Seasonal and Spatial Dynamics of Alate Aphid Dispersal in Snap Bean Fields in Proximity to Alfalfa and Implications for Virus Management

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Environ. Entomol. 33(6): 1593–1601 (2004)

ABSTRACT Alfalfa is a source for viruses that may be acquired by aphids and transmitted to snap bean, *Phaseolus vulgaris* L. Snap bean fields in proximity to alfalfa could have an increased risk of virus infection. Knowledge of the abundance and temporal and spatial dispersal patterns of commonly encountered aphids in commercial snap bean fields, varying in distance from alfalfa, could provide insight into this risk. Alate aphids were monitored using water pan traps in snap bean and alfalfa fields that were adjacent to or >1 km away from each other. The pea aphid, *Acyrthosiphon pisum* (Harris), was the most common aphid species captured in early-planted snap bean fields in 2002 and 2003 (56 and 23% of total, respectively), whereas the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), also was common in 2003 (15% of total). In contrast, the yellow clover aphid, *Therioaphis trifolii* (Monell), and soybean aphid, *Aphis glycines* Matsumura, were the most abundant species trapped in late-planted snap bean fields in 2002 (77% of total) and 2003 (64% of total), respectively. These species were prevalent in traps in alfalfa as well. The abundance and temporal dispersal patterns of these species in snap beans adjacent to and >1 km away from alfalfa were similar, suggesting that the risk for virus infection may not be affected by proximity to alfalfa. A similar number of alate aphids also were captured along snap bean field edges and field centers, regardless of their proximity to alfalfa. This suggests that the aphids dispersed into snap bean randomly rather than directionally from the field edge. The implication of these results is that separating snap bean fields from alfalfa or using crop borders/barriers are not likely to be successful virus management strategies.

KEY WORDS *Aphis glycines*, *Acyrthosiphon pisum*, *Therioaphis trifolii*, *Rhopalosiphum maidis*, landscape ecology

EPIDEMICS OF APHID-TRANSMITTED VIRUSES in snap bean fields, *Phaseolus vulgaris* L., have been prevalent in the northern United States over the past few years (Larsen et al. 2002, Nault 2003). Although several viruses have been detected, Cucumber mosaic cucumovirus (CMV) has been the predominant aphid-transmitted virus in the most severely affected fields as determined by enzyme-linked immunosorbent assays (BAN, unpublished data). Virus-infected snap bean plants may be stunted, bear fewer pods, or have pods that are small, twisted, or necrotic (Hall 1994). CMV is transmitted to plants by aphids (Hemiptera: Sternorrhyncha: Aphididae) in a nonpersistent, stylet-borne manner (Nault 1997). Viruses spread in this fashion are acquired from infected plants within seconds and transmitted just as quickly. There are no snap bean cultivars that are resistant to the strain or strains of CMV that are infecting fields. Thus, knowledge of the temporal and spatial dynamics of alate aphid dispersal into snap bean fields would provide insight into potential aphid/virus management strategies.

The aphid species transmitting CMV into snap bean fields are not known. Noncolonizing aphids, rather than colonizing species, are typically more important in spreading virus to a crop (Raccah et al. 1985, Atiri 1992, Fereres et al. 1993, Dusi et al. 2000). This is because noncolonizing aphids are more likely to probe epidermal leaf cells and continue to disperse rather than to settle down and feed, increasing the likelihood of rapid virus acquisition and efficient transmission (Nault and Bradley 1969). High numbers of inefficient vectors may be more important than low numbers of efficient vectors in the epidemiology of virus diseases (e.g., DiFonzo et al. 1997). In snap bean fields, abundant, noncolonizing aphid species may be the most significant vectors.

The host range for CMV exceeds 800 plant species (Palukaitis et al.1992). However, alfalfa, a perennial crop with known susceptibility to CMV, dominates the landscape in snap bean production regions in New York. In 2002, >230,000 ha of alfalfa were harvested compared with 13,000 ha of snap beans (NYASS 2003).

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In 2002 and 2003, 19 and 13% of plants sampled in New York alfalfa fields were infected with CMV, respectively (DAS, unpublished data). Alfalfa is a major host for the pea aphid, *Acyrthosiphon pisum* (Harris), which has been shown to transmit CMV to narrow-leafed lupin, *Lupinus angustifolius* (Berlandier et al. 1997). In Maryland, densities of *A. pisum* alatae in a lima bean field increased immediately after a nearby alfalfa field was harvested, suggesting that *A. pisum* dispersed from alfalfa into the lima beans (Losey and Eubanks 2000). In 1 of 3 yr in Idaho, Stoltz and McNeal (1982) reported an increase in *A. pisum* alatae densities in some dry bean fields immediately after adjacent alfalfa fields were harvested.

Densities of dispersing *A. pisum* may be greater in snap bean fields adjacent to alfalfa than in fields distant from alfalfa. Furthermore, *A. pisum* may initially enter snap bean fields along field edges (i.e., an "edge effect"), especially those adjacent to alfalfa fields. Winder et al. (1999) reported such an edge effect for the grain aphid, *Sitobion avenae* F., in winter wheat fields. Proximity to alfalfa could therefore significantly increase the risk of virus infection in snap bean. Identifying the abundance and temporal and spatial dispersal patterns of commonly encountered alate aphids in snap bean fields varying in distance from alfalfa would provide insight into this risk. If snap bean fields adjacent to alfalfa are at high risk, potential solutions could be (1) not to plant snap bean fields next to alfalfa, (2) plant a crop border or barrier crop between the snap bean and alfalfa field to intercept viruliferous aphids, (3) harvest nearby alfalfa fields only when emigrating aphids do not pose a threat to snap beans in a vulnerable stage, or (4) control aphids in nearby alfalfa fields.

The goal of this research was to determine if the proximity of alfalfa to snap bean affected alate aphid abundance and temporal and spatial dispersal patterns in snap bean fields. Because *A. pisum* is predominant in alfalfa and this crop dominates the western New York landscape, we hypothesized that (1) *A. pisum* would be the dominant species captured in snap bean and alfalfa fields, (2) fewer aphids would be caught in snap bean fields isolated from alfalfa than in fields adjacent to alfalfa, and (3) more aphids would be caught along field edges than field centers, especially along field edges bordering alfalfa. Based on our findings, we discuss how dispersal of aphids may affect options for managing aphid-transmitted viruses in snap bean fields.

Materials and Methods

Description of Fields, Sampling, and Aphid Identification. Commercial processing snap bean fields were sampled for alate aphids in western New York in 2002 and 2003. Fields were located in Genesee, Niagara, and Orleans Counties. Most of the fields were planted with the cultivar 'Hystyle' (over 50%). Other fields were planted to the cultivars 'Igloo', 'Zeus', a mixture of 'Solei and Masai', 'Labrador', 'Summit', 'Hercules', and one fresh market variety, 'Storm'. Snap bean field size averaged 13.9 ha (range, 3.8–23.7 ha), and fields often bordered woods, corn, wheat, cabbage, and orchards.

The snap bean growing season was divided into two seasons: early and late. The reason for this was that more aphids and more virus-infected plants have been observed in late-planted fields over the past few years. Early plantings occurred from late May through the end of the first week in June, while late plantings were during the first half of July. Snap beans are harvested from the third week of July through the end of September. Six early-planted and six late-planted snap bean fields were sampled each year (n = 12 fields sampled per year, 24 total). One-half of the fields in each planting bordered an alfalfa field, whereas the other half were located >1 km away from all leguminous crops. Snap bean fields adjacent to and distant from alfalfa were paired based on the similarity of planting dates rather than by variety. Alfalfa typically bordered only the west side of the snap bean fields, with the exception of two locations in 2002 and one location in 2003. Theoretically, prevailing westerly winds coupled with the orientation of alfalfa and snap bean fields encourage dispersing aphids to emigrate from alfalfa into snap bean fields. Because we suspected that alfalfa would be a major source for aphids migrating into snap bean fields, we also sampled alate aphids in all alfalfa fields that bordered snap beans using water pan traps. Alfalfa field size averaged 12.1 ha (range, 3.0–27.9 ha), and most of the fields had been in production for 4–6 yr. During our study, most alfalfa fields were harvested initially in late May to early June, while second and third harvests were in late June to early July and in mid- to late August, respectively. In 2003, we also used water pan traps to sample alate aphids in commercial cabbage fields, which are also commonly grown in this region, so that we could compare abundance and dispersal patterns with those in snap bean and alfalfa fields. We selected three fields planted early and three fields planted late. If aphids were dispersing randomly throughout the region, we would expect similar trap-catch results among snap bean, alfalfa, and cabbage.

Water pan traps were placed in each snap bean field to capture alate aphids from the time plants emerged until shortly before harvest. Nine traps were arranged in groups of three such that the first group was within 2 m of one field edge, the next group in the middle of the field, and the last group within 2 m of the field edge opposite the first group. In snap bean fields bordering alfalfa, the first group of traps was always placed along rows nearest to the alfalfa. Traps within groups were spaced at least 20 m apart. In alfalfa and cabbage fields, three traps were placed within 100 m of the field edge. For alfalfa, the edge nearest the snap bean field was chosen.

Traps consisted of a 1.8-l clear plastic container (Rubbermaid Commercial Products, Winchester, VA) mounted to the top of a wire-framed, tomato plant supporter (Woodstock Gardens, Woodstock, IL). The supporter was anchored 20 cm deep into the ground. The top of the container was positioned 22 cm above

Table 1. Cumulative mean no. aphids caught per field for each crop (early- and late-planted snap bean, alfalfa, and cabbage) during the sampling period in New York

Species	Cumulative mean no. aphids caught per field									
	Early season					Late season				
	Snap bean		Alfalfa		Cabbage	Snap bean		Alfalfa		Cabbage
	2002	2003	2002	2003	2003	2002	2003	2002	2003	2003
Acyrthosiphon pisum (Harris)	285	191	61	30	11	90	6	19	5	4
Aphis glycines Matsumura	0	33	0	0	0	0	720	0	220	131
Capitophorus eleagni (Del Guercia)	1	52	2	6	4	2	1	0	2	2
Capitophorus hippophaes (Walker)	0	15	1	0	1	3	8	0	1	1
Hayhurstia atriplicis (Linnaeus)	0	0	0	0	2	46	5	2	4	1
Hyalopterus pruni (Geoffroy)	0	8	0	1	1	4	2	1	1	0
Lipaphis erysimi (Kaltenbach)	16	45	0	0	15	26	7	2	1	4
Myzus persicae (Sulzer)	3	5	0	0	0	15	10	0	0	3
Phorodon humuli (Schrank)	0	8	0	1	1	0	0	0	0	0
Rhopalosiphum maidis (Fitch)	38	123	9	3	8	53	138	7	16	43
Rhopalosiphum padi (Linnaeus)	1	37	0	9	9	5	8	0	6	5
Sitobion avenae (Fabricius)	6	14	0	1	2	4	0	0	0	0
Therioaphis trifolii (Monell)	73	91	28	9	1	1,117	49	244	26	4
Unknown spp.	63	100	8	9	8	49	42	9	2	8
Others[a]	22	105	1	17	12	28	133	5	17	17
Total aphids	508	827	110	86	75	1,442	1,129	289	301	223

No. snap bean, alfalfa, and cabbage fields sampled per season each year was six, three, and three, respectively; no. water traps per snap bean, alfalfa, and cabbage field was nine, three, and three, respectively.

[a]Other species include those representing <1% of total no. of aphids captured in snap bean crop and are listed in the text.

the soil surface until plants approached this height, at which time they were elevated to 44 cm. Positioning the height of the container below 22 cm resulted in a significant amount of soil splashing into the container when it rained. Containers were filled with 0.5-l solution of propylene glycol and water (20:80). A 10.8 by 10.8-cm ceramic tile with a mottled green surface was placed in the bottom of the plastic container (series: Provence; color: moss green; Jasba, Ötzingen, Germany) (modified from DiFonzo et al. 1997). The solution was changed weekly, at which time all trapped alatae were extracted, counted, and transferred to glass vials containing 70% ethyl alcohol. R. Eckel (RVWE Consulting, Frenchtown, NJ) identified all aphids using keys by Smith et al. (1992) and Blackman and Eastop (1984). Voucher specimens are located at the New York State Agricultural Experiment Station (Geneva, NY).

Statistical Analyses. Data from early- and late-planted fields were analyzed separately each year. Aphid dispersal in relation to the different crops (snap bean adjacent to alfalfa, snap bean far from alfalfa, alfalfa, and cabbage) was analyzed by examining the cumulative mean number of alate aphids caught per trap over time. Cumulative counts lead to an accumulation of experimental and sampling errors. This gives rise to a complicated correlation structure, which makes the estimation of SEs at individual weekly sampling times a nontrivial coding task with statistical software packages. Because of this, we did not calculate SEs at individual weekly sampling times. However, data with these properties can be analyzed with a linear mixed model specifying random effects for the experimental errors combined with an unstructured variance-covariance matrix for the cumulative sampling errors (Schabenberger and Pierce 2002). Models were implemented using Proc Mixed in SAS (SAS Institute 2001). Differences between cumulative counts at each weekly sampling time were tested using the appropriate ESTIMATE statements (Littell et al. 1996).

The spatial dispersal of cumulative aphid counts within snap bean fields was also examined using the modeling approach outlined above. For each snap bean field, comparisons were made among the six cumulative count curves that corresponded to the combinations of trap location within fields (edge 1, middle, or edge 2) and position of the field relative to alfalfa (adjacent or distant).

Results

Aphid Species Identified in Snap Beans. A total of 3,906 alatae was captured in snap bean fields during this 2-yr study. Sixty-three species were identified (27 and 61 species in 2002 and 2003, respectively). Twenty-five of the 27 species captured in 2002 were also captured in 2003. Species that represented 1% or more of the total number of aphids collected from snap bean fields are listed in Table 1. In early-planted fields, *A. pisum* was the most abundant species encountered in both years, while the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), also was common in 2003 (Table 1). In contrast, the yellow clover aphid, *Therioaphis trifolii* (Monell), and soybean aphid, *Aphis glycines* Matsumura, were the most prevalent species in late-planted fields in 2002 and 2003, respectively (Table 1). These four species may be key vectors of CMV in snap bean fields; however, virus transmission studies are needed for verification.

Species that represented <1% of the total number of aphids collected from snap bean fields in 2002 included *Anoecia corni* (Fabricius), *Aphis fabae* Scopoli, *Aphis gossypii* Glover, *Aphis pomi* DeGeer, *Aphis* *maidiradicis* Forbes, *Brevicoryne brassicae* (Linnaeus), *Drepanaphis acerfoliae* (Thomas), *Dysaphis plantaginea* (Passerini), *Hyperomyzus lactucae* (Linnaeus), *Macrosiphum euphorbiae* (Thomas), *Macrosiphum rosae* (Linnaeus), *Pemphigus populitransversus* Riley, *Pemphigus populivenae* Fitch, *Rhopalosiphum insertum* (Walker), *Schizaphis graminum* (Rondani), and *Therioaphis riehmi* (Börner). In addition, the following were observed in snap bean fields in 2003: *Amphorophora rubi* (Kaltenbach), *Anoecia setariae* Gillette and Palmer, *Anoecia* sp., *Aphis cephalanthi* C. Thomas, *Aphis craccivora* Koch, *Aphis forbesi* Weed, *Aphis helianthi* Monell, *Aphis nasturtii* Kaltenbach, *Aphis pulchella* Hottes and Frison, *Aphis rumicis* Linnaeus, *Aphis spiraecola* (Patch), *Aphis virburniphila* Patch, *Aulacorthum solani* (Kaltenbach), *Chaetosiphon* sp., *Chaitophorus* sp., *Drepanaphis nigricans* Smith, *Drepanaphis* sp., *Essigella pini* Wilson, *Eulachnus rileyi* (Williams), *Geoica squamosa* Hart, *Hyadaphis foeniculi* (Passerini), *Hysteroneura setariae* (Thomas), *Macrosiphum pseudocoryli* Patch, *Nearctaphis bakeri* (Cowen), *Nearctaphis clydesmithi* Hille Ris Lambers, *Nearctaphis crataegifoliae* (Fitch), *Nearctaphis* sp., *Ovatus crataegarius* (Walker), *Pemphigus populicaulis* Fitch, *Pleotrichophorus* sp., *Rhopalosiphum rufiabdominalis* (Sasaki), *Sipha flava* (Forbes), *Uroleucon* sp., and *Utamphorophora crataegi* (Monell). Unknown species also were encountered during this study, some of which were identified as *Aphis* spp., *Macrosiphum* spp., *Myzocallis* spp., and *Pemphigini* spp.

Twenty-eight species were captured in alfalfa, and 27 species were caught in cabbage. The same aphid species that were most abundant in snap bean fields were generally the most prevalent in alfalfa and cabbage (Table 1). Exceptions early in the 2003 season included *Lipaphis erysimi* (Kaltenbach) in cabbage and *Rhopalosiphum padi* (Linnaeus) in alfalfa and cabbage, whereas *R. maidis* was common in cabbage late in the season. *Rhodobium porosum* (Sanderson) was encountered in alfalfa and *Periphyllus testudinacea* (Fernie) was caught in cabbage, but neither was found in snap bean.

Temporal Dispersal Patterns Among Crops. More alate aphids were caught across all crops late in the season than early in the season in 2002 ($F = 25.7$; df = 1,8; $P = 0.0010$) and in 2003 ($F = 30.2$; df = 1,11; $P = 0.0002$; Figs. 1A and C versus 2A and C). The total number of aphids caught in crops late in the season was over three and two times greater than the number in crops early in the season (2002: 35.6 versus 10.9 aphids/trap/week; 2003: 31.9 versus 14.9 aphids/trap/week).

In both years, the cumulative number of alate aphids (all species) did not differ significantly among crops, either early or late in the season, or on any particular week in which samples were collected ($P > 0.14$ in all instances; Figs. 1A and C and 2A and C). Similarly, the cumulative numbers of *A. pisum, R. maidis, T. trifolii,* or *A. glycines* trapped did not differ significantly among crops, either early or late in the 2002 and 2003 seasons, or on any specific week that the fields were sampled ($P > 0.05$ in all situations; Figs. 1B, D, and E, and 2B and D).

Spatial Dispersal Patterns Within Snap Fields. There was no effect of trap location within snap bean fields on the cumulative numbers of alatae caught, either early or late in the 2002 and 2003 seasons ($P > 0.29$ in all instances), or on any of the sampled weeks (Table 2). Similar results were found for captures of the individual species *A. pisum* and *T. trifolii* in 2002 and for *A. glycines, A. pisum,* and *R. maidis* in 2003 ($P > 0.07$ for all sampled times considered; Table 3).

Discussion

Snap bean fields in New York may be at equal risk for aphid-transmitted virus epidemics such as CMV, regardless of their proximity to virus-infected alfalfa fields. Abundance and temporal patterns of aphid dispersal in snap bean fields were not associated with proximity to alfalfa fields. Moreover, similar numbers of alatae and temporal patterns of their dispersal were observed among all crops sampled during the entire season. These results are logical for *A. glycines* and *R. maidis* because they do not use alfalfa as a host and would not be expected to be more abundant in snap bean fields relative to their distance to alfalfa. In contrast, alfalfa is a source for colonizing species such as *A. pisum* and *T. trifolii.* Therefore, the similarity in abundance and temporal patterns of dispersal for *A. pisum* and *T. trifolii* in snap beans adjacent to and distant from alfalfa may indicate that these species disperse significant distances from alfalfa. Loxdale et al. (1993) argued that most aphid species migrate "short" distances, from a few meters to as far as several kilometers. Differences in aphid abundance and temporal dispersal patterns in snap beans varying in proximity to alfalfa would not be observed if aphids routinely disperse distances of several kilometers. It is also possible that alfalfa is not the only significant source for *A. pisum* and *T. trifolii,* and these species migrate into snap bean fields from leguminous weeds.

A similar number of aphids were captured along snap bean field edges and field centers, regardless of their proximity to alfalfa. Thus, there was no "edge effect." Our results indicate that the major aphid species encountered in this study migrate into fields randomly rather than directionally from the field edge. Stoltz and McNeal (1982) also observed similar numbers of *A. pisum* alates captured at varying distances up to 100 m from the field edge into the center of dry bean fields that bordered alfalfa.

Aphis glycines, A. pisum, R. maidis, and *T. trifolii* were the most abundant species captured in snap bean fields during our survey. These species almost certainly migrated into snap bean fields from other hosts because they rarely, if ever, complete their development on snap bean. The prevalence of *A. pisum* alatae in all crops early in the season was anticipated because alfalfa is a common host and dominates the western New York agroecosystem. However, it is not known why *A. pisum* alatae were much less common in all crops sampled late in the season. The rate of *A. pisum*

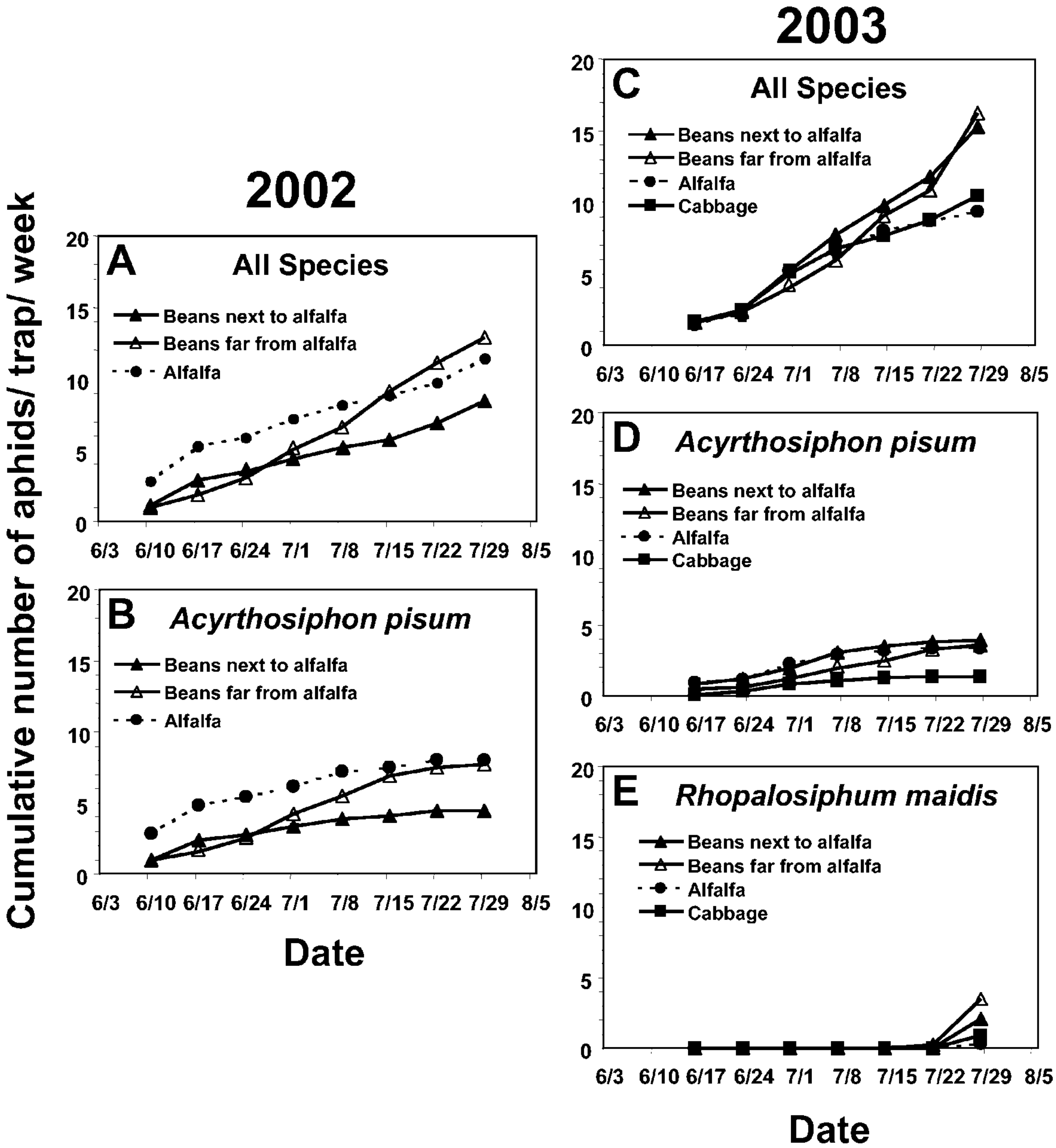

Fig. 1. Cumulative mean number of aphids (all species) (A and C), *A. pisum* (B and D), and *R. maidis* (E) captured per water pan trap in commercially grown snap bean, alfalfa, and cabbage fields early in the snap bean growing season in New York. Each data point represents a mean of three fields.

capture in snap bean and alfalfa fields was similar during our study, indicating no discrete periods of migration from alfalfa or immigration into snap bean fields.

In contrast to our results, Losey and Eubanks (2000) observed increased activity of *A. pisum* alatae in a small lima bean field in Maryland within several days after a nearby alfalfa field was cut. In Idaho in 1 of 3 yr, Stoltz and McNeal (1982) reported an immediate increase in densities of *A. pisum* alatae in a few commercial dry bean fields after adjacent alfalfa fields were harvested; no differences in densities occurred between these crops in the other 2 yr. Crowding, changes in host quality, day length, and exposure to natural enemies are known to increase the proportion of aphid offspring that develop into alatae (Dixon 1998, Sloggett and Weisser 2002). Harvesting alfalfa reduces host quality, which would cause alatae to migrate from alfalfa to more suitable habitats. However, significant populations of *A. pisum* alatae must have been present at the time the alfalfa fields were harvested. Therefore, populations of *A. pisum* in the

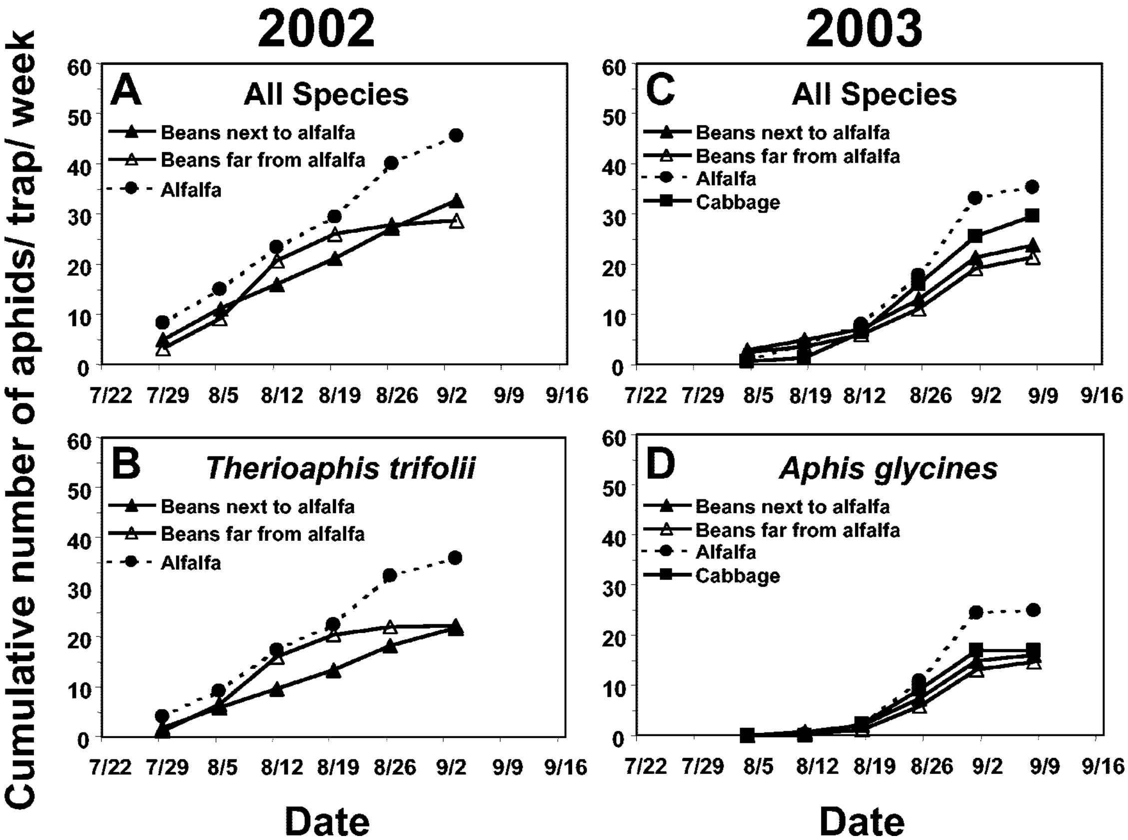

Fig. 2. Cumulative mean number of aphids (all species) (A and C), *T. trifolii* (B), and *A. glycines* (D) captured per water pan trap in commercially grown snap bean, alfalfa, and cabbage fields late in the snap bean growing season in New York. Each data point represents a mean of three fields.

Maryland and Idaho studies must have been subjected to one or more of these stress factors before the field was harvested. Perhaps during our survey, *A. pisum* populations in alfalfa fields were not under sufficient stress to produce significant numbers of alatae. If this occurred, it would explain why we did not observe the distinct increases of *A. pisum* alates in crop fields as was observed in past studies. Another possibility is that populations of *A. pisum* in New York may disperse great distances rather than locally after disturbance by harvest, resulting in similar numbers of *A. pisum* trapped in snap bean fields adjacent to or distant from alfalfa.

Table 2. Cumulative mean no. alate aphids (all species) caught per water pan trap in snap bean fields that were either adjacent to or far (>1 km) from alfalfa in New York

Proximity to alfalfa field	*n*	Location within snap bean field[a]	Cumulative mean no. aphids per trap			
			2002		2003	
			Early season	Late season	Early season	Late season
Adjacent	3	Edge 1	5.0	31.1	12.9	19.8
	3	Middle	7.5	28.7	17.0	29.0
	3	Edge 2	5.3	23.8	16.1	22.9
Far	3	Edge 1	8.4	28.6	18.3	20.1
	3	Middle	10.9	27.6	16.6	22.2
	3	Edge 2	11.0	22.2	13.8	21.6

Nine traps were placed in each field, three each along opposite field edges, and three in the middle of the field.

[a] Traps placed within the first two rows of snap bean field for both edge 1 and edge 2. For snap bean fields adjacent to alfalfa, edge 1 was nearest to the alfalfa, and edge 2 was farthest from alfalfa. For snap bean fields far from alfalfa, edge 1 was typically the west end of the field, whereas edge 2 was the east end.

Therioaphis trifolii also uses alfalfa as a host. In 2002, it is not known why their abundance in snap bean and alfalfa fields late in the season was greater than early in the season. Additionally, it is not known why they were more common in 2002 than in 2003.

Aphis glycines was first reported in western New York in 2001 (Losey et al. 2002). However, *A. glycines* was absent in our 2002 survey. *A. glycines* colonizes soybean fields in the spring and summer, and alatae often disperse from soybean en masse late in the summer. In 2002, populations of *A. glycines* in New York soybean fields were very low, which likely explained why none were trapped in snap bean fields (Table 1). In contrast, *A. glycines* commonly occurred in soybean in 2003, and it was abundant in all crops later in the season (Table 1). In particular, immigration of *A. gly-*

Table 3. Cumulative mean numbers of *A. pisum*, *T. trifolii*, *R. maidis*, and *A. glycines* caught per water pan trap in snap bean fields that were either adjacent to alfalfa fields or > 1 km away from alfalfa in western New York in 2002 and 2003

Proximity to alfalfa field	*n*	Location within snap bean field[a]	Cumulative mean no. aphids per trap				
			2002		2003		
			A. pisum[b]	*T. trifolii*[c]	*A. pisum*[b]	*R. maidis*[b]	*A. glycines*[c]
Adjacent	3	Edge 1	2.7	23.0	3.1	1.0	15.7
	3	Middle	5.0	20.8	4.0	2.8	21.4
	3	Edge 2	2.7	16.3	5.1	2.5	9.1
Far	3	Edge 1	5.8	22.2	3.8	4.9	11.9
	3	Middle	7.4	23.1	2.8	4.2	12.2
	3	Edge 2	7.5	17.8	3.8	1.5	15.1

Nine traps were placed in each field, three each along opposite field edges, and three in the middle of the field.

[a]Traps placed within the first two rows of snap bean field for both edge 1 and edge 2. For snap bean fields adjacent to alfalfa, edge 1 was nearest to the alfalfa, and edge 2 was farthest from alfalfa. For snap bean fields far from alfalfa, edge 1 was typically the west end of the field, whereas edge 2 was the east end.

[b]Early season.

[c]Late season.

cines alatae in all crops sampled was most pronounced during the last half of August (see Fig. 2D). Soybean acreage has nearly tripled in New York over the past 10 yr (23,000 ha in 1993 to 65,000 ha in 2001) (NYASS 2003), suggesting that *A. glycines* dispersal from soybean into snap bean fields may become a common occurrence.

Rhopalosiphum maidis specializes on grasses, especially corn, and was common in our survey only in 2003, early in the season. *R. maidis* also has been one of the most abundant species encountered in aphid surveys in Illinois, Minnesota, and North Dakota (Schultz et al. 1985, DiFonzo et al. 1997, Favret and Voegtlin 2001). As in our study, DiFonzo et al. (1997) reported substantial differences between years in the proportion of *R. maidis* captured in potato fields during a season.

Because *Aphis glycines*, *A. pisum*, *R. maidis*, and *T. trifolii* were the most abundant species captured in snap bean and alfalfa fields, they may be key vectors of the viruses encountered in snap bean in New York. It is not unusual for only a few commonly occurring species to be responsible for a majority of virus incidence in the field (Raccah 1986). Additionally, these aphids survive poorly on snap bean and can be considered as noncolonizing species, which are often the most important vectors for virus spread (Halbert et al. 1981, Raccah et al. 1985, Irwin 1994). *A. pisum* and *T. trifolii* can transmit CMV into narrow-leafed lupin (Berlandier et al. 1997). The ability of *A. glycines* to transmit CMV is not known, but it has been shown to transmit soybean mosaic virus and alfalfa mosaic alfamovirus in soybean (Hill et al. 2001, Clark and Perry 2002).

Implications for Virus Management. Spread of nonpersistent, stylet-borne viruses in crops can occur quickly when inoculum and vector flight activity are high. As a consequence, management must be preventative rather than remedial (Irwin 1999). Unfortunately, the use of virus-resistant cultivars, typically the most effective strategy, is not a current option because commercially available snap bean cultivars are not resistant to viruses detected recently. Attempts to reduce the incidence of viruses spread in a nonpersistent manner by controlling aphid vectors with insecticides have been ineffective in the past (Raccah 1986, Perring et al. 1999, Madden et al. 2000, Thackray et al. 2000, Nault and Taylor 2003). Similarly, controlling aphids in other crops before they emigrate into snap beans is not a realistic option because aphids likely emigrate from a number of crop and noncrop hosts at varying times and distances.

Strategies such as reflective mulches, row covers, and mineral oils have been used successfully in some vegetable cropping systems to control or repel aphid vectors to reduce or delay infection by viruses (Loebenstein et al. 1975, Simons and Zitter 1980, Basky 1984, Perring et al. 1989). However, these strategies likely are too expensive and labor intensive for snap bean growers in the northern United States. Biological control of vectors is similarly not a plausible strategy for managing viruses because neither predation nor parasitism of aphids occurs quickly enough to prevent transmission of these viruses.

Planting susceptible crops away from known sources of virus-infected plants or at times during the season when risk of infection is unlikely has been recommended to reduce incidence of virus (Walkey, 1991, Cho et al. 1989). Based on our results, this strategy is not likely to work because aphid abundance and patterns of dispersal in snap bean fields planted >1 km away from alfalfa fields did not differ from fields planted adjacent to alfalfa. Aphid dispersal was greater late in the season than early in the season, suggesting that risk for virus infection may be greater late in the season. Avoiding planting snap beans late in the season is not feasible because fields are planted sequentially throughout the season to ease labor constraints and maximize packing plant efficiency.

Crop borders or crop barriers have reduced the incidence of nonpersistent, stylet-borne viruses in a variety of crops (Toba et al. 1977, DiFonzo et al. 1996, Fereres 2000). This strategy requires strips of the border/barrier crop to be planted around the periphery of the main crop. In the studies mentioned above, reduction of virus-infected plants in the main crop relies on viruliferous aphids purging their mouthparts of virus while probing leaves on the border/barrier crop, thereby reducing the probability of infecting the main crop. For this strategy to work, immigrating aphids must land and probe on plants along field edges sooner than on those in field interiors. Our results indicated no evidence of greater aphid dispersal activity along snap bean field edges than in field centers; therefore, a crop border or crop barrier strategy is unlikely to work. An exception could be to identify a crop border host that is more attractive than the main snap bean crop.

Acknowledgments

We thank D. Walthew, K. Straight, and M. Hessney for technical assistance, R. Eckel for identifying the aphids, and L. Nault and G. English-Loeb for comments on an earlier draft of the manuscript. We are grateful to the New York Vegetable Research Council/Association for primarily supporting this project.

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Received 11 June 2004; accepted 30 August 2004.