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SURVIVAL, DEVELOPMENT AND POPULATION DYNAMICS OF *EMPOASCA FABAE* (HOMOPTERA: CICADELLIDAE) ON THREE LEGUME HOSTS

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ABSTRACT

Survival and development of potato leafhopper, *Empoasca fabae*, nymphs were measured on alfalfa (*Medicago sativa*), birdsfoot trefoil (*Lotus corniculatus*), and red clover (*Trifolium pratense*). Survival was not significantly different among host plants (mean = 62%). There was no interaction between sex and host plant for developmental time. Males developed significantly faster than females. Developmental time was fastest on alfalfa, intermediate on trefoil, and slowest on red clover. Plots of alfalfa, trefoil, and red clover were planted to compare the seasonal abundance of the potato leafhopper in the three forages. Nymphs were more abundant in trefoil than in alfalfa and red clover late in July, but no differences occurred on the other sample dates. At their peak, adults were more abundant in alfalfa than in trefoil and red clover.

The potato leafhopper, *Empoasca fabae* (Harris), is a highly polyphagous insect that causes injury to a variety of crops including alfalfa, soybeans, and potatoes. In alfalfa, the potato leafhopper is the most important insect pest in the northcentral and eastern United States. Red clover (*Trifolium pratense*) and birdsfoot trefoil (*Lotus corniculatus*) offer alternatives in forage production where alfalfa is difficult or impractical to grow. The potato leafhopper is commonly collected in birdsfoot trefoil (Neunzig and Gyrisco 1955, Guppy 1958, Wipfli et al. 1989), though injury symptoms such as 'hopperburn' are seldom observed in trefoil (D.B.H., pers. obs.). Leafhopper development and survival have been documented on alfalfa and red clover (Simmons et al. 1984b), but leafhopper performance on trefoil is unknown.

In addition, little is known about the preference and relative abundance of the potato leafhopper among forage crops. The potential abundance of the leafhopper in various forage crops would be useful to growers choosing crop locations and strategies. The purpose of this study was to compare development and survival of potato leafhopper nymphs on alfalfa, trefoil, and red clover and to compare patterns in field population dynamics in those crops.

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MATERIALS AND METHODS

Development and Survival of Nymphs. 'Vernal' alfalfa, 'Norcen' birdsfoot trefoil, and 'Arlington' red clover were grown from seed in a greenhouse in 1989. Six pots (20 cm diameter) of each plant species were planted. Plants were eventually thinned to two plants per pot. The greenhouse was heavily whitewashed and light was supplemented by two 40 watt cool white florescent bulbs, 81 cm from the soil level of the pots. Average light intensity was measured on a cloudless afternoon by a Li-Cor LI-188 Quantum/ Radiometer/ Photometer to be 167.9 $\mu Em^{-2}s^{-1}$. Plants were watered three to four times per week. Temperature in the greenhouse ranged from 19° to 37°C and the relative humidity ranged from 30 to 100%.

Adult potato leafhoppers were captured by sweep-net in alfalfa at the University of Wisconsin's Arlington Agricultural Research Station. The adults were held in ventilated cages with fresh green bean pods, *Phaseolis vulgaris*, for feeding and oviposition. First-instar nymphs were collected from the bean pods by anaesthetizing them for approximately 15 s with CO_2. Nymphs were then transferred to forage host plant cages using a camel hair paint brush (no. 000).

Cages consisted of a plastic tube 3.5 cm in diameter and 10.1 cm in length. Two 1.8-cm holes were cut in the sides and organdy screen was cemented over the holes for ventilation. The top closed with a removable cap which also had a 1.8-cm diameter screened hole. The bottom of the cage was plugged with a foam cylinder, cut radially to surround the plant stem without damaging it. A metal wire (2 mm diameter, 40 cm long) was inserted into the soil and the cages were secured to the wire by two rubber bands. A maximum of two cages per pot were allowed.

Six first-instar nymphs were placed in each cage. Surviving nymphs were counted and given new stems every 3 d until the ninth day. After 9 d, nymphs were counted and given new stems every day. When new stems were provided, nymphs were randomly redistributed to new cages on the same species of host plant. Nymphs were randomly mixed in this way to avoid introducing a cage effect and each nymph was considered an experimental unit.

Because larger nymphs are able to damage plant stems faster, fewer late-instar nymphs were allowed per cage than early-instar nymphs. Thus, on day 3, the maximum number of nymphs per cage was reduced to five, and on day 6, until the end of the experiment, the maximum number of nymphs was reduced to three.

Degree-day (DD) accumulations were calculated by the sine wave method (Higley et al. 1986), with a temperature threshold of 8°C (Hogg 1985). Analysis of variance (ANOVA) was used to test for differences in development among sexes and host plants. The means were compared by the protected least significant difference (LSD) method ($P = 0.05$). The overall proportion surviving on each host was tested for homogeneity using a chi-square test for a binomial sample.

Population Dynamics. A field trial was conducted at the Arlington Agricultural Research Station in 1989 in a field that was previously planted with corn, *Zea mays*. Three treatments, 'Dart' alfalfa, 'Leo' birdsfoot trefoil, and 'Arlington' red clover were replicated four times in a randomized complete block design. Plots were 14.4 by 28.8 m with a 6.6 m alfalfa border on two sides. Plots were direct seeded at 16.9 kg/ha (15 lb/A) for alfalfa, 9.0 kg/ha (8 lb/A) for trefoil, and 13.5 kg/ha (12 lb/A) for red clover. All plots were planted on 18 April 1989. From 16 June to 16 August sweep samples were taken from each plot every other week. The sample unit was 20 pendulum sweeps, in a "U" shaped pattern in each plot. Sweep samples were placed in organdy bags,

Table 1.—Percent survival of potato leafhopper from eclosion to adulthood on alfalfa, birdsfoot trefoil, and red clover. No significant differences among hosts occurred.

	PERCENT SURVIVAL (n)			
DAY	ALFALFA	TREFOIL	CLOVER	TOTAL
0–3	72.9 (48)	67.4 (49)	58.3 (48)	66.2 (145)
3–6	97.1 (35)	100.0 (33)	100.0 (28)	99.0 (96)
6–9	100.0 (34)	97.0 (33)	100.0 (28)	99.0 (95)
9–15	93.1 (29)	100.0 (31)	96.3 (27)	96.6 (87)
0–15	66.0 (47)	65.3 (49)	55.3 (47)	62.2 (143)

frozen and then potato leafhopper nymphs and adults were counted. All plots were cut on 21 July.

The split-plot approach to repeated measures analysis of variance was used; F-tests were adjusted with the Huynh-Feldt adjustment (SAS Institute 1982). The least significant difference method was used to separate means.

Voucher specimens from this study, including six males and six adult females of *E. fabae*, have been deposited in the Insect Research Collection of the Department of Entomology, University of Wisconsin-Madison.

RESULTS AND DISCUSSION

Development and Survival of Nymphs. Overall survival ranged from 55 to 66% and was not significantly different among hosts during any time period (Chi-square = 1.43–2.32; df = 2; $P > 0.25$) (Table 1). Survival was lowest in the first three days (mean = 68%) but increased to over 95% thereafter. Poos and Smith (1931) found large variation in nymphal survival for various host plants. Survival was highest on Peruvian alfalfa (91%) and lowest on zigzag clover, *Trifolium medium* (18%). Survival on various alfalfas ranged from 54 to 91%, while on red clover survival ranged from 20 to 66%. We found that survival on alfalfa and red clover was 66 and 55%, respectively, which are in the ranges found by Poos and Smith (1931).

There was no interaction between host plant and sex of leafhoppers for developmental time ($F = 1.68$; df = 2,83; $P > 0.10$). Males developed significantly faster than females ($F = 24.18$; df = 1,83; $P < 0.0001$) and there was a significant difference among hosts for developmental time ($F = 10.92$; df = 2,83; $P < 0.0001$). Development on alfalfa was significantly faster than on trefoil which was significantly faster than on red clover (Fig. 1). Previous studies have shown that potato leafhopper males develop faster than females (Hogg 1985).

Simmons et al. (1984b) found differences in developmental rate of potato leafhopper at 24°C between alfalfa and red clover varieties. Development on 'Kenstar' red clover was slower than on the three varieties of alfalfa tested. They also found that potato leafhopper females usually developed slower than males. In addition, females preferred to oviposit on alfalfa compared to red clover (Simmons et al. 1984a), though adult female longevity was not different between alfalfa and red clover varieties.

Simonet and Pienkowski (1980) reported that 174 DD were needed for first-instar to adult development on broad bean (*Vicia faba*). In our experiment, development was somewhat longer on all three hosts (minimum = 185 DD). Simmons et al. (1984b) also found that potato leafhopper developed faster on broad bean than 'Apollo' and 'Riley' alfalfa and 'Kuhn' and 'Kenstar' red clover. However, as Hogg and Hoffman (1989) indicate, the differences in potato

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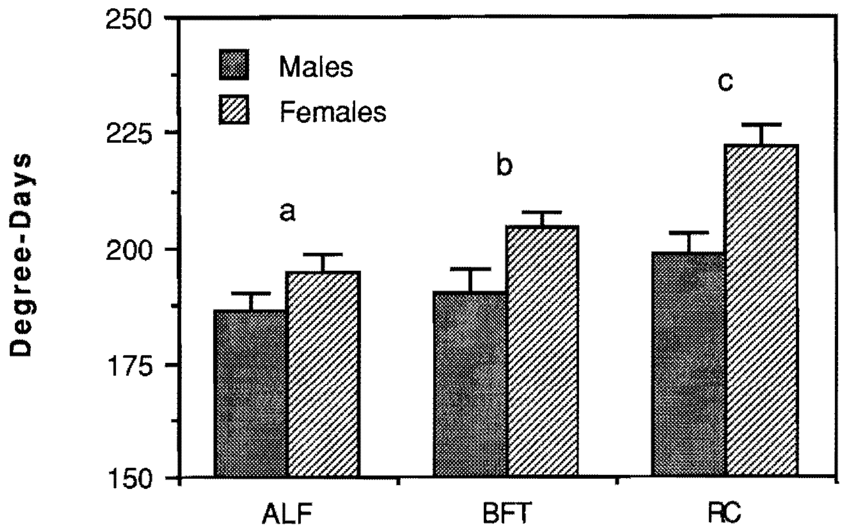

Figure 1. Developmental time in degree-days (8°C threshold) for potato leafhopper nymphs on alfalfa (ALF), birdsfoot trefoil (BFT), and red clover (RC). Host plants with different letters are significantly different by protected LSD ($P < 0.05$). Vertical lines represent SEM.

leafhopper development on various hosts may be statistically significant, but are generally not large.

Population Dynamics. Direct comparisons among crops for sweep counts of leafhoppers should be made with caution. The efficacy of the sweep-net was probably variable among crops because of differences in crop densities and heights. Also, the sweep-net is more effective at capturing larger nymphs than small ones. However, before clipping (14 July), all hosts were comparable in height and variation in sweeping efficacy was probably lowest at that time.

Sweep counts of potato leafhopper nymphs peaked on 14 July in alfalfa and red clover, and on 28 July in trefoil (Fig. 2A). A weak interaction between sample date and crop occurred for nymphs ($F = 2.30$; $\epsilon = 0.667$; df = 10,30; $P < 0.10$). Univariate ANOVA revealed that on 28 July a significant difference among crops occurred ($F = 6.96$; df = 2,6; $P < 0.05$). On that date, significantly more nymphs were collected in trefoil than in alfalfa and clover.

Adult potato leafhopper populations peaked on 14 July in all three crops (Fig. 2B). Potato leafhopper levels declined sharply after mid-July. A strong interaction occurred between sample date and crop ($F = 10.84$; $\epsilon = 0.594$; df = 10,30; $P < 0.0001$). On 29 June and 14 July adults were significantly more abundant in alfalfa than in trefoil or clover ($F = 12.95$–19.09; df = 2,6; $P < 0.01$). However, by 3 August adults were equally abundant in alfalfa and trefoil, while in clover, adult counts remained significantly lower ($F = 18.48$; df = 2,6; $P < 0.01$).

In the alfalfa plots, leaf-tips began turning yellow by 14 July. This symptom is typical of leafhopper injury. Both trefoil and red clover never showed 'hopperburn,' but leafhopper populations were not as high in those crops.

Our study shows that in comparison to alfalfa, potato leafhopper develop-

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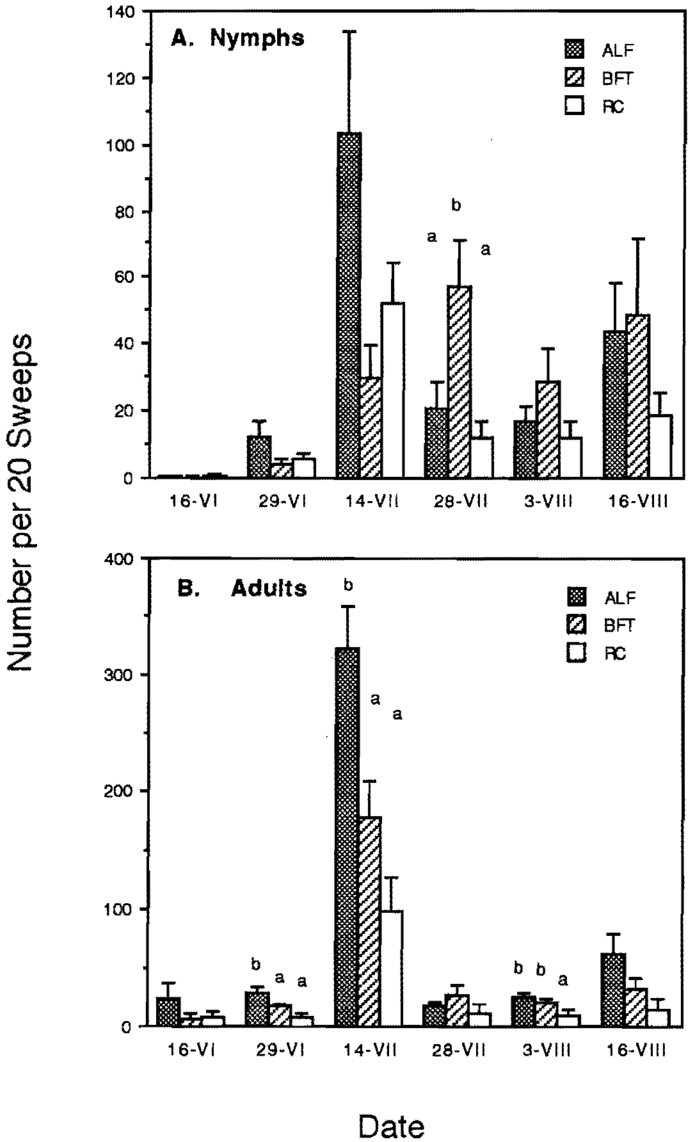

Figure 2. Population dynamics of potato leafhopper nymphs (A) and adults (B) on alfalfa (ALF), birdsfoot trefoil (BFT), and red clover (RC). Host plants within a sample date with different letters are significantly different by protected LSD ($P < 0.05$). Vertical lines represent SEM.

ment was slightly slower on birdsfoot trefoil and slower still on red clover. If hosts that provide the fastest developmental rates are preferred, then we would expect adults to be most abundant in alfalfa, intermediate in trefoil, and least abundant in clover. Because the adults are adapted for dispersal, any preference response would be most apparent in this stage. On 14 July, the adult peak, this exact pattern was observed, although the difference between red clover (98) and trefoil (178) was not significant statistically (LSD = 90, $\alpha = 0.05$). Our study indicates that among these legumes, potato leafhopper adults prefer the host which offers the fastest developmental rate.

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