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Assessment of sweepnet and suction sampling for evaluating pest insect populations in hay alfalfa[1]

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ABSTRACT

Insect populations in alfalfa grown for hay can be sampled using several methods. However, in a pest management program a relatively easy, quick, and reliable method of sampling is essential for making effective pest control decisions. A study was conducted to determine if two different sampling methods, sweepnet sampling and suction sampling, led to similar pest control decisions. Differences between sweepnet and D-Vac insect population estimates varied over sampling dates and years and were dependent on the insect species, their developmental stages, and abiotic factors. Our results indicate that, for many sampling dates, decisions on control of some pest insects would be similar for the two sampling methods.

Insecta, *Medicago sativa*, alfalfa weevil, pea aphid

INTRODUCTION

Economically viable, environmentally responsible pest insect management depends on regular, accurate assessments of insect populations. The correlation between estimates from samples and absolute population estimates varies with crop growth factors (Bechinski and Pedigo 1982, Saugstad *et al.* 1967), the insects being sampled (Sedivy and Kocourek 1988), wind, and air temperature (Saugstad *et al.* 1967). The sampling method used is also a source of error in estimating insect populations. The method chosen must be sufficiently accurate to identify population fluctuations, but also simple and quick enough that it can be done frequently to allow timely management decisions.

Comparisons of sampling methods have been inconclusive. In lentils, population estimates of *Lygus hesperus* Knight from absolute, D-Vac, and sweepnet sampling were similar, but nymphal numbers were lower with sweepnet sampling (Schotzko and O'Keefe, 1986a). In soybeans, Bechinski and Pedigo (1982) found that for the predators, *Nabis* spp., *Chrysopa* spp. and Coccinellidae, sweepnet sampling was superior, in terms of cost and variability, to plant shake, absolute and vacuum sampling. Vacuum sampling was the least efficient method. However, Shepard *et al.* (1974) found no significant differences among insect samples collected from soybeans by

D-Vac, sweepnet, and plant shake. The Insectavac was reported to sample more insects per unit area per volume of cotton sampled and, therefore, give a more accurate estimate of population density than did the sweepnet (Ellington *et al.* 1984). Smith *et al.* (1976), however, reported that both sweepnet and D-Vac sampling were adequate to identify population fluctuations and indicate absolute populations in cotton. In alfalfa, Sedivy and Kocourek (1988) found that D-Vac did not collect large, heavy insects such as caterpillars.

The objective of this study was to determine whether sweepnet and D-Vac sampling show similar trends of pest insect populations in hay alfalfa and lead to similar decisions regarding insect control in a variety of weather and crop conditions.

MATERIALS AND METHODS

At two sites in southern Alberta, insect populations in alfalfa (*Medicago sativa* L.) were sampled weekly from May to October by a sweepnet and a D-Vac suction sampler (Dietrich 1961) both before and after cutting for hay. The sites were located at the Agriculture Canada Research Station at Lethbridge, Alberta. At Site 1, there were six plots, 10 x 20 m, of "Beaver" alfalfa, and at Site 2, four plots, 10 x 15 m, of "Vernal" alfalfa. Both sites were sampled in 1978 and 1979. The two sites were about 1 km apart.

The insect samples consisted of five full-arm (180°) sweeps taken with a 38 cm diameter sweepnet from half of each plot, and 10 suction samples (30.4 cm diameter) taken from the other half of the plot with a D-Vac suction sampler (Model 1-A, D-Vac Company, Riverside, CA). All sampling was conducted by the same person between 10:00 am and 12:00 am MST. The samples were taken under dry conditions when the wind was less than 15 km/hour. In 1978, the crop was cut for the first time on 26 June and again on 29 August. In 1979, the first cut was on 5 July and the second on 7 September.

The pest insects identified and counted in the studies were: alfalfa weevil, *Hypera postica* (Gyllenhal); pea aphid, *Acyrthosiphon pisum* (Harris); leafhoppers, Cicadellidae; lygus, *Lygus* spp., and alfalfa root curculio, *Sitona scissifrons* Say. With the exception of the alfalfa root curculio, the pest insects were separated into mature and immature groups. The larvae of the alfalfa root curculio are subterranean and, therefore, were not sampled.

With any sampling method, the actual number of insects obtained is directly dependent on the volume of herbage sampled, regardless of the efficiency of the sampling method. Schotzko and O'Keeffe (1989) determined that sampled herbage volume provided a better estimate of absolute insect counts than considering only the area that was sampled. With sweepnet sampling, the volume of herbage sampled is determined by the net diameter, the number of sweeps, the length of each sweep, and the penetration of the crop canopy. The net size and the number of sweeps can be kept constant, but the length of the sweeps and canopy penetration vary. Therefore, the volume of herbage sampled is not fixed. Similarly for D-Vac sampling, the net size, the number of samples, and the height of the canopy determine the volume of herbage sampled. The height of the canopy varies, so the sampling volume is not constant for D-Vac sampling. Using a conversion factor to obtain similar sampling volumes assumes a simple relationship between insect densities and herbage volume, which may not be valid. As pointed out by Schotzko and O'Keeffe (1989), volume adjustments do not compensate for the location of the insects in the canopy; they merely attempt to standardize the amount of canopy sampled. In our case, the height of the canopy was different at each sampling date, so any attempt at standardizing the sampled volume would have been unfeasible; therefore, we can provide only approximations of the sampled volume.

The handle on the sweepnet was 0.90 m, the net opening had a 0.19-m radius, and five 180° sweeps were taken. Therefore, from the volume equation for a torus, the theoretical sampled volume is about 1.94-m^3 (volume = $pi^2 X 0.19^2 X (0.90 + 0.19) X 5$). In practice, no more than half of the sweepnet would usually penetrate the canopy, so the actual volume of herbage sampled was less than 1.0 m^3. The D-Vac had a net opening with a 0.152-m radius, and 10 samples were taken each consisting of moving from the top of the canopy to the ground. Therefore, its volume is $V = pi X H X 0.152^2 X 10$, where H is the height of the canopy. From the forgoing, the sweepnet and D-Vac appear to sample similar volumes when $V = 1.0$ m^3, or when $H = 1.38$ m. Alfalfa is cut two to three times per year, generally before it reaches a height of 1.38 m; therefore, in our study the sweepnet probably sampled a larger volume of the canopy than the D-Vac.

Owing to the problems in sampling volumes as discussed above and because exact sampled volumes were not obtained in this study, no statistical tests were made to compare directly the differences in actual insect counts between the two sampling methods. Therefore, for our study, the decision on control for an insect pest is based on the population trends obtained by the two methods, not on specific economic thresholds. We followed procedures similar to those of Braman and Yeargan (1990) to compare the two sampling methods. The means of the replicates and their standard errors were calculated for each sampling date and plotted in order to display discrepancies in insect counts between the sampling methods over the growing season. Each year's data were treated separately. Correlations between sweepnet and D-Vac insect counts were calculated using estimates obtained from each replication throughout the sampling period. This provided estimates of the trends over all sampling dates. Correlations were also calculated between insect counts obtained on a given sampling date and those obtained from the previous sampling date (lag 1 correlations). In the absence of eradication measures, insect populations generally should not change drastically within one week. Therefore, if the sampling methods provide consistent estimates of insect populations, these lag 1 correlations should be high. All calculations were made with SAS (SAS Institute Inc. 1985).

Table 1

Correlations (r) between sweepnet and D-Vac sampling estimates for five insects, two years, and two locations

	1978		1979	
Insect	Site 1 (n = 56)	Site 2 (n = 83)	Site 1 (n = 56)	Site 2 (n = 84)
Aphid				
Wingless	0.54**	0.81**	0.94**	0.86**
Winged	0.50**	0.54**	0.84**	0.87**
Lygus				
Nymphs	0.20	0.51**	0.92**	0.76**
Adults	0.53**	0.06	0.48**	0.63**
Alfalfa weevil				
Larvae	0.64**	0.54**	0.64**	0.79**
Adults	0.15	0.36**	0.25	0.35**
Leafhoppers				
Nymphs	0.38**	0.11	0.78**	0.14
Adults	0.54**	0.73**	0.55**	0.68**
Alfalfa root curculio	0.17	0.40**	–0.02	0.54**

** Indicate significant correlations between the two sampling methods at p = 0.01.

Table 2

The lag 1 correlations (r) between observations from a given sampling date and those from the previous sampling date for sweepnet and D-Vac sampling for five insects, two years, and two locations

	1978				1979			
	Site 1 (n = 55)		Site 2 (n = 82)		Site 1 (n = 55)		Site 2 (n = 83)	
Insect	Sweep	D-Vac	Sweep	D-Vac	Swee	D-Vac	Sweep	D-Vac
Aphids	0.80**	0.75**	0.80**	0.78**	0.84**	0.84**	0.85**	0.90**
Lygus	0.40**	0.54**	0.79**	0.65**	0.80**	0.71**	0.80**	0.83**
Alfalfa weevil	0.72**	0.60**	0.80**	0.68**	0.40**	0.81**	0.71**	0.72**
Leaf hopper	0.33*	0.31*	0.62**	0.56**	0.16	0.34*	0.53**	0.67**
Alfalfa root curculio	–0.05	0.16	0.52**	0.37**	–0.03	–0.02	0.57**	0.47**

**,* Indicate significant correlations at p = 0.01 and p = 0.05, respectively.

RESULTS AND DISCUSSION

Pea aphids

Correlations between sweepnet and D-Vac sampling ranged from 0.54 to 0.94 for the wingless and from 0.50 to 0.87 for the winged pea aphids (Table 1). Within a given year and location, the correlations for the two aphid groups were quite similar. The lag 1 correlations ranged from 0.75 to .90, indicating that the two sampling methods generally provided consistent estimates of pea aphid populations over time (Table 2). In 1978, few large differences between sampling methods were observed, the only exception being the fifth sampling date at Site 1 for wingless aphids (Fig. 1). There the sweepnet sampling indicated almost 10 times as many wingless aphids as the D-Vac. In 1979, the D-Vac counts tended to be higher for winged and wingless aphids at peak population levels at both locations (Fig. 1).

Pea aphid counts in alfalfa are influenced by temperature, RH, cloud cover, the height of the alfalfa, and wind speed (Saugstad *et al.* 1967). For this insect, sweepnet sampling may not be sufficiently precise to make absolute insect population comparisons, but may be useful for determining population trends (Saugstad *et al.* 1967). Butin and Isenhour (1989) found that stem and sweepnet counts were highly correlated for pea aphids in alfalfa. Our high correlations between sampling methods in 1978 and 1979 indicate a generally good agreement throughout the sampling period (Table 1). Therefore, decisions on control of pea aphid populations would probably have been similar for the two sampling methods (Fig. 1).

Lygus spp.

Correlations of lygus counts between sweepnet and D-Vac sampling ranged from 0.06 to 0.92, but the two sampling methods were inconsistent in detecting trends (Table 1). Lag 1 correlations ranged from 0.40 to 0.83, indicating low agreement between successive sampling date estimates at some locations (Table 2). The lag 1 correlations for the two sampling methods were generally similar. In 1978, lygus nymphs at Site 2 and lygus adults at Site 1 showed few consistent trends (Fig. 2). For 1979 at Site 1, the agreement between the two sampling methods was consistent throughout most of the season. Neither sampling method consistently provided higher lygus population estimates.

Schotzko and O'Keeffe (1986a) found that lygus nymph counts with sweep-net sampling in lentils were influenced by RH, temperature and light intensity, but adult lygus were not influenced by any of the abiotic factors. These authors also found that the appropriate time for sampling adult lygus bugs with the sweepnet did not coincide with that for sampling lygus nymphs. In our study, the sweepnet and D-Vac sampling methods probably sampled different areas of the alfalfa canopy; therefore, differences in counts between the two sampling methods for lygus nymphs and adults, as well as the low lag 1 correlations, seem to indicate that both were influenced by abiotic factors. Schotzko and O'Keeffe (1986b) concluded that sweepnet sampling provided reliable estimates of adult lygus in lentils, but D-Vac sampling probably overestimated both lygus adults and nymphs. Since the two sampling methods in our study provided almost identical lygus counts on some sampling dates and significantly different counts on others (lygus nymphs at Site 2 in 1978 and 1979), we can make no statement about the reliability of either method for sampling lygus in alfalfa. The sweepnet probably sampled a larger volume of alfalfa and often provided higher lygus counts; nevertheless, for some sampling dates the D-Vac produced much higher counts than the sweepnet. This lack of consistency makes decisions about the need to control lygus in alfalfa dependent in part on the sampling method and abiotic factors at the time of sampling.

Alfalfa weevil

Correlations for adult alfalfa weevil ranged from 0.15 to 0.36, while correlations for larvae ranged from 0.54 to 0.79 (Table 1). Within a given location and weevil growth stage, the correlations for the two years were similar. In 1978, the lag 1 correlations for the two sampling methods were similar (Table 2). Lag 1 correlations ranged from 0.40 to 0.81, and were different for the two sampling methods at site 1 in 1979. For 1978, the sweepnet sampling produced higher larval counts for most of the sampling dates at both locations (Fig. 3). In 1979, both sampling methods provided similar larval counts for most sampling dates. Adult alfalfa weevil counts were low for both locations in both years (Fig. 3). Neither sampling method produced consistently higher adult weevil counts, but for some sampling dates, the D-Vac produced substantially higher counts than the sweepnet.

Cothran and Summers (1972) compared alfalfa weevil counts obtained from sweepnet and square-foot, absolute sampling, and found that the sweepnet underestimated the actual populations, with the most severe underestimations occurred early in the developmental period of the weevil larvae. They suggest replacing the sweepnet with another sampling method when accurate estimates of alfalfa weevil are required. In our study, the alfalfa weevil larval population estimates obtained from sweepnet sampling in 1978 were substantially higher than D-Vac counts for most of the sampling periods at both sites (Fig. 3). The higher counts obtained by the sweep-

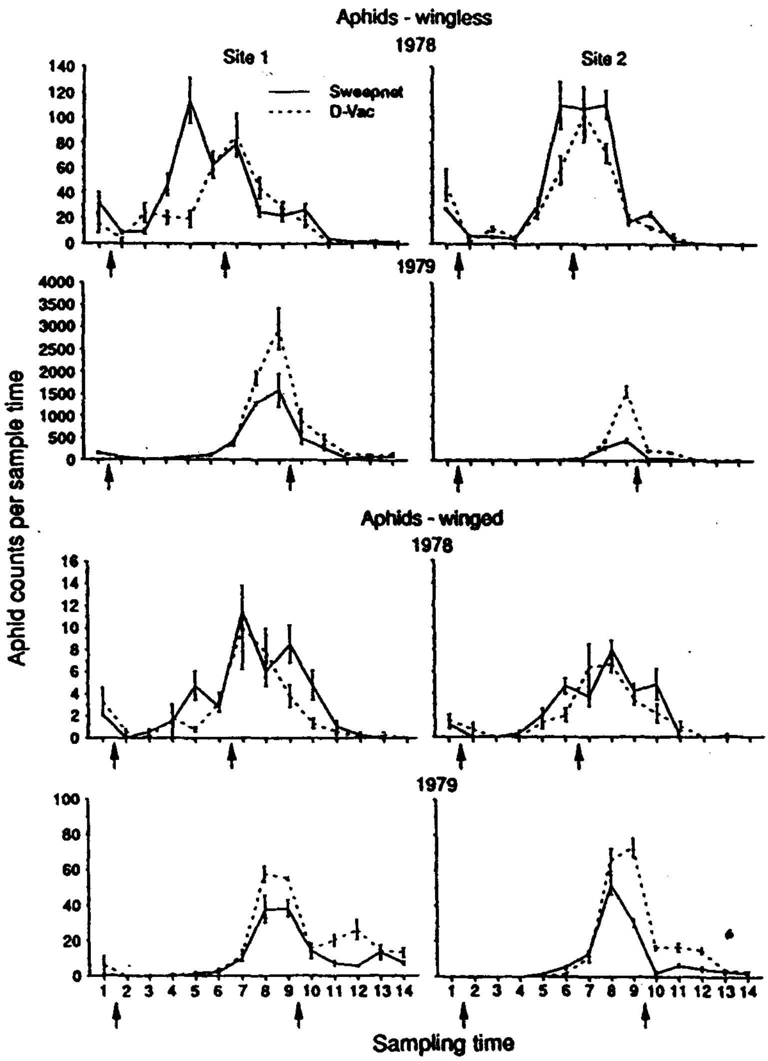

Figure 1. Influence of sampling method on counts of aphids.
^ = Time of cut.

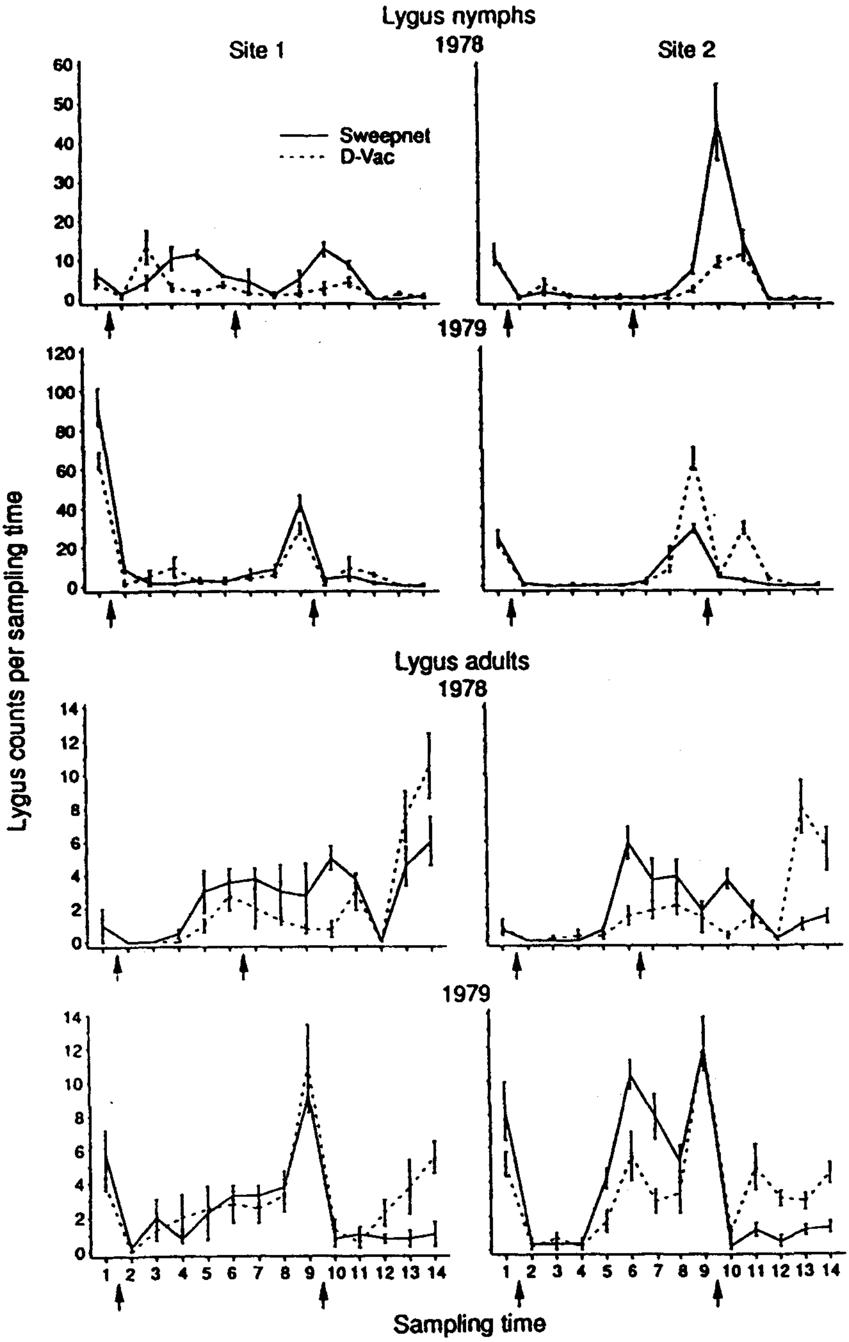

Figure 2. Influence of sampling method on counts of lygus bugs.
^ = Time of cut.

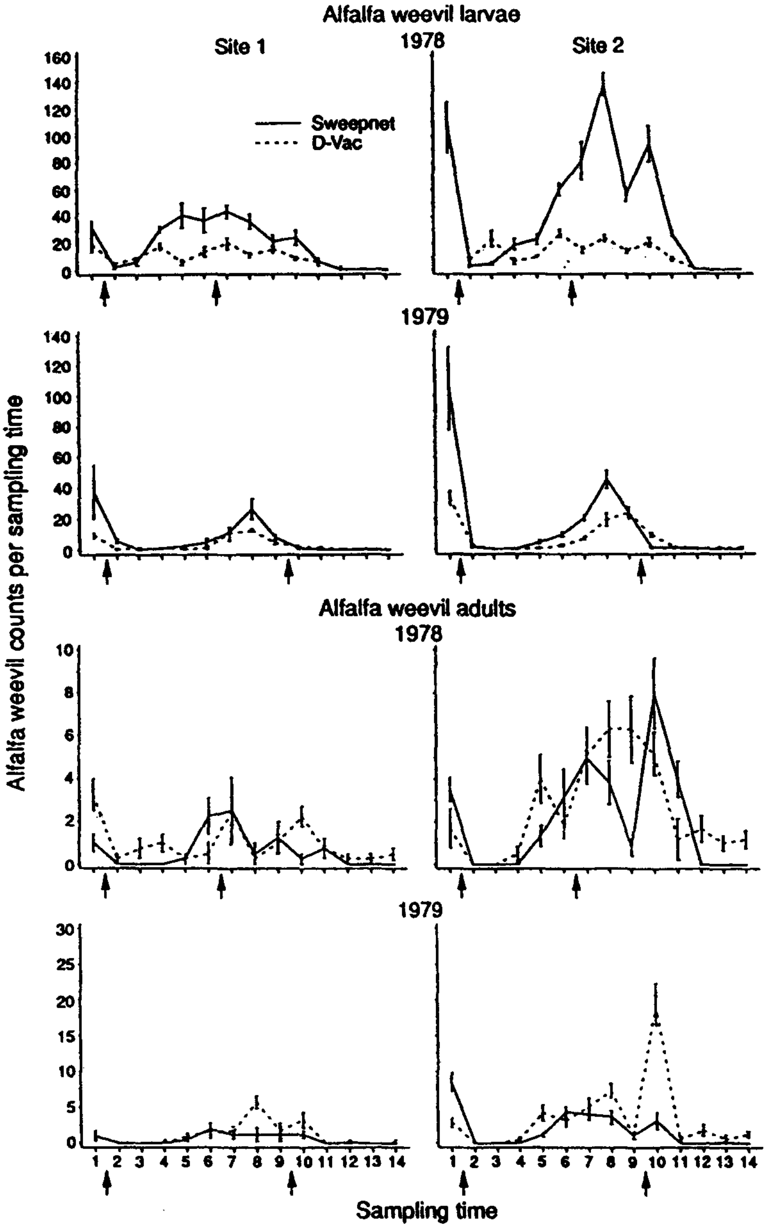

Figure 3. Influence of sampling method on counts of alfalfa weevils.
^ = Time of cut.

net could be due to a larger sampled volume, but if that is the case, why did the two sampling methods produce very similar counts for some sampling dates? The D-Vac captured higher numbers of adult alfalfa weevils than the sweepnet for some sampling dates, but there was no consistency (Fig. 3). The early larval instars are located in the newly developing leaf and flower buds and are not easily dislodged, whereas the late instar larvae and adults are found on the leaves and are easily captured; therefore, the location of alfalfa weevil within the canopy may have favoured one sampling method over the other on certain sampling dates. The low lag 1 correlations for the sweepnet at site 1 in 1979 seem to support this suggestion.

Decisions about the need to control the alfalfa weevil would probably have been different for the two sampling methods in 1978, but would not have differed in 1979. If sweepnet sampling drastically underestimates alfalfa weevil larvae populations, as Cothran and Summers (1972) found, then the underestimations from D-Vac sampling in our study seem to be even more severe. However, the differences between D-Vac and sweepnet in alfalfa weevil population estimates appear to be related to abiotic factors and weevil development.

Leafhoppers

Correlations between the two sampling methods for adult leafhoppers ranged from 0.54 to 0.73, and correlations for leafhopper nymphs ranged from 0.11 to 0.78 (Table 1). Lag 1 correlations were generally low and ranged from 0.16 to 0.67, indicating that neither sampling method provided consistent population estimates (Table 2). Nymphal leafhopper counts were quite low for most sampling dates and few practically significant deviations were observed between the two sampling methods (Fig. 4). Some noticeable exceptions were very high counts for the D-Vac on the third sampling date in 1978 at Site 1, and the first sampling date at Site 2 in both 1978 and 1979. D-Vac sampling produced higher adult leafhopper counts for most of the sampling dates at both locations in 1979 (Fig. 4). Differences between sampling methods for adult leafhoppers in 1978 were not as consistent as in 1979, but D-Vac sampling tended to have higher counts.

Delong (1932) discussed some of the problems involved with sweepnet sampling and concluded that, for active insects such as leafhoppers, sweepnet sampling is not very useful for obtaining accurate population estimates. Saugstad *et al.* (1967) obtained a high positive correlation between leafhopper counts from sweepnet sampling and the height of the alfalfa, whereas Cherry *et al.* (1977) found that wind and temperature were the two most important factors in sweepnet estimates of adult leafhopper populations in alfalfa. These findings may explain some of the variability between sampling methods and the low lag 1 correlations that we observed over years, locations, and sampling dates. In 1979, adult leafhopper counts were higher in D-Vac samples than in sweepnet samples for the whole sampling period. We can only speculate that abiotic factors favoured D-Vac sampling because, theoretically, the volume of alfalfa sampled by the sweepnet should have been higher than the volume sampled by the D-Vac. In 1979, decisions to control leafhopper populations would have been different for the two sampling methods.

Alfalfa root curculio

Correlations between sampling methods ranged from -0.02 to 0.54 (Table 1). The small negative correlation was the result of very low alfalfa root curculio counts at Site 1 in 1979 (Fig. 5). The D-Vac samples had higher curculio counts than the sweepnet for the latter half of the sampling period at both sites in 1978, and at Site 2 in 1979. The location of the curculio within the alfalfa canopy was probably responsible for the higher counts obtained with D-Vac sampling, even though the sweepnet may have sampled a larger volume. The very low lag 1 correlations for both sampling methods indicate that neither sampling method provided consistent population estimates (Table 2).

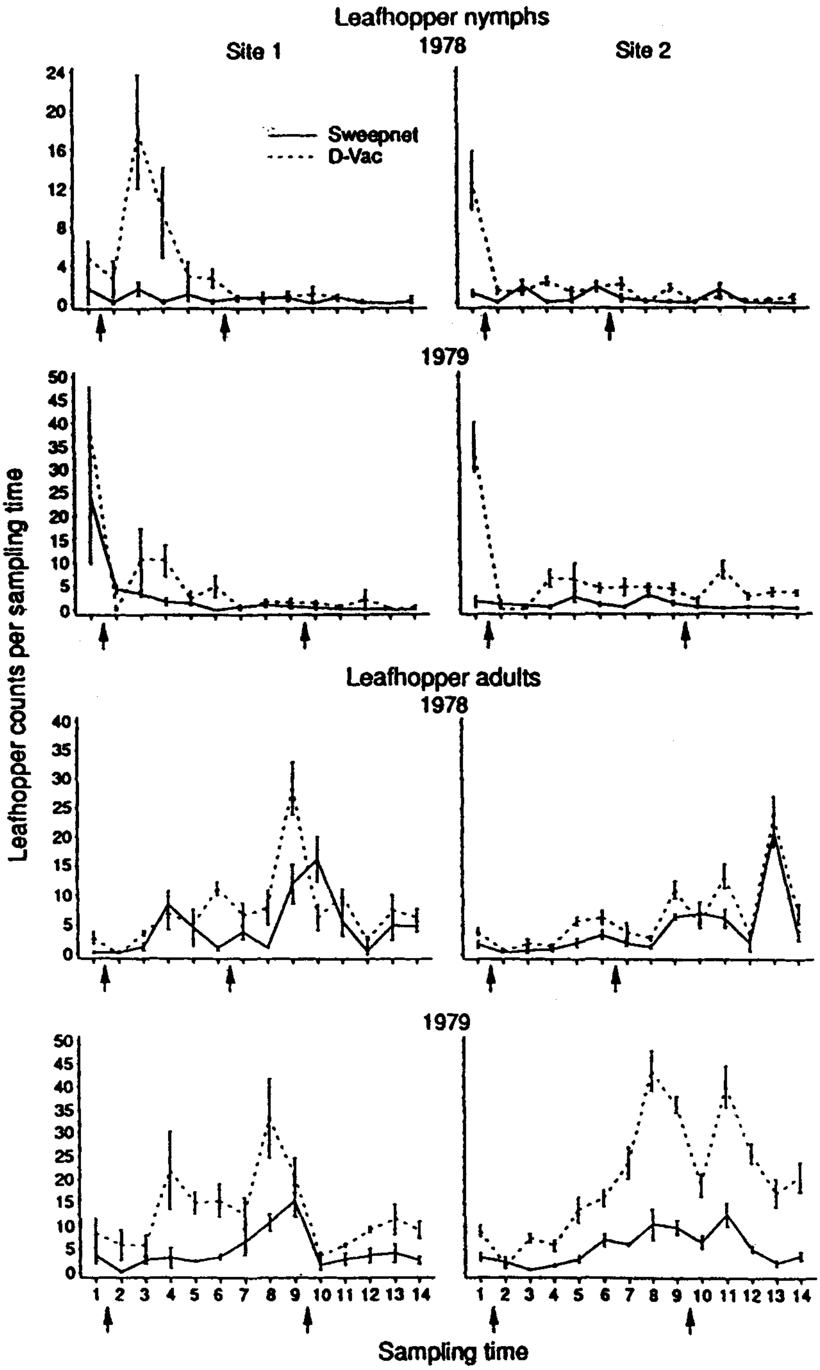

Figure 4. Influence of sampling method on counts of leafhoppers.
^ = Time of cut.

CONCLUSIONS

From our results, we conclude that, to obtain reasonable estimates of insect populations on which to base insect control decisions with sweepnet or D-Vac sampling, the behaviour and feeding patterns of the target insect need to be understood. Sampling conditions should optimize the probability of capturing the target insect. This implies that sampling on fixed dates at fixed times will probably influence the estimated insect populations since the abiotic factors will not necessarily be optimal at the preselected sampling times. Furthermore, the optimal sampling conditions vary among insect species and their developmental stages.

We also conclude that higher sampling volumes do not necessarily produce higher insect counts, since the location of the insect in the alfalfa canopy and other factors are also important. This makes the validity of post-sampling volume and area standardization questionable. After alfalfa growth reaches 30 to 35 cm in height the sweepnet generally only samples the top portion of the alfalfa canopy and, therefore, underestimates insects dwelling mainly in the lower portion of the canopy. Sweepnet and D-Vac insect estimates are dependent on the insect species, their stage of development, their location within the canopy, the crop being sampled, and abiotic factors. Therefore, when making pest control decisions, any sampling scheme that incorporates either of these two sampling methods must consider the above factors to obtain accurate population estimates or trends.

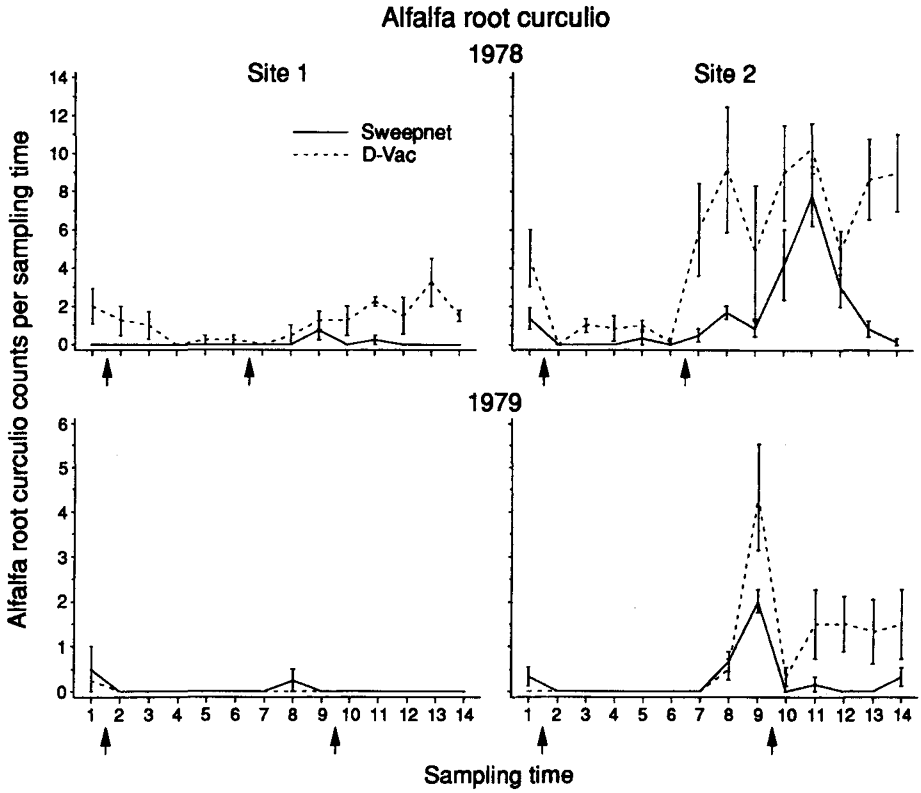

Figure 5. Influence of sampling method on counts of alfalfa root curculio.
^ = Time of cut.

NOTES

1. Contribution 3878943.
2. Retired.

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