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Nominee Name of Team/Group/Project: North Central Soybean Entomology Research and Extension Team
Nominee Main Contact for Group (if applicable): Dr. Kelley Tilmon
Nominee Title (if applicable): Associate Professor of Entomology
Nominee Affiliation (if applicable): The Ohio State University, Dept. of Entomology
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• A summary of the program's accomplishments

The North Central Soybean Entomology team has been cooperatively engaged in insect IPM for soybean for over 15 years, most recently led by Dr. Kelley Tilmon. The team employs a unique blend of applied and basic sciences (including genomics, plant breeding, ecology, and biological control), along with dedicated extension programming. The team researches and develops integrated soybean insect management strategies and provides recommendations through collaborations with university extension, industry, and soybean commodity boards at the state, regional and national levels, and industry.

Initially the main focus of the program was the soybean aphid; the team has since branched out to other pests and beneficial insects including stink bugs, thrips, parasitoids, and pollinators. The team was first formed in response to the soybean aphid, an invasive pest that has severely damaged soybean production in the north central US. This team developed and tested the well-established and commonly used action threshold of 250 aphids per plant. The adoption of this threshold has dramatically reduced insecticide applications, saving growers costly inputs while preserving natural enemies and pollinators. In addition, and in true spirit of IPM, this team integrated other research such as host-plant resistance and biological control. Soybean breeders on this team developed soybean varieties with natural resistance to the soybean aphid. This team is actively promoting their use. Members of the team are also using genomics to develop strategies that extend the durability of aphid resistant soybean; this research contributed to the completion of the soybean aphid genome. Researchers have identified and released parasitoid wasps that provide natural control of the soybean aphid. Truly integrating and promoting these aspects provide substantial resources for soybean producers and a demonstrated improvement of soybean insect IPM.

Notably, this team has included other important issues in soybean insect management. Much focus and public interest centers on the impact of insecticides to honey bees and other

pollinators. The team is currently documenting pollinator diversity in soybean fields across the north-central region. The team has also performed extensive research on the performance of insecticidal seed treatments, which are controversial not only for their impact pollinators, but also because their use is usually inconsistent with IPM approaches. The team is also monitoring for new invasive insects as well as shifts in susceptibility to insecticides.

This team has had extraordinary impact on extension activities that engage soybean producers. These include the *Soybean Aphid Field Guide*, the *Visual Guide to Counting Soybean Aphid*, a three-part webinar series available for free any time on the Plant Management Network, an award-winning series of three animated scouting videos for soybean aphid, and an outreach booth at the 2015 Commodity Classic.

Dr. Ed Anderson, Executive Director of the North Central Soybean Research Program (NCSRP), remarked that "…the aphid and now the broader soybean insect pest programs funded by NCSRP…are the poster children for successful regional programs." Through the cooperation among 12 north central states, and the leadership of Dr. Kelley Tilmon, this team has had tremendous impact for soybean insect IPM.

• Describe the goals of the program being nominated; addressing why the program was conducted and what condition does this activity address? :

The main purpose of this project initially was research and outreach on the soybean aphid, *Aphis glycines*. The soybean aphid is the most damaging insect pest to soybean production in the North Central region, capable of causing yield losses of 40% or more if not properly managed. More recently, stink bugs have become an increasingly prominent pest in soybean, both through the spread of the introduced brown marmorated stink bug, and through range and population expansion of native stink bugs. The goals of this program are to provide producers with research-based information and pest management approaches including well-researched economic thresholds, host plant resistance, and biological control. Additional goals of the program are to document and conserve pollinators in soybean as well as monitor for new and expanding soybean insect pests in the North Central region. The Extension and Outreach component of the team is designed to ensure that the research results generated by multi-disciplinary components are integrated and delivered in a user-friendly format to soybean producers and other stakeholders in a coordinated fashion. In an era of shrinking extension systems and budgets and reduced extension staff, the team implements a coordinated approach to content delivery for efficient use of project resources.

These management factors and choices have potentially large financial implications. This team is developing IPM solutions based on multi-year, multi-location research on soybean insect biology and interactions within the soybean system to provide much needed information to producers, thereby enhancing IPM for soybean insects. Through their collaboration, this team also is able to

respond quickly and effectively to new and emerging issues in soybean insect control, such as erroneous management information, increasing resistance to insecticides, and new insect pests.

• Describe the level of integration across pests, commodities, systems and/or disciplines that were involved. (250 words or less):

This team is composed of 26 scientists in 12 states including entomologists, geneticists, plant breeders, agricultural economists, and extension specialists focused on soybean aphid biology, insect management and pollinator diversity. The breadth of the expertise encompasses applied and basic experimental approaches, ranging from field trials to mapping and cloning resistance genes and completing genomes. The team values collaborative work—many field trials and sampling protocols are standardized and repeated in several North Central states, which increases the power and confidence of data-based management recommendations. The regional approach allows evaluation of aphid resistant varieties, monitoring for insecticide resistance and shifting soybean insect complexes, measuring pollinator diversity surveys, and enhancing biological control. The team has expertise in all facets of IPM for insects and decision making such as breeding for resistance, population genetics, biological control of insects; sustainable IPM approaches; and extension. In addition, the team has had tremendous impact of training the next generation of IPM scientists—the project is currently responsible for training 8 MS and PhD students as well as 3 postdoctoral and 2 undergraduate research and extension projects. The team has leveraged additional support with more than 20 research projects, mostly through state commodity boards and industry that allow more enhanced and expanded research and extension deliverables.

• What outcome describes the greatest success of the program?

This team made excellent strides in key areas in soybean insect IPM.

1. Pest Biology: Characterized biotypes of soybean aphid in the region, identified the virulence phenotypes and how they may develop, sequenced and assembled the soybean aphid genome. They are also documenting the spread of new stink bug pests and insecticide resistance in soybean aphid
2. Host resistance: Identified 16 new sources of resistance to the soybean aphid and determined that a *Rag1 + Rag2* resistant gene pyramid is as effective as an insecticide. In addition they determined experimentally that the combination of these 2 resistance genes with a refuge should provide protection for 25 years. This team mapped resistance and identified candidate genes for *Rag1* and *Rag2*. More importantly, cultivars with these genes are available as a result of this project.

3. Insecticide: Determined that traditional IPM had higher chance of net positive returns than insecticidal seed treatments. Identified the critical threshold during a growing season for economically feasible management of soybean aphid, related critical soil fertility parameters that may enhance or deter the effects of soybean aphid feeding on soybean, developed a speed scouting methodology to enhance implementation of management decisions.
4. Biocontrol: Identified and released 2 parasitoid species. Determined that overwintering is possible and tracked the spread of parasitoids
5. Outreach: Developed field guides, scouting cards, webinar series, and many presentations to train producers on IPM techniques.
6. Sustainability: documented at total of 68 species of pollinators in the North Central region.

• **Provide evidence of change in knowledge, behavior, or condition because of the program.**

The team has an excellent track record of providing such deliverables. The produced the *NCSRP Soybean Aphid Field Guide* (with 17,500 hard copies distributed in the region, and a free download available on NCSRP's Soybean Research and Information Initiative website); the *Visual Guide to Counting Soybean Aphids* field scouting card (4,000 copies distributed, plus free download); a 3-part webcast series on soybean aphid management for the Plant Management Network (open-access presentations available any time); an award-winning a 3-part animated video series to educate producers on aphid-resistant soybean varieties; a postcard with a flash drive to distribute multiple NCSRP publications while reducing printing costs (2,000 copies distributed); an NCSRP multistate research update field event in the summer of 2014; and an outreach booth at the 2015 Commodity Classic where we distributed outreach material and made approximately 2,000 direct stakeholder contacts. Members of this team published an article on stink bugs in the North Central region in May 2017—as of June 2017 this article had 425 page views and discussed by 6 news outlets.

• **Provide evidence of client adoption of IPM practices, improve economic benefits, or pesticide use reduction because of project implementation**. (500 words or less)

The soybean aphid thresholds developed by this group have been adopted by every state extension system in the North Central Region. Song and Swinton (2009) calculated that adoption of the soybean aphid threshold devised by the North Central Soybean Entomology team had a projected economic net benefit of $1.3 billion and a rate of return of 124%, over the 15 years since soybean aphid IPM research began in 2003. Recent work on the economic value of insecticidal seed treatments by the team found an expected net return for the use of scouting and

a foliar treatment at this threshold was was $121.07/ha, compared to an expected net return of $6.97/ha for a prophylactic (e.g., non-IPM) neonicotinoid seed treatment (Krupke et al. 2017).

Song F**,** Swinton SM**.** 2009. Returns to integrated pest management research and outreach for soybean aphid. *J. Econ. Entomol.* 102:2116–25.

Krupke, C. K., A. M. Alford, E. M. Cullen, E. W. Hodgson, J. J. Knodel, B. McCornack, B.D. Potter, M. I. Spigler, K. Tilmon, K. Welch. 2017. Assessing the value and pest management window provided by neonicotinoid seed treatments for management of soybean aphid (Aphis glycines Matsumura) in the Upper Midwestern United States. Pest Management Science. In press.

• Describe the team building process; how did the program being nominated get partners involved?

One of the strengths of this team is its very inclusive nature. It was first formed in response to the crisis of the invasive soybean aphid early in the century. Led by Dr. David Ragsdale, then at the University of Minnesota, field crop entomologists in the North Central Region came together to quickly respond to this new pest, to devise research-based economic injury levels, thresholds, and outreach material. The group was funded in this effort by the North Central Soybean Research Program, a regional soybean check-off organization. The group worked so well together that (with continued support of the NCSRP) they decided to tackle other aspects of insect IPM in soybean, including the development of resistant varieties, research on the ecology of biological control, classical biological control releases, further evaluations of chemical management, and population genetics of pests. Leadership of the group was assumed by Dr. Kelley Tilmon in 2013. Both Drs. Ragsdale and Tilmon have taken a very inclusive approach to team building. Every state in the North Central Region with a field crop entomologist at the Land Grant university participates in the project (with funding), and as new scientists are hired to work in soybean in the region they are invited into the project. Objectives are determined by group consensus, and overall coordination is provided by the project leader.

- **Did this project utilize any innovative methods that could be shared with others?**

This project is innovative in that it considers so many facets of IPM for the benefit of soybean production – best uses of chemical treatment, host plant resistant, biological control, and a strong focus on system ecology. The team has also implemented unique and award winning delivery methods for extension information.

Please share one article that represents the work of the team

Krupke, C. K., A. M. Alford, E. M. Cullen, E. W. Hodgson, J. J. Knodel, B. McCornack, B.D. Potter, M. I. Spigler, K. Tilmon, K. Welch. 2017. Assessing the value and pest management window provided by neonicotinoid seed treatments for management of soybean aphid (*Aphis glycines* Matsumura) in the Upper Midwestern United States. Pest Management Science. In press.

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