Final Report Project: 10-15-64-19-205-7527

Proposal Title: **2019 NW Minnesota Soybean Research and Tech Transfer**
Institution/Organization: **Regents of the University of Minnesota**
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Schedule/Timeline: **Fiscal Year: 2019**
Start Date: 2019-05-01
Completion Date: 2020-04-30

RFP Reference: **FY19 Production RFP**
Focus Area: Action Team Defined
Area of Focus: **Tech Transfer**

There are three objectives addressed in this project: Soybean Cyst Nematode (SCN), Weed Management Issues and a Soybean Pest and Disease Survey. Our SCN educational efforts are enhanced through cooperation with the soybean breeding team on varietal evaluation. Plots demonstrated the management options of varietal selection and the importance of surveillance. Variety evaluation trials promoted understanding by growers regarding the role of SCN-resistant varieties, provided context for performance by using infested sites, illustrated the importance of SCN population suppression as a component of resistance management, and served as a screening site for UMN SCN-resistant genetics for the northern production area. The weed management projects were studies co-located with the state-wide soybean breeding program and used in field day programs. The study addressed the impact of multiple post-emergence PPO-inhibitors on yields in NW MN where a short season and other factors are more likely to significantly impact yield. Finally, UMN Extension continued the IPM soybean survey initiative in 2019. The survey provided weekly overviews of pest and crop status. As production issues emerge, having people in the field facilitates collection of data and plant material if needed. The program was responsive to developing issues and generated timely alerts for crop managers to assist in making sound economic decisions. In 2019, the survey will also worked to both survey soybean diseases and ground-truth the spore-caster white mold risk application in northwestern Minnesota.

Proposal Objective and Goal Statements:

1) **Soybean Cyst Nematode Variety Trials.** *(PI: A. Peltier in cooperation with J. Goplen, A. Lorenz and A. Killam)*
   a) Assess SCN resistant soybean varieties in NW MN
      i) Assess early maturity SCN-resistant varieties for yield in the region
      ii) Assess impact of varieties on SCN post-season populations.

2) **Soybean Weed Management in NW MN.** *(PI: J. Goplen in cooperation with A. Peltier)*
   a) Assess the effect that PPO inhibitor herbicides have on soybean yield and injury at field sites with IDC and SCN pressure.
   b) Assess herbicide programs for herbicide-resistant weed control

3) **Soybean Crop and Pest Survey.** *(PI: A. Peltier in cooperation with J. Goplen)*
   a) Conduct field surveys to report soybean crop stage and pest conditions in NW and WC MN.
      i) Partner with NDSU in conducting and reporting field and pest conditions across a region that includes NW and WC MN and eastern ND.
      ii) Deliver weekly crop updates based on field observations with emphasis on soybean aphid, bean leaf beetle and other crop conditions as they develop.
      iii) Collect information regarding soybean disease incidence and severity in surveyed fields.
      iv) Ground-truth the spore-caster white mold risk app in NW MN.

Objective 1: SCN Variety Evaluation

The SCN variety trials partnership with the UMN Soybean Breeding program were established at three locations in NW MN (Moorhead in Clay, Callaway in Becker and Gary in Norman County). Plot sites were maintained by the PI and co-PI, implementing necessary weed management during the season. Soil samples were collected by the PI in spring of 2019 to identify fields for field trials in Thief River Falls, Gary and Callaway.

Harvest was completed in mid-October and variety results compiled, summarized and formally published in the "2019 Soybean Field Crop Trials Results" by Minnesota Agricultural Experiment Station and the College of Food, Agricultural and Natural Resource Sciences and is available online (https://adobeindd.com/view/publications/7bafcdad-d10d-49f3-bfda-753594f9d539/6dnr/publication-web-resources/pdf/2019_Soybean.pdf).

Objective 2: **Soybean Weed Management in NW MN.**

Sub-objective a. - Assess the effect that PPO inhibitor herbicides have on soybean yield and injury at field sites with IDC and SCN pressure.

As herbicide resistant weeds have become more problematic in NW Minnesota, the use of PPO-inhibitor herbicides has increased. One of the issues associated with the use of PPO-inhibitor herbicides is the level of soybean injury that can result from herbicide applications. University of Minnesota research in southern Minnesota has shown that soybean yields are not typically affected by PPO-inhibitor herbicides, especially with early-season applications. There has not been research determining the effect that PPO-inhibitor herbicides have when applied to plants suffering from the iron deficiency chlorosis (IDC) symptoms prevalent in NW Minnesota.

We established three sites to evaluate the effect that PPO-inhibitor herbicides have on soybean yield at sites where soybeans may be stressed by IDC and SCN pressure. Early POST applications were made on June 26 and late POST applications on July 18 (Table 1).

Plots were visually rated for percent crop injury on July 25. Data among different locations are combined in Table 2. In general, those plots that received either early POST PPO inhibitor treatments or did not receive a PPO inhibitor treatment sustained less crop injury than soybeans in those plots that received combination early/late POST treatments or late POST treatments. Injury ratings from plots receiving the late POST Flexstar GT treatment were statistically indistinguishable from all other treatments.

Sub-objective b. - Assess herbicide programs for herbicide-resistant weed control.

In an effort to demonstrate relative efficacy of weed control efficacy of PRE-emergence, POST-emergence or combination PRE/POST programs, weed management trials were established at farms near Moorhead, Callaway and Gary in Clay, Becker and Norman Counties, respectively. PRE treatments were applied on May 20 at the Callaway and on June 3 at the Moorhead and Gary locations and POST treatments were applied on June 26 at all locations (Table 3).

Plots were visually rated for percent weed control on July 18. Data is presented in Table 4 in two different ways. The Gary trial location had higher and more diverse weed pressure than the other two locations and so data is presented both separately and when combined with other locations. When data from the three trial locations was combined, all PRE, POST and PRE+POST treatments had significantly better weed control than the weedy check except Outlook applied pre-emergence.

At the Gary location all herbicide treatments were significantly better than no treatment, however some were significantly better than others. Valor SX plus Dual II Magnum and Flexstar GT 3.5 applied pre-emergence and Authority First applied pre-emergence alone or in combination with Flexstar GT 3.5 post-emergence alone or with Warrant all had significantly better weed control than pre-emergence Outlook. Valor SX PRE plus Dual II Magnum POST, Authority MTZ PRE and Flexstar GT 3.5 and Roundup PowerMax POST were not significantly different from any other herbicide treatment.

While one of the pre-emergence only treatments (Authority First) provided among the highest levels of weed control, it is risky for one to rely on a pre-emergence treatment alone as longevity and timing of weed management is dependent upon both active ingredient activation (a function of soil moisture) and concentration (which tends to decline over time). Alternatively, post-only treatments are also risky as herbicide-resistant weeds leave limited post options and adverse field conditions can result in weeds quickly outgrowing herbicide efficacy. A combination of cultural weed management strategies (pre-plant tillage, cultivation, a plant population and row-spacing that promotes canopy closure and crop rotation) and diverse pre and post-emergence herbicide treatments is needed to maintain soybean yield potential and reduce weed seed additions to the soil seed bank.

It would have been ideal to take these experiments to yield. However as they were located in fields owned and managed by our farmer cooperators, we felt it disrespectful to do so and consequently either mowed or roto-tilled these plots before the weeds went to seed.

Objective 3: Soybean Crop and Pest Survey.

a) Conduct field surveys to report soybean crop stage and pest conditions in NW and WC MN.

i) Partner with NDSU in conducting and reporting field and pest conditions across a region that includes NW and WC MN and eastern ND.

ii) Deliver weekly crop updates based on field observations with emphasis on soybean aphid, bean leaf beetle and other crop conditions as they develop.
iii) Collect information regarding soybean disease incidence and severity in surveyed fields.
iv) Ground-truth the spore-caster white mold risk app in NW MN.

The Soybean IPM Survey was funded and conducted for the first time in 2015. We continued this survey in 2019 in coordination with similar efforts in North Dakota. All survey maps are archived by year on the NDSU Pest Management website at: https://www.ag.ndsu.edu/ndipm/ipm-survey-archives/soybeans-archives.

While scouts informally visited random soybean fields starting in early June, later than typical planting and delayed crop development was common throughout the southern four-fifths of Minnesota (Figure 1). Formal soybean field surveys were therefore initiated after Independence Day, lasting until mid-August. A total of 246 formal field visits occurred in Minnesota in 2019. In addition to disease and soybean aphid, scouts also surveyed for two-spotted spider mite infestations on the edge and inside of fields, periodically finding edge-of-field infestations (Figure 2).

A primary focus of the survey was documenting soybean aphid population dynamics. Surveys used a protocol based on the "Speed Scouting" procedure which bases treatment decisions for soybean aphid on the treatment threshold of 250 aphids per plant. Scouts inspected a minimum of 31 plants at random from randomly selected soybean fields; plants with aphids were noted and used to determine the percentage of plants with at least one aphid. Aphid population densities on individual plants were visually estimated and tallied on field cards (Figure 3) by the numerical range estimated.

It has been noted during the survey when using this sampling protocol in years past, that surveyed fields were unlikely to approach treatment thresholds until fields had 90% or more of the plants infested. However having greater than 90% of plants infested did not mean that fields had reached treatable levels. People scouting fields to determine infestation levels should keep this in mind and consider using "Soybean Aphid Speed Scouting" for assistance in determining the need and timing for treatment. The concept of aphid speed scouting, including the distribution of scouting worksheets and cards and the demonstration of the "Aphid Speed Scout" app on both Android and iOS tablets, was shared with farmers and other agricultural professionals at soybean plot tour programs in August.

Although incidence and severity remained low, detectable aphid infestations were found in SE & S central (C) North Dakota beginning between June 28 and July 12 and in NW and SE Minnesota between July 19 and 26 (Figures 4 and 5). By August 9, individual fields with as high as 100% infested plants were found in WC and SE MN but densities averaged fewer than 20 aphids per plant. Aphid densities reached as high as 100 aphids per plant in a field in SE Minnesota by August 16 (Figure 5). The later than

normal planting date and related delayed crop development (Figure 1) along with cooler temperatures that occurred in late August 2019 indicated that there had been favorable conditions and time for aphid densities to reach treatment thresholds in some regions of Minnesota in 2019.

There were no soybean diseases of note observed by scouts. Additionally, canopy closure was slow in 2019 and a dry period occurred during the beginning flowering (R1) to beginning pod (R3) growth stages throughout much of the northwest minimizing the threat of white mold developing.

Tech Transfer.

In an effort to both publicize this check-off sponsored survey and provide timely pest management information, ten articles were written and one podcast was taped and posted to UMN Extension websites, receiving 6,066 page views as of this date.

2019 UMN Extension NW MN scouting program underway. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota. June 6, 2019: 583 page views.

Now is time: Monitor for soybean aphids. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota. July 19, 2019: 609 page views.

Have you yet found soybean aphids in 2019? Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, July 26, 2019: 551 page views.

NW MN soybean plot tours – August 13 & 14. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 1, 2019: 538 page views.

Spider mites in soybean. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 2, 2019: 486 page views.

Soybean aphid update. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 2, 2019: 577 page views.

Insect pests trying to avoid detection. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 7, 2019: 489 page views.

Soybeans grown under duress. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 7, 2019: 572 page views.

Soybean aphid update. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 8, 2019: 501 page views.

Soybean aphid update. Peltier. UMN Extension, Cropping Issues in Northwest Minnesota, August 16, 2019: 510 page views.

IPM Podcast: Late season pest considerations in northwest Minnesota. Peltier and Nicolai. UMN Extension, Minnesota Crop News. August 26, 2019: 650 page views.

Field Days for showcasing research plots, variety and breeding work have become an integral part of soybean outreach in northwest Minnesota. One hundred thirty five people attended the five soybean plot tour programs where this and other MSRPC-sponsored research projects were highlighted by the project PI and co-PI, the research director of the MSRPC, members of county soybean and corn grower's associations and reps from companies that had supplied varieties (Table 5).

A twelve question survey was administered to plot tour attendees to gauge whether the NW MN soybean plot tour programs met UMN Extension objectives. Fifty-two percent of attendees (70 people) completed this single page, two-sided survey. Survey respondents farmed a total of 107,286 acres or managed/provided advice for a total of 223,500 acres. Combined, these 330,786 acres represent more than the total number of acres in farms in Clearwater, Mahnomen, Pennington and Red Lake Counties. Respondents were asked to indicate how they would respond to the following statements: Statement 1: I have a deeper understanding of the subject matter as a result of this session; Statement 2: I have situations in which I can use what I have learned in this session and; Statement 3: I will change my practices based on what I learned from this session.

More than 82, 87 and 54 percent of respondents either agreed or strongly agreed that they have a deeper understanding of the subject matter as a result of the session, they have situations in which they can use what they learned in the session and will change their practices based on what they learned in the session, respectively (Table 6).

Summaries of the PPO inhibitor and herbicide programs for herbicide-resistant weed control demonstrations, the soybean crop and pest survey and last fall's MSRPC-sponsored soybean cyst nematode sampling and education program were compiled and submitted for publication in the on-farm research trials booklet distributed at the Prairie Grains Conference on December 11 and 12, 2019 at the Alerus Center in Grand Forks, ND and at many other events held in NW MN over the winter of 2019-2020. At the Prairie Grains Conference the crop and pest survey results were shared during the soybean research reporting session.

To the 384 people in attendance Peltier presented a demonstration session, "Soybean Gall Midge" at the Best of the Best in Wheat and Soybean Research conferences in Grand Forks on February 5 and in Moorhead on February 6. A program evaluation of the session was administered to conference attendees. Results of the Grand Forks program evaluation are listed outside of the brackets and results from the Moorhead location within brackets. Zero percent (4%) indicated that at the Soybean Gall Midge demonstration session nothing was presented that they didn't already know, 24% (15%) reported that while they were already familiar with the topic, the review was useful, 57%

(60%) indicated that they learned something new and useful and 20% (22%) indicated that they gained important insight and information that they will apply in their farming operation, management and/or grain marketing.

Tables and Figures Project: 10-15-64-19-205-7527

Table 1. Herbicide treatment, groups, application rate and timing for 2019 PPO-inhibitor herbicide trials on farm fields near Callaway, Gary and Moorhead

Herbicide treatment	Herbicide Group	Application rate (per acre)	Application timing
Roundup PowerMax[vx]	9	32 fl oz	Early POST
Roundup PowerMax[vx]	9	32 fl oz	Late POST
Cobra[vy]	14	12.5 fl oz	Early POST
Roundup PowerMax	9	32 fl oz	Early POST
Flexstar GT 3.5[vz]	14, 9	2.68 pt	Early POST
Cobra[vy]	14	12.5 fl oz	Late POST
Roundup PowerMax	9	32 fl oz	Late POST
Flexstar GT 3.5[vz]	14, 9	2.68 pt	Late POST
Cobra[vy]	14	12.5 fl oz	Early POST
Roundup PowerMax	9	32 fl oz	Early POST
Cobra[vy]	14	12.5 fl oz	Late POST
Roundup PowerMax	9	32 fl oz	Late POST
Flexstar GT 3.5[vz]	14, 9	2.68 pt	Early POST
Cobra[vy]	14	12.5 fl oz	Late POST
Roundup PowerMax	9	32 fl oz	Late POST

[v] 3 qt/A N-Pak AMS added as adjuvant.

[x] 6.4 oz/A Preference added as adjuvant.

[y] 1 pt/A Crop oil concentrate added as adjuvant.

[z] 1.6 pt/A MSO added as adjuvant.

Table 2. Herbicide treatments, rates, application timing and percent crop injury for 2019 PPO-inhibitor herbicide trials on farm fields near Callaway, Gary and Moorhead

Herbicide treatment	Rate (per acre)	Application timing	Crop injury (%)
Roundup PowerMax[vx] Roundup PowerMax[vx]	32 fl oz 32 fl oz	Early POST Late POST	6.6 b[*]
Cobra[vy] Roundup PowerMax	12.5 fl oz 32 fl oz	Early POST Early POST	2.5 b
Flexstar GT 3.5[vz]	2.68 pt	Early POST	1.3 b
Cobra[vy] Roundup PowerMax	12.5 fl oz 32 fl oz	Late POST Late POST	28.3 a
Flexstar GT 3.5[vz]	2.68 pt	Late POST	18.3 ab
Cobra[vy] Roundup PowerMax Cobra[vy] Roundup PowerMax	12.5 fl oz 32 fl oz 12.5 fl oz 32 fl oz	Early POST Early POST Late POST Late POST	33.3 a
Flexstar GT 3.5[vz] Cobra[vy] Roundup PowerMax	2.68 pt 12.5 fl oz 32 fl oz	Early POST Late POST Late POST	30.0 a

[*] Percent crop injury ratings followed by the same letter are not statistically different at *P* = 0.05.

[v] 3 qt/A N-Pak AMS added as adjuvant.

[x] 6.4 oz/A Preference added as adjuvant.

[y] 1 pt/A Crop oil concentrate added as adjuvant.

[z] 1.6 pt/A MSO added as adjuvant.

Table 3. Herbicide treatments and groups, application rates and timings in weed management trials established in 2019 on farms near Moorhead, Callaway and Gary

Herbicide treatment	Herbicide group	Application rate (per acre)	Application timing
Weedy control	NA	NA	NA
Valor SX Dual II Magnum	14 15	3 fl oz 1.67 pt	PRE POST
Authority First	14, 2	6 oz	PRE
Authority MTZ	14, 5	15 oz	PRE
Outlook	15	18 fl oz	PRE
Flexstar GT 3.5[xy]	14, 9	2.68 pt	POST
Roundup PowerMax[xz]	9	32 fl oz	POST
Authority First Flexstar GT 3.5[xy]	14, 2 14, 9	6 oz 2.68 pt	PRE POST
Authority First Warrant Flexstar GT 3.5 [xy]	14, 2 15 14, 9	6 oz 1.5 qt 2.68 pt	PRE POST POST
Valor SX Dual II Magnum Flexstar GT 3.5 [xy]	14 15 14, 9	3 fl oz 1.67 pt 2.68 pt	PRE POST POST

[x] 3 qt/A N-Pak AMS added as adjuvant.

[y] 1.6 pt/A MSO added as adjuvant.

[z] 6.4 oz/A Preference added as adjuvant.

Table 4. Herbicide treatment, application rate and timing and percent weed control at the Gary location or the Gary, Callaway and Moorhead trial locations combined

Herbicide treatment	Application rate (per acre)	Application timing	All locations	Gary
			Percent control	
Weedy control	NA	NA	64.4 b*	41.6 c
Valor SX Dual II Magnum	3 fl oz 1.67 pt	PRE POST	89.5 a	89.3 ab
Authority First	6 oz	PRE	95.6 a	95.3 a
Authority MTZ	15 oz	PRE	91.1 a	88.0 ab
Outlook	18 fl oz	PRE	80.6 ab	71.6 b
Flexstar GT 3.5[xy]	2.68 pt	POST	93.5 a	91.3 ab
Roundup PowerMax[xz]	32 fl oz	POST	89.2 a	83.3 ab
Authority First Flexstar GT 3.5[xy]	6 oz 2.68 pt	PRE POST	96.7 a	98.0 a
Authority First Warrant Flexstar GT 3.5 [xy]	6 oz 1.5 qt 2.68 pt	PRE POST POST	96.4 a	94.3 a
Valor SX Dual II Magnum Flexstar GT 3.5 [xy]	3 fl oz 1.67 pt 2.68 pt	PRE POST POST	95.7 a	97.0 a

[x] 3 qt/A N-Pak AMS added as adjuvant.

[y] 1.6 pt/A MSO added as adjuvant.

[z] 6.4 oz/A Preference added as adjuvant.

* Values within a column followed by the same letter are not significantly different at *P* = 0.05.

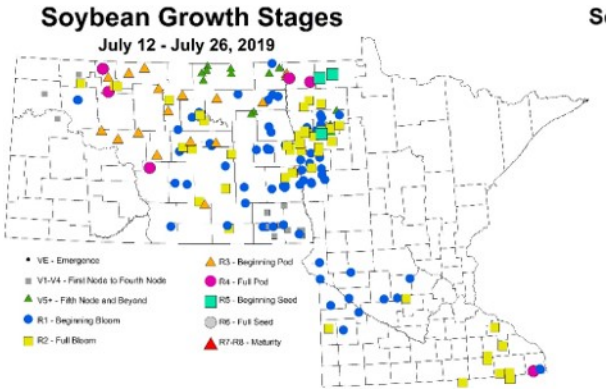
Table 5. Summer plot tour dates, county locations (plot sponsors) and attendance

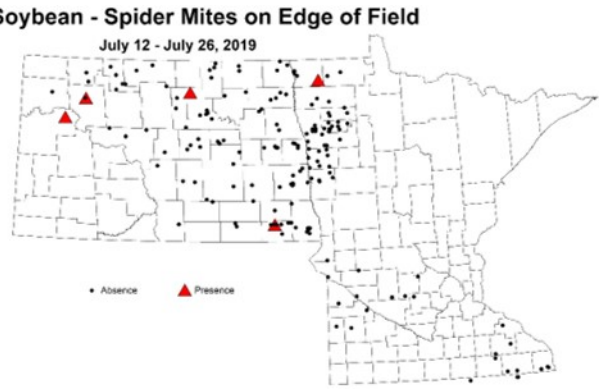
Date	County	Attendance
August 13	Marshall (Potucek Farms)	20
August 13	Pennington/Red Lake (Mehrkens Farms)	30
August 13	Polk (Olson Farms)	30
August 14	Norman (Hanson Farms)	35
August 14	Becker/Mahnomen (Zurn Farms/Select Ag)	20

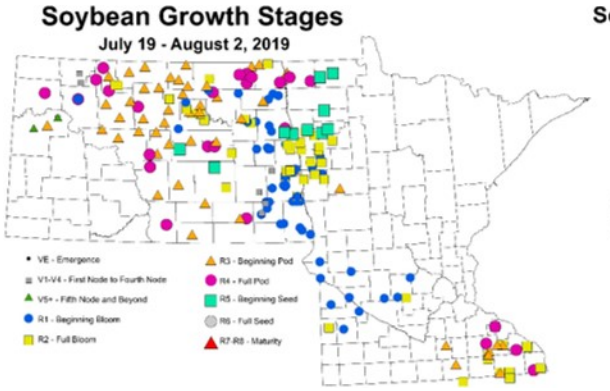
Table 6. Survey responses, expressed as percentage of respondents, to three statements*

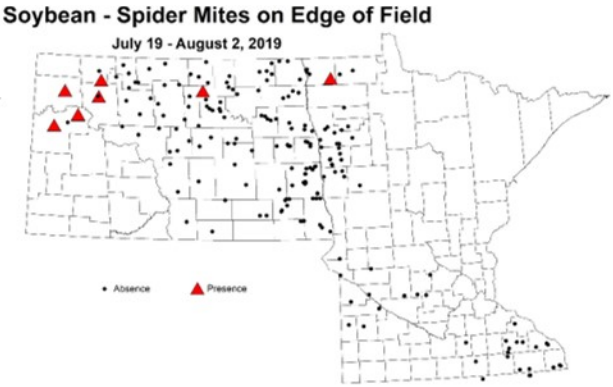
	Survey responses (percentage of respondents, n = 70)					
Statement (n =)	Strongly agree	Agree	Somewhat agree	Somewhat disagree	Disagree	Strongly disagree
1 (69)	18.8	63.7	14.5	1.4	0	1.4
2 (69)	20.3	66.7	10.1	1.4	0	1.4
3 (68)	10.3	44.1	42.6	1.5	0	1.5

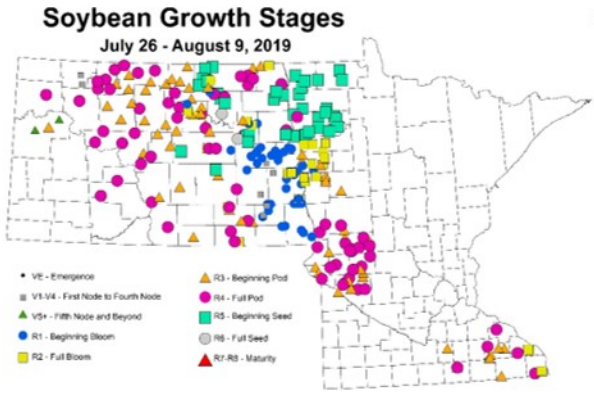
*Statements: 1: I have a deeper understanding of the subject matter as a result of this session; 2: I have situations in which I can use what I have learned in this session and; 3: I will change my practices based on what I learned from this session.

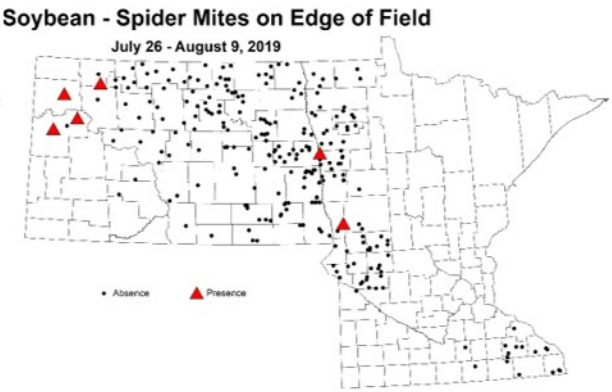


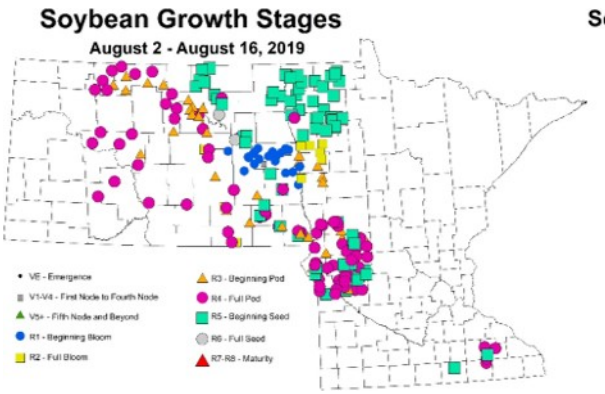












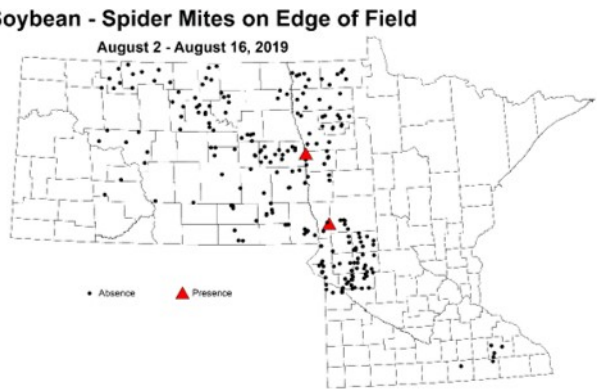


Figure 1. Growth stage of randomly surveyed soybean fields.

Figure 2. Presence (red diamond) or absence of two-spotted spider mites in surveyed soybean fields.

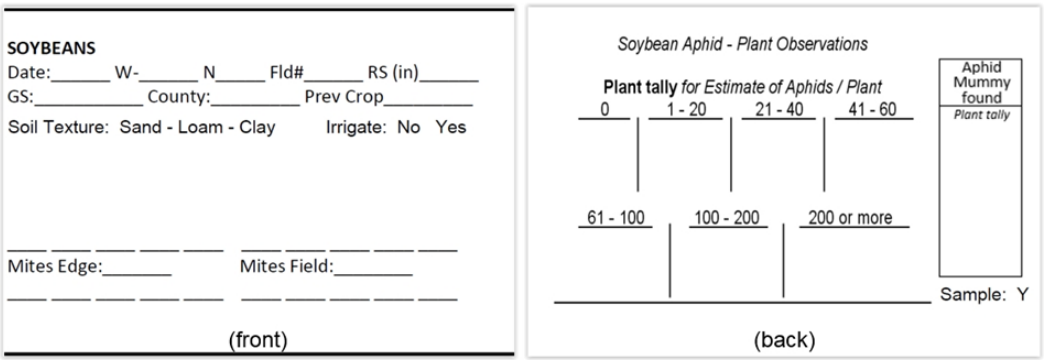
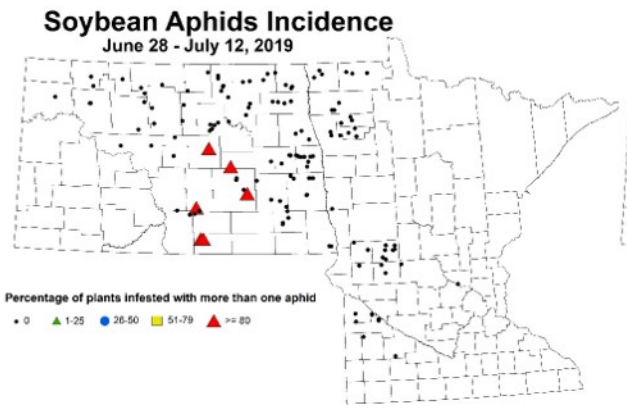
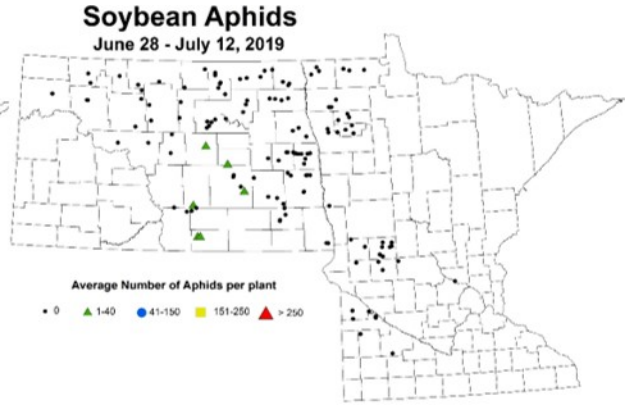
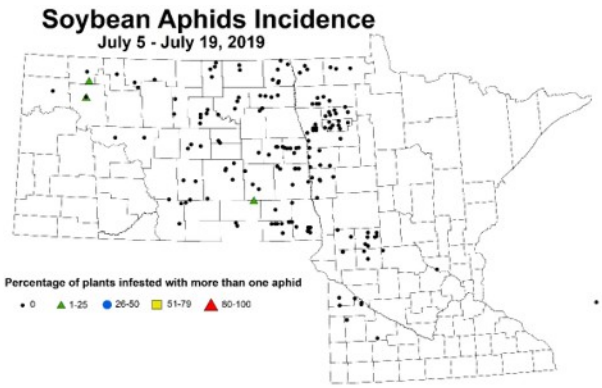
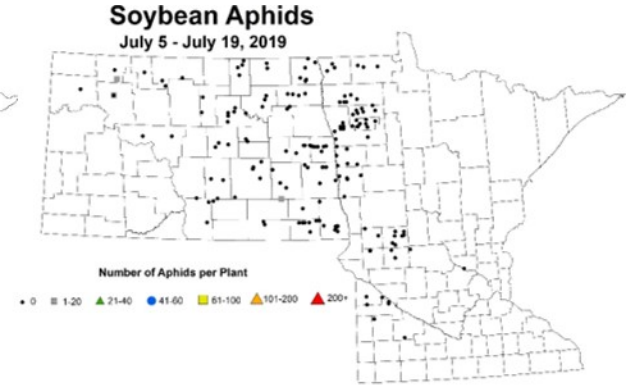


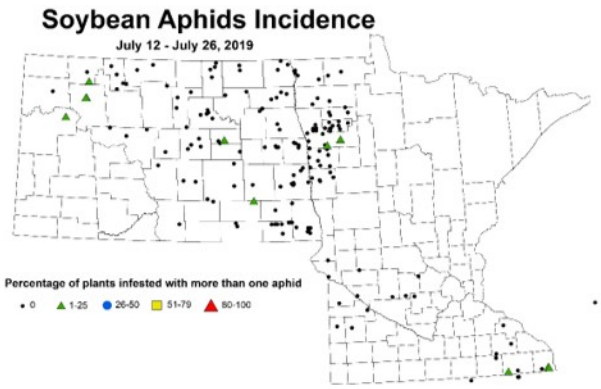
Figure 3. Pocket-sized card used to scout soybean fields for the crop survey.











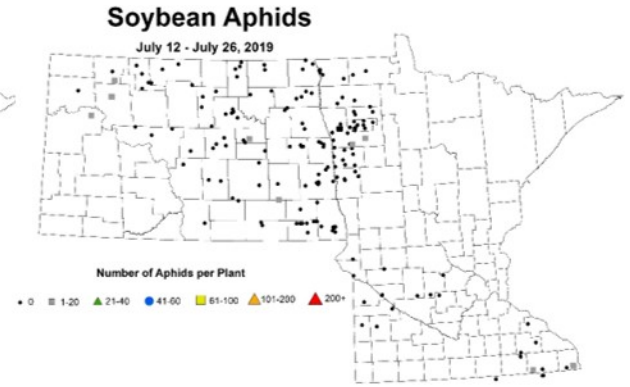
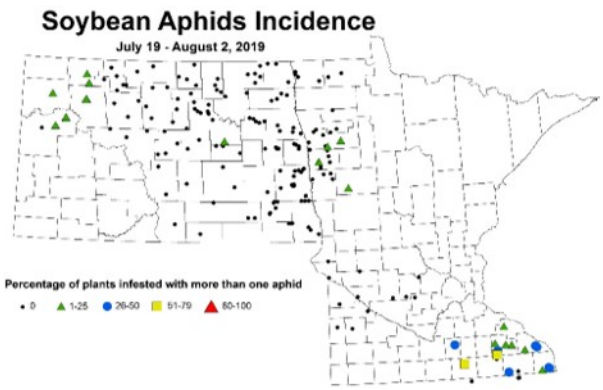
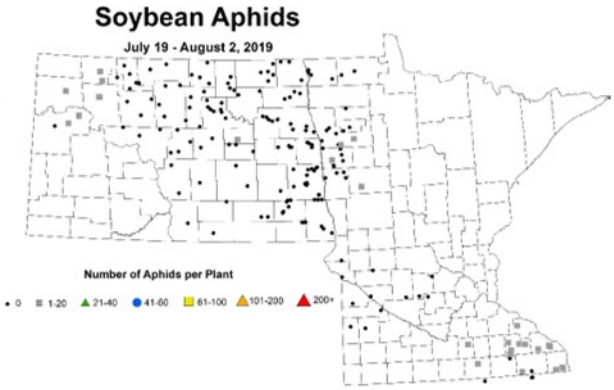
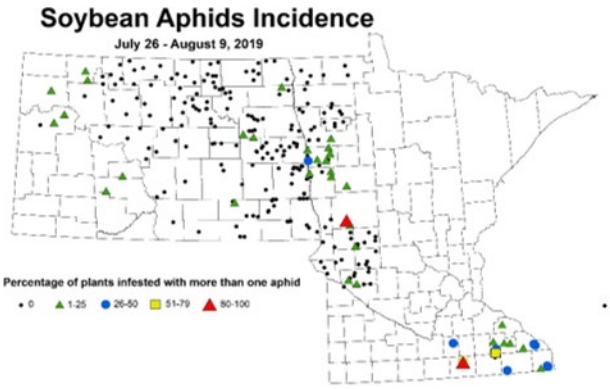


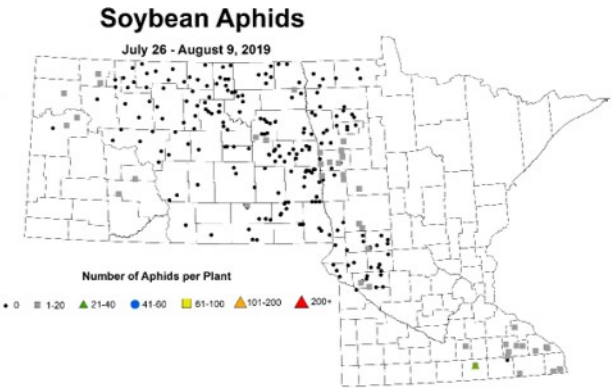
Figure 4. Percentage of surveyed soybean plants with at least one soybean aphid.

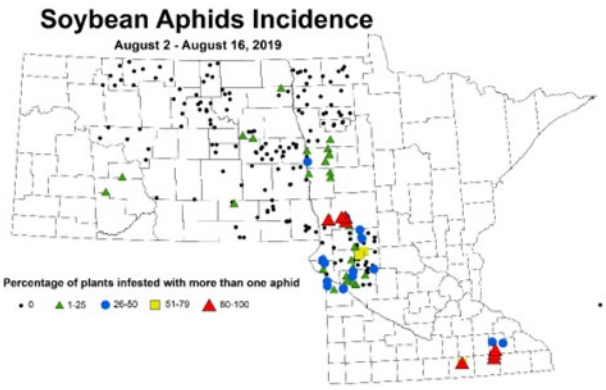
Figure 5. Average number of soybean aphids estimated per surveyed plant.











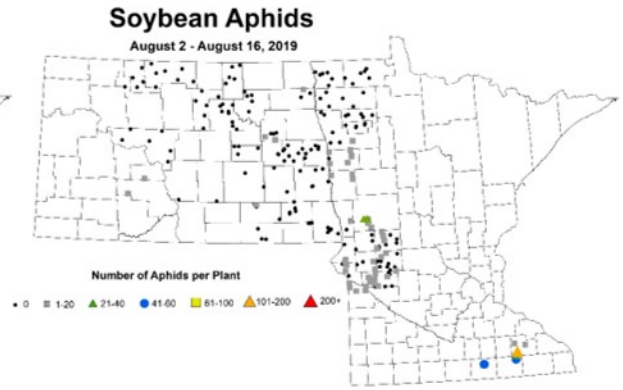


Figure 4. Percentage of surveyed soybean plants with at least one soybean aphid (*continued*).

Figure 5. Average number of soybean aphids estimated per surveyed plant (*continued*).

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