DOES SOYBEAN GENETICS AFFECT SOYBEAN APHID/VIRUS MANAGEMENT?

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The soybean aphid, *Aphis glycines* Matsumura, is one of the most important economic pests affecting soybean production in Wisconsin and neighboring states. Since its discovery in 2000, the soybean aphid has become established in the North Central Region and presents a potential threat to the soybean industry. Insecticides are available for control of the soybean aphid, but are an additional production cost that erodes an already thin margin of profit. Besides issues related to economics, insecticides provide only temporary suppression of aphid populations. Biological control shows promise, but is still unpredictable. Research is needed to explore the possibility of soybean genetics as a long-term means to control soybean aphids.

Direct and Indirect Affects of the Soybean Aphid on Soybean Performance

The soybean aphid is the aphid species in North America to colonize and reproduce on soybean. The soybean aphid directly and indirectly reduces soybean yield by causing physiological injury to soybean, and transmission of viruses (Hill et al., 2001). Besides reduced grain yield, seed from virus-infected plants are mottled which results from hilum pigments bleeding into the seedcoat (Hill, 1999). Mottled grain can be graded lower because of the discolored appearance and growers receive a discounted price. This situation occurs most often for food grade soybeans. Insecticides are an effective control option for soybean aphids, but are an added production cost to growers. Results from insecticide trials in Wisconsin have demonstrated that the soybean aphid causes yield loss across a range of insect population densities. Insecticides have improved yield as much as 20 bushels/acre, but yield responses of 6 to 10 bushels/acre are more typical (Table 1; Myers and Wedberg 2002). Although insecticides are effective, alternative control options are sought to reduce production costs. Observations suggest that early-planted soybeans are at less risk to both direct damage, and virus transmission by soybean aphids. However, early-planted fields are attractive to overwintered bean leaf beetles resulting in a high incidence of *Bean pod mottle virus*.

Soybean aphids are documented to transmit *Soybean mosaic virus* (SMV) and *Alfalfa mosaic virus* (AMV) in Wisconsin. Transmission of each virus increases dramatically as populations of the soybean aphid rise during the growing season. Soybean viruses are controlled by avoidance of transmitting insects, and planting virus resistant soybean varieties. Although two public soybean varieties have been identified as resistant to SMV, varieties resistant to Round Up and viruses are not available. Thus control of viruses must be directed at the soybean aphid. Transmission of SMV has been

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reduced by the application of an insecticide resulting in improved soybean yield in one Wisconsin study (Fig. 1). Research is being conducted to determine whether aphid reproductions differs among soybean varieties, and if so, determine whether this trait has an impact on virus transmission.

Table. 1. Comparison of foliar to seed applications of insecticides to control soybean aphids and improve soybean yield in 2001.

Treatment	Rate of insecticide	No. Aphids – per leaflet	Yield – bu/a
None	-----	5.33a	45.3a
Warrior – foliage	0.028 lb ai/a	2.70b	51.7b
Cruiser - seed	50 GA/100 kg seed	2.50b	55.4b

Aphid control rating – number of aphids/leaflet plant of top trifoliate leaf: 1= 0, 2= 1-10, 3= 11-25, 4 = 26-50, 5 = 51-100, 6= 101-200, and 7= >200. Different letters by treatment means signifies statistical significance at p=0.05.

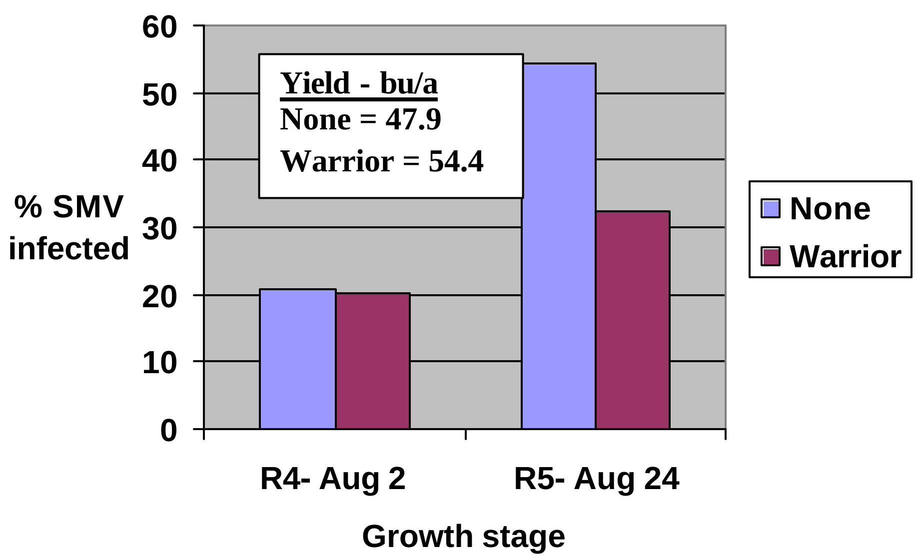

Figure 1. The incidence of soybean plants infected by *Soybean mosaic virus* (SMV) was compared in plots treated or not treated with the insecticide Warrior (lambda-cyhalothrin) after application at 2.56 oz/a on June 27 (V3) and July 30 (R1), 2002 (Arlington, WI). Treatment means were not significantly different (p=0.10) at the R4 growth stage but were different (LSD = 7.3%) at growth stage R5.

Overview of Soybean Genetics and Management of Soybean Aphids and Viruses

Host resistance to components of the insect-virus complex is viewed as the next step in developing a comprehensive management plan for soybean aphids and associated viruses. Field observations suggest that soybean varieties support differing population densities of the soybean aphid. Resistance to SMV is available and is being used in major soybean breeding programs. Recent research has shown that resistance to the soybean aphid is a naturally occurring trait of soybean (Hill et al., 2002). However, sources of resistance are soybean accessions adapted to the southern USA. Efforts are needed to evaluate northern soybean germplasm for resistance to the soybean aphid. Host resistance to the insect-virus complex is viewed as a cost effective long-term solution to the current problem. Research is needed to define the genetic potential of soybean cultivars to control the soybean aphid and associated viruses. Without this information soybean farmers will be forced to rely on insecticides to control soybean aphids, an option less desirable from an economic and environmental perspective.

Soybean germplasm may possess genes that both directly modify insect activity and crop damage, or express traits that allow plants to escape damage by an asynchrony between plant growth and development and the insect life cycle. Mechanisms of genetic resistance to insects are antixenosis (nonpreference), antibiosis and tolerance. Antixenosis (nonpreference) and antibiosis result in reduced population densities of target insect, while tolerance functions by plant recovery and acceptable crop productivity following feeding activity (Horn, 1988; Pedigo, 2000). Resistant host genotypes do not allow, or slow normal growth and development and impede the ability of the insect to complete its life cycle (Pedigo, 2000). Disruption of insect life cycles can be associated with antixenosis (nonpreference) and antibiosis.

Resistance to insects has been reported for soybean germplasm and has focused primarily on Mexican bean beetle, soybean looper, velvetbean caterpillar and corn earworm. All of these insects are foliar feeding insects of soybeans grown in the southern USA. Resistance to leafhoppers, a piercing-sucking insect, has been linked to pubescence, a common trait among commercial soybean cultivars. It is not known whether density of pubescence has an effect on reproduction by the soybean aphid.

Prior to the arrival of the soybean aphid, there was no need for resistance because none of the native aphid species were capable of colonizing soybean and causing direct injury. Variation for varying degrees of resistance to the soybean aphid has been found in soybean germplasm in studies in China (Fan, 1988) and the USA (Hill et al., 2002). Appreciably lower populations of the soybean aphid are observed on specific soybean genotypes in both field and controlled environment studies. Frequently, soybean genotypes are reported to express a resistant reaction in one environment but express a susceptible reaction in another trial. Soybean genotypes with stable responses are reported. Investigators emphasize the importance of evaluating soybean genotypes in multiple environments before classifying genotypes for interaction phenotype to the soybean aphid (Fan, 1988). It was not clear from published reports whether antibiosis or antixenosis (nonpreference) was the mechanism lowering soybean aphid populations in some soybean lines. Tolerant soybean lines were reported (Fan, 1988) and may represent a more common mechanism to reduce yield loss caused by the soybean aphid.

Although immunity to virus disease may be a desired trait, it is not always possible to achieve. It will be several years before virus resistant soybean varieties will be available for Wisconsin soybean growers. Consequently, avoidance or control of aphid vectors may be the most feasible control of soybean viruses in the short-term.

Wisconsin Research on Resistance to the Soybean Aphid and Viruses

A research project was started in 2002 to validate the concept that soybean varieties have a significant role in management plans directed at the control of soybean aphids and associated viruses. The primary goal of this project was to determine whether soybean varieties modify the need and efficacy of insecticides to control the soybean aphid and associated viruses.

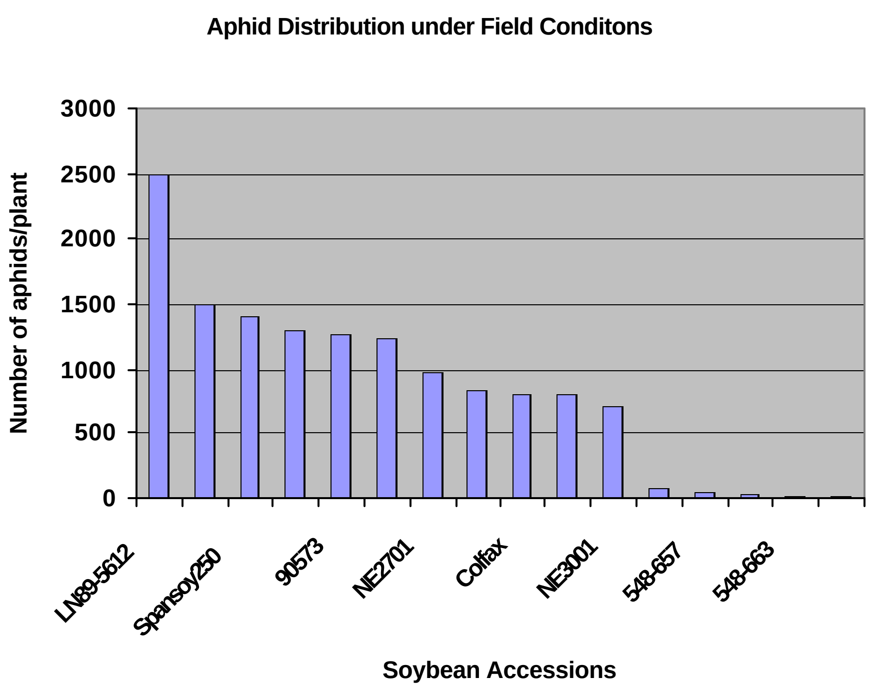

Figure 2. Soybean varieties and lines compared for ability to support reproduction of the soybean aphid in field trials at the Arlington Agricultural Research Station in 2003. Aphid population densities determined on July 28, 2003. Varieties and lines are rated as maturity group II.

Resistance to the Soybean Aphid

Soybean varieties and lines (accessions) were evaluated for colonization and feeding injury caused by the soybean aphid at the Arlington Agricultural Research Station. Plants were evaluated at specific growth stages corresponding to the migration of soybean aphids into plots. Soybean aphids were counted as the total number of soybean aphids per plant between mid-July (R2-3) and August (R5).

Soybean accessions differed for total numbers of soybean aphids observed during early reproductive growth stages in 2003. Accessions adapted to Wisconsin supported moderate to high population densities of the soybean aphid (Fig. 2). The accessions 548445, 548480, 548657, 548663 and 71506 supported 25 or fewer soybean aphids (Fig. 2). Besides low numbers, soybean aphids present on these lines where smaller in size and of a lighter color compared to soybean aphids observed on the other lines. This observation suggests that antibosis may be a mechanism involved to keep population densities low on these lines. These lines are not adapted to Wisconsin, but provide evidence that not all soybean varieties are equally susceptible to the soybean aphid. These accessions are currently being used in breeding programs to transfer aphid resistance genes to elite soybean lines adapted to Wisconsin. Although most soybean varieties and lines supported soybean aphid population densities of 1,000 or more per plant, Colfax, Sturdy, and NE3001 are commercial varieties that supported fewer than 1,000 aphids per plant. These results suggest that soybean varieties and lines adapted to the Northern US differ in susceptibility to the soybean aphid. Elite commercial varieties should be monitored for differences in their ability to support reproduction of the soybean aphid.

Soybean Germplasm Yield Response to Insecticides

A set of soybean varieties and lines were planted at the Arlington Agricultural Research Station in 2003. Each entry was either not treated or treated with Warrior insecticide three times from early July (late vegetative stage) to August 1. Plants were assessed for total number of aphids per plant multiple times during the season. Plots were mechanically harvested at crop maturity.

Four of six soybean lines produced higher yields after treatment with an insecticide compared to untreated plots of each entry. However, BSR 101 and 90573 did not respond to applications of Warrior insecticide even though population densities of the soybean aphid were similar to densities observed on lines that responded to applications of Warrior (Fig. 3). BSR 101 and 90573 are regarded as tolerant to feeding by the soybean aphid.

Genetic Resistance to Soybean Viruses

Feeding injury caused by soybean aphid and soybean aphid reproduction was assessed for experimental soybean lines. Percent of leaf tissue damaged was estimated visually at late vegetative stages and from first flowers to full pod growth stages. Experimental lines were rated visually for severity of leaf symptoms caused by viruses. The incidence of mottled seed was also used to estimate activity of aphid transmitted viruses.

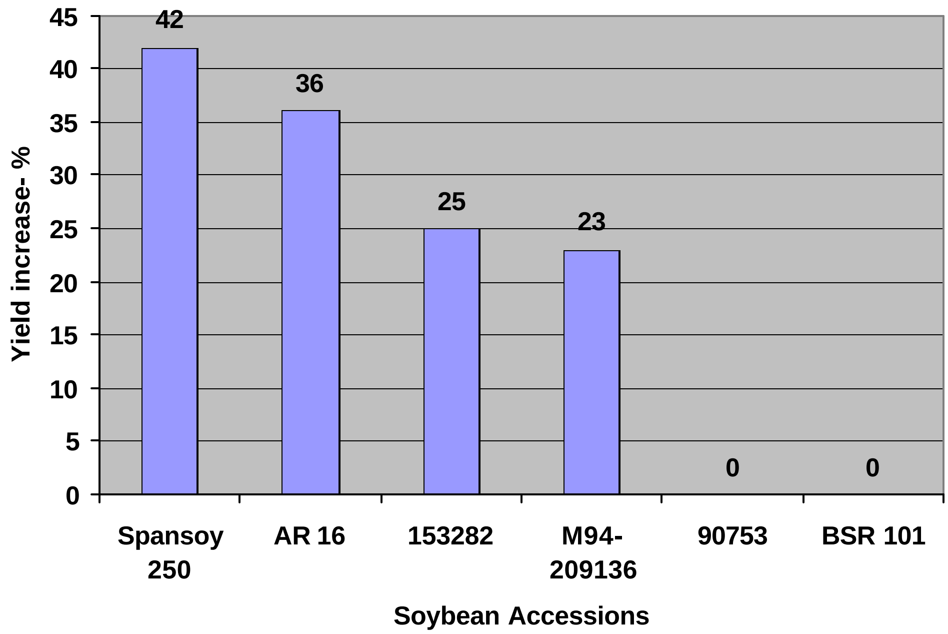

Figure 3. Yield response of soybean varieties and lines treated with Warrior insecticide in field trials at the Arlington Agricultural Research Station in 2003.

Colfax and NE3001, resistant to SMV, had significantly higher grain yield compared to the susceptible variety IA2008R in field trials in 2003. Severity of foliar symptoms, caused by SMV, was significantly lower for the resistant varieties. Control of SMV by soybean genetics greatly improved seed quality (Table 2). Soybean aphid populations were of moderate density and aphid populations were similar for each of the three soybean varieties.

Table 2. Symptom severity and agronomic performance of soybean varieties resistant or susceptible to *Soybean mosaic virus* in field studies in 2003.

Lines	Virus Rating	Yield Bu/a	Symptom severity %	Seed mottle %
Colfax	Resistant	60.0	5	2
NE3001	Resistant	49.9	5	8
IA2008R	Susceptible	37.2	40	65
LSD (p=0.10)		8	27	24

Summary

Resistance to the soybean aphid does exist within soybean germplasm. However, resistance has been identified, but in southern adapted lines and not northern types. Within northern types, there are lines that support lower population densities of soybean aphids, but most varieties are likely susceptible and would respond to applications of insecticides. There is evidence that some soybean lines may not respond to applications of insecticides. These lines supported moderate to high populations of soybean aphids and are considered as tolerant to the soybean aphid. Efforts are needed to evaluate commercial soybean varieties for tolerance to the soybean aphid. Frequently yield improved for soybeans treated with an insecticide to control soybean aphids. However, there are cases documented where a yield response has not been observed. Generally, explanations for this situation are focused on product efficacy, timing and population density of the soybean aphid. Tolerant soybean varieties are another explanation to consider for why yields were not increased by insecticide applications.

Resources

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