rate reductions occur at low aphid intensities and are not associated with chlorophyll loss. Plant growth parameters (e.g., plant growth stage, plant height, number of branches) and yieldparameters (e.g., number of 0-, 1-, 2-, and 3-seeded pods, pod, seed, and stem dry weight) also will be taken. ANOVA procedures will be used to identify significant treatment effects and regression analyses will be used to identify significant relationships. Results of these studies identify the physiological basis of yield loss and will be used to develop economic injury levels. Use of similar or common procedures and common measurements will allow analysis of plant response data regionally (within appropriate groupings, such as soybean maturity groups).

Develop management strategies for soybean aphid. -- Preliminary studies indicate host plant resistance holds promise for managing soybean aphid. Illinois studies identified 18 cultivars that exhibited resistance to soybean aphid. Trials will continue to be conducted to identify and characterize soybean aphid resistant cultivars. Preliminary studies also indicate planting date plays a role in aphid population build-up and resultant feeding injury; late-planted soybeans appear more susceptible to large aphid population build-up and injury. Soybean aphid management must occur in the context of other soybean production and pest management practices. In particular, grower practices may significantly influence soybean aphid population buildup and natural enemies. Studies will be conducted to determine the effect of planting date and cropping system on soybean aphid establishment, build-up, biology, injury, and economic damage to soybean. Insecticide trials also will be conducted. Treatments will combine planting date, row spacing, cropping system, different compounds, and plant stage-specific insecticide application. Initial work on resistance management will focus on establishing baseline susceptibility of aphid populations regionally for comparison of susceptibility in later years. Depending on need over the life of the project, additional work on monitoring, discriminating dosages, and management plans may be undertaken.
Sub-objective 1b. Validate emerging management strategies for the bean leaf beetle.

Recent research from Iowa has resulted in a bean leaf beetle management strategy based on sweep-net sampling the F1 population, using the F1 population densities to predict if the F2 population will reach economically damaging populations, and if necessary, treating the F2 population early in its population growth period. Because overwintering habitat and other environmental factors vary, studies will be conducted to validate this strategy where it occurs. Potential fields will be identified and sweep-net sampling of F1 beetles will begin. Sampling will continue on a weekly basis through late reproductive stages to validate that F1 population densities are closely correlated to F2 population densities, and that F1-based predictions of F2 economic thresholds are valid.

Sub-objective 1c. Develop management strategies for insect pests of soybean under evolving cropping systems.

Threshold development for soybeans under multiple stresses. -- Research will be conducted to develop economic thresholds for soybeans under multiple stresses. General procedures will include insect/injury treatments combined with other stresses as appropriate to location. Experimental design will be a randomized complete block with 4 replications. Treatment design will be split-plot or split-split plot, depending on the combination of stresses. Depending on location and combination of stresses, physiological responses (e.g., photosynthetic rate, stomatal conductance, transpiration rate) will be measured at different plant stages. Plant growth parameters and yield parameters will be taken. ANOVA procedures will be used to identify significant treatment effects and regression analyses will be used to identify significant relationships.

Threshold development for value-added soybeans. -- Studies will be conducted to examine the effects of early season and mid-season defoliation on value-added soybean varieties including high sucrose and high protein varieties. Experimental design will be a randomized complete block with 4 replications. Treatment design will be a split-split plot consisting of soybean variety as main plots, insect injury as subplots. Plant growth parameters and yield parameters will be taken. ANOVA procedures will be used to identify significant treatment effects and regression analyses will be used to identify significant relationships.

Arthropod pest management in transgenic soybeans. -- Studies will be conducted to examine the arthropod complex in transgenic, Bt soybeans, with particular emphasis on secondary pests and beneficial organisms. Initial studies will include arthropod sampling, including sweep net, visual counting, sticky trap, and pit-fall trap. As insect resistant transgenic soybean production is in its infancy, research procedures will evolve as experience and understanding of these soybean varieties develop. Work on resistance management will initially focus on the development of baseline susceptibility data.

Objective 2 (GA, IA, IL, MI, MN, NE, OH, and WI)

Sub-objective 2a. Examine relationships between bean pod mottle virus and its primary vector, the bean leaf beetle.
Bean leaf beetle overwintering and initial transmission of bean pod mottle virus to soybean. -- Visits will be made in early spring to areas that had noticeable F2 generation bean leaf beetle populations the prior year. Bean leaf beetles will be collected from overwintering sites prior to spring emergence. Cages also will be used to confine fall-collected beetles throughout the winter. Beetles will be tested for the ability to transmit soybean mosaic virus. Earlier observations suggest that a positive ELISA finding for the virus does not reflect an ability to transmit the virus to newly emerged plants. Thus, individual bean leaf beetles will be placed on to potted greenhouse plants to determine their ability to transmit the virus. We will determine the ability of the overwintered beetle to transmit the virus throughout the soybean growing regions of the United States.

Soybean planting dates in relation to bean leaf beetle infestations and incidence of bean pod mottle virus. -- Soybean fields within a limited geographic area, planted at various planting dates in the spring, will be located. The various generations will be sampled from these fields to include representatives of the overwintered, F1, and F2 generation. Beetles will be assayed with ELISA to determine the presence of the virus. Observations will be recorded for viral symptoms during the growing season started on late vegetative stages and proceeding through the reproductive stages. This would include recording the presence of green stem syndrome and mottled seeds at harvest. In those cases where symptoms exist, leaves will be taken to plant virologists for virus detection by ELISA.

Insecticide control of bean leaf beetle and management of bean pod mottle virus. -- Preliminary data suggest that an insecticide application following crop emergence, followed by a second insecticide application in July at the beginning of the F1 generation is effective at reducing the incidence of bean pod mottle virus (Krell & Pedigo, personal comm.). Studies will be conducted using large, replicated plots. Plots will be arranged in a randomized complete block design with at least 2 treatments, plots with both spray applications and plots without any spray. The presence of bean leaf beetles will be monitored during the summer using sweep net sampling. Near plant maturity, plants will be examined for the presence of virus symptoms including green stem syndrome. At harvest, representative samples of seed will be collected for examination of mottled seeds. Analyses of variance will be used to determine whether the spray applications reduced the incidence of virus-symptoms.

ESPS in wide row and narrow row production in relation to bean leaf beetle populations and incidence of bean pod mottle disease. -- Insect population densities and disease levels (ELISA procedure) will be quantified for varieties of different maturity groups in different replicated, large plot early season production systems (ESPS) in narrow row and conventional plantings to determine dynamics of the bean leaf beetle and bean pod mottle disease for making decisions on the need for application of insecticide or other control measure for insect pest and disease management. Yield measurements and cost/benefit economic analysis of insect control, resulting in reduction of bean pod mottle disease, will determine the economic benefits obtained, if any, of insect pest management in the different soybean production systems.
Sub-objective 2b. Examine the potential for soybean aphid to be an effective vector of soybean mosaic virus, and whether the virus is increasing in incidence in the major soybean growing areas of the U.S.

Research has determined that the soybean aphid is able to transmit North American strains of soybean mosaic virus and alfalfa mosaic virus in controlled environment experiments. The question remains how effective of a vector the aphid is in the field, and whether the incidence and severity of aphid transmitted viruses will become greater. At this time, observations suggest that they are not on the increase. However, this project feels it is important to maintain vigilance towards that possibility. Throughout the soybean growing production areas, the incidence and severity of virus-like symptoms will be continuously observed. During any and all studies involving the soybean aphid, we will examine the plants within the various plots for differences in symptoms. In those cases where symptoms exist, leaves will be taken to plant virologists for virus detection by ELISA. If soybean viruses do become a greater problem, we anticipate working closely with virologists and the NCR-200 regional project to develop appropriate management tactics.

Objective 3 (AR, IL, KY, MI, MN, MS, OH, WI, and USDA (MO and MI))

Sub-objective 3a. Importation of exotic natural enemies for controlling soybean aphid.

Foreign exploration of natural enemies, including parasitoids and predators, began in the summer of 2001 with 2 expeditions, one to northeastern China (Drs. Heimpel, Wu and Ragsdale) and one to Japan (Drs. O’Neil and Voegtlin). The aphidiine braconids, Lipolexis gracilis Foerster and Lysiphlebus fabarum (Marshall) were found attacking soybean aphid in China. An aphelinid, Aphelinus albipodus Hayat and Fatima, was found attacking soybean aphid in Japan. These parasitoids were shipped to the USDA Beneficial Insect Introduction Research Unit in Delaware and reared under quarantine. Only L. gracilis and Aphelinus albipodus are now in culture with L. fabarum being lost in a mixed culture.

Research thrusts to be considered will include the development of a set of protocols to guide decisions on natural enemy releases and evaluation of impact, continued exploration for SBA in Asia, collaborating with Asia scientists to define essential relationships among SBA its natural enemies and host plants, determination whether there are different strains of natural enemies adapted to conditions similar to U.S. soybean production areas, and monitor releases, and evaluation of the success of natural enemy establishment and impact on SBA populations and damage.

The effort will examine all types of natural enemies and is not limited to parasitoids. Appropriate permits from USDA/APHIS/PPQ and responsible state agencies will be facilitated by cooperating project members. This regional project will develop linkages to regional biological control groups (e.g., NCR-125 in the Midwest) to aid in research coordination and communication. The following objective will be an initial effort of this project:
Release of Aphelinus albipodus. -- A. albipodus has been released in the western U.S. against the Russian wheat aphid. This parasitoid has USDA APHIS approval for release in the U.S. but researchers will need approval from state regulatory authorities prior to release within any state where the soybean aphid now occurs. In late 2001, personnel from the USDA APHIS laboratory in Niles, MI were able to collect A. albipodus from Wyoming. This winter they demonstrated that the Wyoming strain of A. albipodus will parasitize soybean aphids under laboratory conditions. In 2001, this same parasitoid was found attacking soybean aphid in Japan. The Japanese strain of A. albipodus is currently being maintained in 2 separate laboratories awaiting further host testing prior to making an application to USDA APHIS for permission to release the Japanese strain of A. albipodus. USDA APHIS personnel are able to provide state cooperators with A. albipodus mummies (Wyoming strain) for the purposes of establishing their own colony. No special precautions are needed to prevent accidental release once state approval for release is obtained.

Releases will be made in 6 x 6 foot cages containing soybean with small soybean aphids colonies with plants that are in the early vegetative stages. Soybean aphids will be sampled twice weekly with adult aphids or mummies returned to the laboratory to confirm parasitization. When a high proportion of aphids are parasitized (>25%) cages will be removed and parasitoids will be allowed to move outside of the cage to adjacent soybean fields. Sampling at known distances from the release point will continue twice weekly until soybeans reach maturity. Soybeans will be planted in subsequent years either in adjacent fields or in the same field and monitored for presence of parasitoids to determine the success of this species to overwinter locally. As the Japanese strain of A. albipodus becomes available or other parasitoids are approved, releases of these natural enemies will be made. At least 2 locations will be selected for initial releases, with additional states participating as the project proceeds.

Sub-objective 3b. Conserving natural enemies.

Research will focus on native and naturalized natural enemies already present in North America. As the invasion front of the soybean aphid passes it appears that soybean aphids are not reaching as high a density (C. DiFonzo, personal comm.). Work on generalist predators, e.g., Nabidae, Anthocoridae, Chrysopidae, and Coccinellidae, is underway in many states. There is also a suite of pathogens that will infect soybean aphids and there may be cultural practices that will encourage earlier onset of epizootics of entomophthoraceous fungi. Research will focus on how to conserve natural enemies through management practices implemented by growers and how to account for natural enemies as economic thresholds are developed.

Objective 4 (LA, ND, NE, TX, and VA)

This objective is to develop criteria for insecticide application based on remote sensing technology (digital aerial photography) that is cheaper and more efficient than the method currently used. Currently, the decision to employ control measures is based on scouting fields and employing a control tactic when insect damage in terms of yield loss is equivalent to the cost of control. It would be more cost efficient to be able to scout fields from the air (either airplanes or satellites). Scouting by airplane would increase statewide yields, lower production costs to producers (thus increasing profit margins), and bolster the entire consulting/aerial applicator
industry by increasing their efficiency and lowering their costs. Radiometers or digital cameras mounted on airplanes could quickly assess leaf area weekly during periods when defoliation is likely. We propose to develop models based on ground based collections reflectance spectra and canopy light attenuation curves from soybean fields using handheld radiometers and ceptometers. Models then will incorporate leaf angle distributions to arrive at estimates of leaf area based on the light penetration. New technology will be incorporated including satellite imagery, digital orthographic images or quadrangles (DOQs), geographic information (GIS) software, and global position systems (GPS) in current management practices and scouting techniques.

Explore the relationship of vegetative indices, leaf area index, and soybean yield. -- To link remote sensing data to the canopy light interception and leaf area, we will rely on procedures established on measuring the light interception of agricultural crops and generating remote sensing reflectance spectra associated with those agricultural crops (Board & Boethel 2001, Ma et al. 2001). A series of plots will be established to achieve different canopy sizes using 4 planting dates and 5 plant populations. Stand counts will be taken to determine plant population. LAI measurements and aerial color and infrared photos will be taken from a fixed wing aircraft every 2 weeks beginning at the V5-6 growth stage until flowering - and weekly after flowering. Vegetative indices will be developed from infrared photos using the ArcView GIS software. Yields will be taken using a small-plot research combine. Correlation and regression analyses will be used to determine the relationship of vegetation index (VI), leaf area index (LAI), and yield. Because of the focus of the project, the expertise of plant pathologists, geographers, agronomists, entomologists, and consultants may be needed.

Measurement of Progress and Results:

Outputs:

Develop standard sampling protocols and multiple management strategies for the soybean aphid. Determine the overwintering survival ability of the bean leaf beetle and determine the correlation between the F1 and F2 generations.

Develop thresholds for value-added soybeans and when the crop is under multiple stresses.

Determine how bean pod mottle virus is transmitted by the bean leaf beetle in the field, and examine the ability to lesson the impact of the virus by insect management with multiple applications of an insecticide.

Establish an incidence base line for aphid transmitted viruses (soybean mosaic virus and alfalfa mosaic virus) and monitor annually to determine trends in incidence associated with soybean aphid.

The release and establishment of one or more natural enemies of the soybean aphid. Determine the correlation between VI, LAI, and soybean yield using new precision agricultural technologies.
Outcomes or projected Impacts:

Standard sampling protocols for the soybean aphid will allow stakeholders to manage this new pest using multiple tactics, and thus, ensuring soybean profitability.

F1 bean leaf beetle generation thresholds can be used to make treatment decisions for the F2 beetle generation, thus, providing more efficient management of the second generation and reducing pod injury.

Development of new thresholds for value-added soybeans and when under multiple stresses will allow better decision-making by stakeholders and ensuring profitability.

Disease management of bean pod mottle virus is accomplished by control of the bean leaf beetle with two, well-timed insecticide applications.

Released natural enemies are effective in reducing soybean aphid densities and thus, reducing insecticide applications.

Increased use of geospatial and precision technology in pest management in aiding stakeholders to more prescriptively manage existing pest problems.

Milestones:


thresholds under various environments. Continue threshold studies with value-added soybeans and when grown under various stresses. Evaluation of released natural enemies. Develop criteria for insecticide application based on remote sensing technology, and incorporate new precision technologies into management practices and scouting techniques.


Projected Participation: Include a completed Appendix E form

Outreach Plan:

Distribution of the information generated by the new project will be disseminated via the Internet and traditional outreach programs including the various extension programs that exist in all states. Numerous Internet sites concerning the soybean aphid are already established in many of the states, with a central source of information from the North Central IPM Center (http://www.pmcenters.org/Northcentral/Saphid/aphidindex.htm). Because the project will contain southern and north central participants, virtually all the soybean growing area of the United States will be represented and thus, growers in underserved and underrepresented areas should have access to the data generated in a timely manner.

Organization and Governance:

The Technical Committee is comprised of the voting members from each state. The Executive Committee consists of the Chair, Chair-Elect/Secretary, and the Coordinators of the research objectives. The Administrative Advisor and the CSREES representative serve as ex-officio members of the Executive Committee. Each year a Chair-Elect/Secretary is elected and the following year ascends to the position of Chair. The current Chair of S-281 is Gary Lentz, Tennessee, with Ron Hammond, Ohio, serving as Chair-Elect/Secretary.

Literature Cited:


Attachments: [participating-states-by-sub-obj.doc]

Internal Linkages: AR, GA, IA, IL, IN, KS, KY, LA, MI, MN, MS, ND, NE, OH, TN, TX, VA, WI

External Linkages: USDA, APHIS, CPHST, USDA, ARS

Signature(s): [NIMSS Menu] [Multistate Research Guidelines] [Help Page] [Logout]
Participating States by Objectives and Sub-Objectives

Objective 1. Characterize the dynamics and impact of evolving insect pests and optimize insect management as an integral element of developing cropping systems.

Sub-objective 1a. Develop management strategies for the soybean aphid.

- Document distribution and develop standardized sampling protocols. Participating states and provinces will include AR, GA, IA, IL, IN, KS, KY, LA, MI, MS, ND, NE, OH, TN, TX, VA, WI, and USDA (MO).
- Determine soybean response to the soybean aphid. Participating states and provinces include KS, NE, OH, and WI.
- Develop management strategies for soybean aphid. Participating states and provinces include IA, IL, IN, KS, MI, ND, NE, OH, and WI.

Sub-objective 1b. Validate emerging management strategies for the bean leaf beetle. Participating states include IA, IL, IN, GA, MS, NE, OH, and WI.

Sub-objective 1c. Develop management strategies for insect pests of soybean under evolving cropping systems.

- Threshold development for soybeans under multiple stresses. Participating states and provinces include NE and OH.
- Threshold development for value-added soybeans. Participating states and provinces include IN, LA, MO, NE, and WI.
- Arthropod pest management in transgenic soybeans. Participating states include AR, GA, KS, LA, MS, TX, and NE.

Objective 2. Define insect-vector ecology and virus-disease relationships and develop management strategies.

Sub-objective 2a. Examine relationships between bean pod mottle virus and its primary vector, the bean leaf beetle.

- Bean leaf beetle overwintering and initial transmission of bean pod mottle virus to soybean. Participating states will include IA, NE, and OH.
- Soybean planting dates in relation to bean leaf beetle infestations and incidence of bean pod mottle virus. Participating states will include NE and OH.
Insecticide control of bean leaf beetle and management of bean pod mottle virus. Participating states will include IA, IL, MI, NE and OH.

ESPS in wide row and narrow row production in relation to bean leaf beetle populations and incidence of bean pod mottle disease. Participating states will include GA and MS.

Sub-objective 2b. Examine the potential for soybean aphid to be an effective vector of soybean mosaic virus, and whether the virus is increasing in incidence in the major soybean growing areas of the U.S. Participating states will include IA, MN, OH, and WI.

Objective 3. Biological control of the soybean aphid in North America.

Sub-objective 3a. Importation of exotic natural enemies for controlling soybean aphid. Participating states will include KY, MN, OH, WI, and USDA (MI).

Sub-objective 3b. Conserving natural enemies. Participating states will include AR, IL, KY, MI, MN, MS, OH, WI, and USDA (MO and MI).

Objective 4. Apply geospatial and precision technologies to advance pest management in soybeans.

Participating states will include LA, ND, NE, TX, and VA.
ACKNOWLEDGMENTS
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