THE RELEASE OF A NEW BENEFICIAL INSECT FOR THE BIOLOGICAL CONTROL OF SOYBEAN APHID, A CROP PEST IN SOUTH DAKOTA

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ABSTRACT

The soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae), is an important insect pest of soybean, a major crop in South Dakota. First discovered in the USA in 2000, it was accidentally introduced from Asia and spread quickly throughout Midwest. Insecticides are currently the primary control method for this pest, but biological control—control of pests through beneficial species—is a promising management approach. Soybean aphid is seldom a problem in its native Asia largely because of a group of natural enemies that feed on it. Universities and USDA entomologists have identified the Asian parasitoid *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae) as a promising species to release in the US for biological control of the soybean aphid. Since 2007 South Dakota has been part of a multi-state project to introduce *B. communis* to the region. In the summer of 2008 seven Midwestern states participated in parasitoid releases. Releases in South Dakota were a cooperative effort between SDSU scientists, Extension Educators, and South Dakota producers. We released *B. communis* in ten soybean fields in ten counties in eastern South Dakota. We inoculated release sites with a small number of parasitoids which might increase and spread over time. Two weeks after release we recovered parasitoids in eight of ten fields.

Keywords

Soybean aphid, insect control, biological control, parasitoids, Binodoxys communis

INTRODUCTION

Soybean Aphid—Soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae), is an important pest of soybeans in South Dakota, a major crop in the state. It was accidentally introduced to the United States in 2000 from Asia. Since then, soybean aphid has spread quickly through the Midwestern states (Venette and Ragsdale 2004). Soybean aphids can severely effect soybean production in the Upper Midwest. Before soybean aphid became established, Midwestern soybeans were seldom treated with insecticides; now soybeans are frequently treated. Under heavy aphid infestation, the yield might be reduced as much as 40% from feeding damage (DiFonzo and Hines 2002).

Soybean aphid can also impact yield by transmitting several plant pathogenic viruses, such as Soybean mosaic virus and Alfalfa mosaic virus (Clark and Perry 2002). Soybean aphid has thrived in the USA for several reasons. First, the alternate host plant of soybean aphid is abundant in the Midwest. Soybean aphid must spend the winter on common buckthorn (*Rhamnus cathartica*) (Voegtlin et al. 2004). Common buckthorn is an invasive plant in the region, without which soybean aphid could not have established successfully.

Another factor that has most likely aided in establishment and spread of soybean aphid in the USA is that when soybean aphid was first introduced it lacked the specialized beneficial insects that prey on it and help suppressed in its native range. Soybean aphid is rarely an abundant pest in its native Asia probably because a community of natural enemies has evolved there which contribute to aphid mortality. Some of these natural enemies, like parasitoids, specialize almost exclusively on soybean aphid.

Parasitoids are a class of natural enemy that have an obligatory relationship with the host and are usually fairly specialized to a few closely related host species (Godfray 1994). The adult female parasitoid lays an egg inside a host (in this case an aphid), after which the parasitoid develops from an egg to a larva which feeds on the host aphid from within. The dead aphid becomes a hardened protective shell (a mummy) inside which the parasitoid becomes a pupa. The adult parasitoid emerges from the mummy and seeks additional hosts to parasitized, completing the life cycle (Godfray 1994). In the USA, soybean aphid lacks such specialized parasitoids that evolved with it in its native range (Schmitt et al. 2008). This fact has made soybean aphid a candidate for importation biological control.

Importation Biological Control—Importation (classical) biological control is one type of biological control whose goal is to explore the native habitat of an exotic pest to identify the natural enemies that are particularly effective in suppressing it there, so they can be introduced in the pest's new range to control the pest in the new habitat (Caltagiore 1981). Classical biological control agents of insect pests can be nematodes or pathogens, but are frequently predatory or parasitic insects. Such programs have been practiced in the USA since the 1800s (Caltagiore 1981), often with great success. One very successful example of this is the introduction of parasitoids to control the alfalfa weevil (Kingsley et al. 1993).

In soybean fields in the USA soybean aphid is preyed upon by existing aphid general predators such as Asian multicolored lady beetles *Harmonia axyridis* (Pallas) (Coleoptera:Coccinelidae) (Fox et al. 2004), but specialist parasitoids have been missing as a group of natural enemies. In order to identify potential parasitoids for use in importation biological control of soybean aphid, USA entomologists, with the aid of Asian entomologists, have conducted foreign exploration to assess and collect parasitoids specialized on soybean aphid in Asia (Heimpel et al.

2004). Binodoxys communis (Gahan) (Hymenoptera: Braconidae) was selected as one of the best candidates to introduce into the USA.

Host Range Test—Before a new species, such as a natural enemy, is introduced into the environment, an important consideration is whether it will have a negative impact on other species. For a parasitoid, the most likely potential negative impact would be that it might parasitize non-target hosts. Extensive host range testing is required before the United States Department of Agriculture will issue a permit for the release of an exotic natural enemy.

Goerge Heimpel and colleagues performed rigorous host-range testing to determine what other aphid species B. communis might attack by testing it with 21 native and introduced aphid species, including soybean aphid and the following native species: *Aphis asclepiadis, Aphis monardae, Aphis neri, Aphis oestlundi, Uroleucon leonar,* and *Uroleucon* sp. in order to identify which species *B. communis* could successfully parasitize. The only native species parasitized to any degree was *A. monardae* (Heimpel unpublished data). However, further investigation showed that even though *B. communis* can parasitize this host under laboratory conditions, when the aphids reside on their host plant (bee balm), they nestle in the flower heads away from parasitoid attack, and are further protected by ants (Wyckhuys et al. 2009). These and related investigations indicated that the risk of *B. communis* having negative non-target environmental impacts is very slim, paving the way for the USDA to issue a general permit for its introduction in 2007. Binodoxys communis was brought to South Dakota for local release under USDA Animal and Plant Health Inspection Service permit number: P526P-07-15515.

After the permit to release *B. communis* we conducted a release program to introduce the parasitoid in South Dakota soybeans. Our objective was to investigate the ability of *B. communis* to survive and reproduce in field cages as the first step in release process. Our second objective was to explore the movement of *B. communis* to the surrounding vegetation after the removal of the release cages. Together, these objectives help inform our methodology for future releases.

METHODS

Seven states cooperatively released *Binodoxys communis* in 2008: Illinois, Indiana, Iowa, Michigan, Minnesota, South Dakota, and Wisconsin. The release of *B. communis* in South Dakota (an ongoing project) is a cooperative project between South Dakota State University scientists, SDSU Extension Educators, and South Dakota soybean producers.

The goal of most importation biological control programs is to inoculate certain sites with small numbers of control agents with the expectation that population will become well-established and spread geographically over time, rather than to inundate a large area with high numbers of the new species. Thus we chose ten release sites in ten different counties in eastern South Dakota (Figure 1 and Table 1). Three of these release sites were on SDSU research farms and the other seven were on local producers' fields. Extension Educators identified ap-

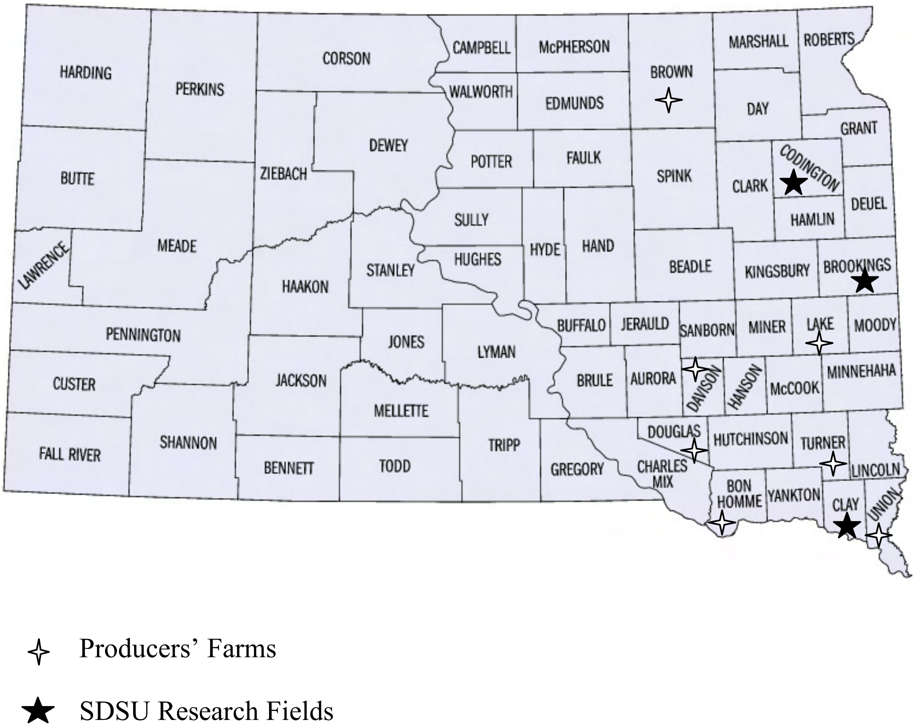

Figure 1. Binodoxys communis release site in Eastern South Dakota in summer 2008.

propriate fields in their districts and willing producers with whom to cooperate. All release sites, except those in Clay County, were next to shelter belts containing common buckthorn.

Release Procedure—Our release procedure involved several steps. In early July we erected fine mesh (Lumite Inc, Greensville, GA) release cages in soybean fields. The cages measured 2 x 2 x 2 meters, and were bottomless so that they could be placed directly over soybean plants. We removed all other insects (including predatory insects) that we found on caged plants to prevent possible interference with parasitoids and host insects. In mid July we thinned soybean plants to 100/cage and added soybean aphids to serve as hosts to the parasitoids. We collected leaves containing soybean aphids in the same field where cages were erected, placed them on the top of 5-6 soybean plants in each cage and allowed them to increase in number for two weeks.

In late July we added two potted soybean plants containing first-generation *B. communis* mummies to the cages. This parasitoid population was first obtained from the colony of G. Heimpel (University of Minnesota) in 2007 and was reared in our greenhouse. The number of mummies varied by location (depending on how successful the greenhouse-rearing was on each plant) and ranged from 337 to 696 per cage (Table 1).

A generation of *B. communis* takes approximately 10-12 days, to complete depending on temperature and other conditions. To amplify the number of mummies in the field beyond what we were able to rear in our greenhouse colony, we allowed sufficient time for adults to emerge from the first-generation mummies and parasitize caged aphids, and for second-generation mummies to form (approximately two weeks). We counted the number of second-generation mummies on soybean plants in the release cages in early to mid August, carefully examining every plant in the cage at each site for mummies. Then we removed the cages, thus permitting any adult parasitoids emerging from them to spread into the surrounding field to parasitize other aphids for another generation.

The final phase of the release for the season was performed in late August and early September. We examined plants around the release point for third-generation mummies to determine if the parasitoids had attacked soybean aphids and reproduced beyond the release point. We selected four plants beyond the former perimeter of each side of the cage for a total of sixteen plants per site. Plants were approximately 45-60 cm apart extending up to 3 m from each side of the former cage border.

RESULTS

The number of second-generation mummies we counted in mid-August (the first-generation mummies being those we added to cages), ranged from 1 to 70 per cage/site (Table1). We found second-generation mummies in cages at all sites except in Codington County where the cage had collapsed in high winds in July.

We found third-generation mummies at the end of August and early September in Bon Homme, Brookings, Clay, Davison, Douglas, Lake, Turner and Union counties but not mummies in Codington Co. (the site where release cages collapsed) or Brown Co. (plants had started to senesce and leaves to drop, carrying any possible mummies with them). The number of mummies ranged from 1 to 430 (Table 1).

DISCUSSION

Biological control has the potential to provide an economical, sustainable, and environmentally-friendly alternative to pesticides for pest management. Importation biological control has been successfully practiced in the USA for the control of invasive pest species since the 19th century (Caltagirone 1981). Once a natural enemy is established, it can provide free pest control that lasts indefinitely. However, the process of identifying, evaluating and releasing a new parasitoid (and the time it takes to become abundant) can be long, and in many cases may end in failure due to poor or no establishment. The study described in this paper is the first year of multi-year effort to introduce imported natural enemy of a crop pest in South Dakota and monitor its establishment.

Table 1. Locations, time line, and mummy counts of B. communis releases in South Dakota.

County	GPS Positions[a]	First-Generation Mummies[b]	Second-Generation Mummies[c]	Third-Generation Mummies[d]
		Week of 7/28/2008	Week of 8/11/2008	8/28/2008 to 9/8/2008
Bon Homme	N42º54.718’ W97º45.736’	587	50-60	430
Brown	e	>500	35-70	0[f]
Brookings	N44º19.460’ W96º46.582	>500	3-15	13
Clay	N43º04.295’ W96º10295’	547	0-2	3
Codington	N45º06266’ W97º06.012’	>500	N/A[f]	0
Davison	N43º41.239 W98º03.630’	696	10-15	350
Douglas	N43º33802’ W98º44.252	491	1-5	1
Lake	N44º00812’ W97º26.013’	593	0-120	47
Turner	N43º13.218’ W96º59.691’	337	0-14	23
Union	N42º37.775’ W96º35.133	650	5-70	23

[a] The GPS coordinates were recorded with e-Trex Legend GPS receiver, GarminLTD, Kansas City, KS
[b] The first-generation of *B. communis* mummies were reared in the greenhouse and transferred to the cages at the release sites. Number of the mummies added to cages varied depending on the numbers of mummies on the soybean plants on which parasitoids were reared.
[c] Counts of second-generation of *B. communis* mummies which developed in the cages. All plants in each release cage were surveyed and mummies were counted.
[d] Counts of the third-generation of *B. communis* mummies were performed on surrounding vegetation near the cage site two to three weeks after cage removal. We counted mummies on 16 plants evenly spaced around the former release cage perimeter.
[e] Missing data
[f] Plants at this site began to senesce and drop leaves before mummy counts were made
[g] A wind storm blew down the release cage on this site.

Our initial efforts to release *B. communis* in South Dakota have been promising so far. The first-generation mummies were released into cages and amplified to second-generation mummies in caged soybean aphids. We also recovered third-generation mummies on soybean plants beyond the cage borders after cages were removed. These findings confirm that *B. communis* is able to reproduce in the field in our region, at least within a season. A greater challenge will be the ability of the parasitoids to survive the winter and to establish increasing populations that spread throughout the soybean-growing region of the state. Even if the parasitoid establishes and spreads, the degree of its impact on soybean aphid populations remains to be seen.

It should be noted that a failure to find *B. communis* during follow-up monitoring the years immediately after release does not necessarily indicate an ultimate failure to establish. Even in very successful parasitoid releases it can take up to several years for parasitoids populations to reach the level where they are detectable (Hochberg and Yves 2000). Thus to maximize the chance of establishment we will conduct additional releases in the soybean production region in eastern South Dakota in the future.

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