ECONOMIC IMPORTANCE OF INSECTS ON REGROWTHS OF ESTABLISHED ALFALFA FIELDS IN ONTARIO

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Abstract

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Damage caused by *Empoasca fabae* (Harris) and *Philaenus spumarius* (L.), caged on second and third alfalfa harvests, was additive. Numbers of *E. fabae* were linearly correlated negatively with plant height, leaf area, and percentage protein, and positively with percentage chlorosis. Perceptible stunting and yellowing occurred with mean infestations per stem of 0.09 *E. fabae* and 0.6 *P. spumarius* nymphs. *P. spumarius* adults reduced plant height only at infestations of 0.3/stem, while 0.6 nymph/stem also reduced dry weight. *E. fabae* reduced protein at 0.11/stem and dry weight and leaf area at higher populations of 0.17/stem. None of these parameters was affected on subsequent regrowths. *Lygus lineolaris* (P. de B.) could not be maintained on pre-bloom alfalfa and was not considered a pest. *Adelphocoris lineolatus* (Goeze) reduced protein at levels of 0.01 bug/stem and dry weight at 0.06 bug/stem but results were confounded by high mortality. Field populations of all these species were reduced by the second cutting but redeveloped on the regrowth. Although applications of dimethoate (200 g AI/ha) and dimethoate (200 g AI/ha) plus endosulphan (280 g AI/ha) were effective in reducing populations of *E. fabae*, *Acyrthosiphon pisum* (Harris), *A. lineolatus*, and *Hypera postica* (Gyllenhal), insecticides were cost-effective on only one field. This field had 1.9 *E. fabae*/sweep and a 3% loss in protein resulted. Plant height, density, dry weight, protein content, and overwintering survival were not significantly affected at harvest in other fields. With the exception of *E. fabae*, the sum of the maximum field populations, each expressed as a fraction of its threshold, did not reach 50% of an economic threshold.

Résumé

Les dommages dus à *Empoasca fabae* (Harris), et *Philaenus spumarius* (L.) maintenus en cage sur de la luzerne de deuxième et de troisième coupe, étaient additifs. Les nombres de *E. fabae* étaient linéairement corrélés (1) avec la hauteur des plants, la surface foliaire et le pourcentage de protéine, de façon négative, et (2) avec le pourcentage de chlorose, de façon positive. Du fannage visible et du jaunissement se sont manifestés à une densité larvaire moyenne par tige de 0.09 pour *E. fabae* ou de 0.6 pour *P. spumarius*. Les adultes de *P. spumarius* n'ont réduit la hauteur des plants qu'à un niveau d'infestation de 0.3/tige, alors que 0.6 larve/tige ont également réduit le poids sec. *E. fabae* a réduit les protéines à une densité de 0.11/tige, et le poids sec ainsi que la surface foliaire à une densité de 0.17/tige. Aucun de ces paramètres ne fut affecté lors des repousses subséquentes. *Lygus lineolaris* (P. de B.) n'a pu être maintenue sur la luzerne pré-floraison et n'a pas été considérée comme nuisible. *Adelphocoris lineolatus* (Goeze), a réduit les protéines à la densité de 0.01 individus/tige et le poids sec à 0.06/tige, cependant les résultats étaient affectés par la mortalité élevée. Les populations de terrain de ces espèces ont diminué à la deuxième coupe mais ont remonté avec la repousse. Quoique des applications de dimethoate (200 g IA/ha), ou de dimethoate (200 g IA/ha) avec endosulphan (280 g IA/ha) se sont avérées efficaces pour réduire les populations de *E. fabae*, *Acyrthosiphon pisum* (Harris), *A. lineolatus*, et *Hypera postica* (Gyllenhal), les insecticides ont été rentables dans un champ seulement. Ce champ avait 1.9 *E. fabae*/coup de filet, causant 3% de perte en protéine. La hauteur des plants, la densité, le poids sec, la teneur en protéine et la survie hivernale n'ont pas été affectés significativement à la récolte dans les autres champs. A l'exception de *E. fabae*, la somme des maxima des populations de terrain, chacune exprimée en rapport avec son seuil, n'a pas atteint 50% du seuil économique.

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Introduction

Alfalfa, *Medicago sativa* L., is an important forage crop in Canada because of its high protein content and extensive acreage. Protecting alfalfa from insect pests is thus of considerable concern. This protection is becoming increasingly more difficult and complex because of a number of pests including: the alfalfa weevil, *Hypera postica* (Gyllenhal); the alfalfa blotch leafminer, *Agromyza frontella* (Rondani); the potato leafhopper, *Empoasca fabae* (Harris); the meadow spittlebug, *Philaenus spumarius* (L.); and to a lesser extent, the plant bugs, *Adelphocoris lineolatus* (Goeze) and *Lygus lineolaris* (P. de B.).

Forage alfalfa has a low cash return which discourages routine spraying and makes pest management attractive. Indispensible for making pest management decisions are reliable estimates of crop losses and economic thresholds. These estimates for pests on regrowth of established alfalfa have not been adequately developed. It is becoming more important to obtain these measurements of damage because of the biological control programs currently in Canada for the alfalfa weevil and alfalfa blotch leafminer, and the need to limit the use of pesticides on alfalfa to instances when they are cost-effective.

Considerable information is available on crop losses caused by single species, but little data are available that relate the combined potential of several species over time (Wilson *et al.* 1979). Economic injury levels, defined by Stern (1973) as the lowest pest densities that cause economic damage, are difficult to determine. Two methods have been used to estimate damage on field crops. One used controlled infestations in field cages (Newton *et al.* 1970; Kindler *et al.* 1973; Ogundala and Pedigo 1974; Hower 1979), while the other used various field populations obtained by applying insecticides. With the latter method, yield and quality are determined at harvest from insect-free plots and compared with that from insect-infested plots (Davey and Manson 1958; Dondale 1972; Wilson *et al.* 1979). The technique permits a cost-benefit analysis of various field treatments applied at various pest densities.

Alfalfa is harvested two to three times each summer in southern Ontario. Most studies on economic thresholds of alfalfa pests have dealt with damage to the first harvest and insufficient attention has been given to determining economic thresholds on second and third harvests. Thus, research was initiated in 1979 to determine the pest status of *E. fabae*, *P. spumarius*, and other species on the second and third harvests in established alfalfa fields in Ontario, and to determine under what conditions insecticides would be cost-effective.

Material and Methods

Research areas. Fields in three areas of southwestern Ontario were used: Woodstock, Welland, and Guelph. Three fields in 1979, one in each area; seven fields in 1980, two at Woodstock, two at Welland, and three at Guelph; and one in 1981 at Guelph were used for field and cage studies. All fields were second-year stands managed for two or three harvests of forage. Four varieties of alfalfa were included: Thor, Apollo, Vernal, and Vista, with stands ranging from 80% to 100% alfalfa. Stands with less than 100% alfalfa were mixed, either with clover or grasses.

Cage studies. Cages were paced in a 40 by 50 m area of each harvested field to allow regrowth of the second and third crops. The cages, 80 by 50 by 80 cm, were constructed either of lumber or steel rods and covered with netting. These were placed over the regrowth when the alfalfa was approximately 10 cm high. Five plants in 1980 and four in 1981 were maintained within each cage until harvest. Other competing plants were destroyed by weeding. Resident insect populations were removed by spraying for 15 sec with Raid® containing pyrethrin (0.25%) and technical piperonyl butoxide (1.25%) at the time of cage placement, 6 days before infestation.

The cages were infested on 23 June 1980 and 1981 to simulate insect populations on the second harvest and on 29 July 1980 to simulate those on the third harvest. In 1980, 10 randomly assigned treatments were used. The infestations per plant were, a check with no insects; 1 and 3 *E. fabae*; 6 and 18 *P. spumarius*; 1 *E. fabae* with 6 and 18 *P. spumarius*; 3 *E. fabae* with 6 and 18 *P. spumarius*; and 25 *L. lineolaris*. In 1981, seven treatments were established to include a check and six levels of infestation with *E. fabae* (0, 0.5, 1, 1.5, 2, 2.5, and 3/plant). A randomized complete block design was used with 6 replicates in 1980 and 5 in 1981. Male and female adults of *E. fabae*, *P. spumarius*, and *L. lineolaris* were collected from alfalfa near the cages. Nymphs of *P. spumarius* were substituted for adults in the 23 June 1980 experiment as adults were unavailable. Nymphs were placed on the plants along with spittle masses. The cages were reinfested on 30 June 1980 and 1981 and on 5 August 1980 because of mortality. Final insect populations within the cages of the second harvest were recorded on 14 July 1980 and 1981 and of the third harvest on 19 August 1980 to determine insect mortality. Plants, which were caged in 1980, were marked and allowed to regrow without cages to investigate the long-term effects of insect populations on crop quality and quantity.

Cages were also used to study damage to alfalfa caused by *A. lineolatus*. On 6 August 1980, three cages were infested with 25 alfalfa plant bugs/plant, and another three were used as checks without insects. Nine cages on 30 June 1981 were infested to provide 3 replicates at 3 levels of infestation: 0, 10, and 25 bugs/plant. Insect mortality occurred and, consequently, the cages were reinfested on 13 and 20 August 1980 and on 7 and 14 July 1981. Harvests were taken on 4 September 1980 and 20 July 1981 and the parameters were measured as with the other cage experiments.

Alfalfa was harvested to a 5-cm stubble when plants caged without insects were in the late-bud stage, the recommended stage for cutting. The plant height, number of stems, and chlorosis were tabulated in the field. Leaf chlorosis was assessed for whole plants on a scale of 0 to 5 where $0 \leqslant 10\%$, $1 = 11$ to 30%, $2 = 31$ to 50%, $3 = 51$ to 70%, $4 = 71$ to 90%, and $5 \leqslant 91\%$ chlorosis. Individual plants were sealed in plastic bags to prevent water loss and returned to the laboratory within the hour for weighing. The total leaf area of each plant was measured by a leaf-area meter (Area meter Model L1-3100, Lambda Instruments Corp., Lincoln, Nebraska 68504, U.S.A.). These plants were placed in paper bags, dried, and reweighed to determine dry weight. The samples were then mechanically ground and the protein content determined by the modified Kjeldahl method.

Percentage data were transformed by logarithms prior to analysis. Where significant differences occurred, these were analyzed further by Duncan's New Multiple Range Test. In 1980, interaction between *P. spumarius* and *E. fabae* was tested by a factorial analysis of variance.

Field studies. The test area at each of the 3 sites in 1979 was 1 ha, one half of which was sprayed as a stubble treatment ca. 10 days after harvest with dimethoate (200 g AI/ha) and the other half, the check, not sprayed. The experimental area in 1981 was expanded in 6 of the fields to ca. 2 ha to accommodate 3, 0.5-ha plots; one a check and not treated, one with dimethoate as in the previous year, and one with a mixture of endosulphan (280 g AI/ha) and dimethoate (200 g AI/ha). Endosulphan was used because it was registered for control of *P. spumarius* on alfalfa and dimethoate because of registration for control of *E. fabae*. To minimize border effects, a 25-m untreated strip separated the 3 plots, each of which was further subdivided into 5 subplots for sampling.

Populations of insects were monitored in the 10 fields at ca. 10-day intervals from 20 June (following the first cutting) to 14 September (third cutting). Samples were taken in each field simultaneously with a 38-cm net and with panshakes. A sweepnet sample consisted of 50 pendulum sweeps taken diagonally across each subplot. The area sampled was approximately 0.8 sq. m/sweep as calculated following the method of Simonet (1978).

A panshake sample consisted of one, 3-stem bouquet of alfalfa. Stems were defined as all shoots longer than 8 cm. Five samples were taken randomly in each subplot, cut at the base, and shaken into a white, enamel pan measuring 25 by 40 cm. Counts of sedentary insects in the pan were taken in the field.

Crop damage was assessed in all fields from harvests taken within 1 week of the farmer's regular harvest. Plant height, yield, moisture content, stand density, and winter survival were measured, and treated and non-treated areas were compared. This permitted a cost–benefit analysis of the treatments on alfalfa with different natural infestations. Because soil fertility and pH are known to affect yield, the phosphorous, potassium, and magnesium levels, and pH were determined by the Ontario Ministry of Agriculture and Food Soil Testing Laboratory at Guelph. Plant and stem densities were counted in 10 areas, each 0.5 sq. m following both harvests, and the subsequent spring in each field to estimate stand density and overwintering mortality. Yield was estimated from one, 0.87 by ca. 2.0 m strip, cut with a self-propelled Jari® mower, and weighed in each subplot of each field. A randomly selected subsample was weighed to determine fresh weight and dried for 72 h at 50°C to obtain the dry weight. The subsamples were ground and the protein determined by the modified Kjeldahl method.

Results and Discussion

Cage studies. In all experiments, the numbers of stems per plant recorded at harvest were not different ($P \leqslant 0.05$) and therefore did not confound the measurements of plant response. The mean numbers of stems ranged from 8.3 to 15.0/plant with never more than a difference of two stems within each experiment. Survival of the insects in the cages was difficult to measure over time and no allowances were made for gradual mortality or weekly reinfestations. The final mortality was considered a realistic estimate of insect populations for the duration of each experiment and was used, in each case, to correct the initial infestation levels.

Lygus lineolaris could not be maintained on pre-bloom alfalfa. Although cages were reinfested 3 times at 7-day intervals throughout the experimental period, mortality was 100% by harvest. Plants in the check and the infested cages were not different for any of the parameters measured at harvest. *L. lineolaris* is cannibalistic, at least in the laboratory (Curtis and McCoy 1964), predaceous (Wheeler 1974), and survives poorly on pre-bloom alfalfa. Thus, *L. lineolaris* should not be considered part of the pest complex on forage alfalfa.

Populations of *A. lineolatus* (corrected for mortality) at 0.01 bug/stem on the third harvest caused losses in protein, while populations of 0.06 bug/stem on both harvests reduced yield (Table I). These reductions, however, were confounded by high mortality. At the time of harvest, mortality of *A. lineolatus* was 99.5% in 1980 and 93.5% in 1981 despite 3 weekly infestations. The thresholds for populations of *A. lineolatus* are probably high because the final percentage mortality was used in calculating densities. In the field, populations of 0.01 *A. lineolatus*/stem were approached 30% of the time, but were not associated with losses in quantity or quality of hay. The high mortality of *A. lineolatus* when forced to feed solely on alfalfa necessitates further investigations with other food sources and the results of these cage studies must be considered tentative.

When infested on plants 10 cm high, *P. spumarius* at 0.6 nymph/stem (corrected) increased chlorosis and reduced plant height, leaf area, and dry weight of established stands (Table II). Nymphs were more damaging than were adults as the only factor affected on the third harvest was plant height. *P. spumarius* at 0.3 adult/stem reduced plant height 6.4% over the non-infested plants (Table III). Protein content was not affected by this species. This is in contrast to studies by Parman and Wilson (1982) where feeding on forage by spittlebug nymphs caused increases in protein content. The lack of rainfall could have contributed to the increase in damage by nymphs as only 19.2 mm were recorded during the second harvest compared with 42.1 mm during the third. Factorial analysis of this data showed no interaction between the feeding effects of *E. fabae* and *P. spumarius* and it was concluded that the damage was a direct summation of their combined effects.

The lowest populations of *E. fabae* had no effect on plant response on either harvest, except in combination with *P. spumarius* (Tables II, III). The first measurable effects from feeding by *E. fabae* in 1981 were chlorosis and reduced plant height at densities of 0.09 leafhopper/stem (Table IV). Protein content was reduced at 0.11 leafhopper/stem while leaf area and dry weight were not affected until populations of 0.17 leafhopper/stem were caged on these stands. Populations of 0.08 leafhopper/stem reduced the quality of hay on the third harvest (Table III) when environmental conditions such as rainfall were less than optimal. Leaf area and dry weight were not affected at similar levels although earlier in the season, on the second harvest, both factors were reduced. Regression analysis ($P < 0.05$) on data presented in Table IV indicated that damage was linearly related to the numbers of *E. fabae*: positively for chlorosis and negatively for protein content, plant height, and leaf area.

No long-term effects of insect feeding were observed on plants infested and allowed to regrow without cages. The parameters measured on this regrowth where various populations had been caged were not significantly different. The dry weight of each harvest was generally less than the previous one and this was attributed to the lower temperatures and shorter daylengths towards the end of the growing season. Wilson *et al.* (1979) found carry-over effects in plant height following attack by *E. fabae*, *P. spumarius*, and *H. postica* and for yield following attack by *P. spumarius* and *H. postica*. They concluded, however, that under sound agronomic management, with high fertility programs and timely pest control and harvesting, alfalfa could recover fully following severe stress from insect infestations.

Field studies. During the 2 years of this study, the pest species *E. fabae* and *P. spumarius* were most prevalent in the Welland area. At all sites, the second cutting reduced insect populations but did not prevent their build-up on the third harvest. The highest populations of *P. spumarius*, *A. pisum*, and larvae of *H. postica* were recorded on the second harvest, whereas maximum populations of *E. fabae* were found on the third. *A. lineolatus* and *L. lineolaris* were more abundant on the third harvest although densities of *L. lineolaris* were frequently highest at late-bud, immediately prior to both cuttings (Table V).

Dimethoate or dimethoate plus endosulphan reduced populations of all insects; however, in 9 of 10 fields, damage associated with densities of insects did not warrant treatment with insecticides. With the exception of one field in Welland, where a significant 3% loss in protein occurred, dry weight and protein content were not significantly reduced at either harvest (Table VI). In addition, overwintering mortality of these stands, although ranging from 0% to 25%, was not reduced in the check areas over that in the treated areas.

In both years, economic levels of *P. spumarius*, *A. pisum*, *A. lineolatus*, *L. lineolaris*, and *H. postica*, as defined in the literature (Table VII), were not reached in southwestern Ontario. Field studies indicated that *E. fabae* was the only insect that surpassed economic thresholds, and was the most damaging on second and third harvests of alfalfa. Populations of 1.9 *E. fabae*/sweep, twice the economic threshold (Blair 1975), were reported in the one Welland field where protein was reduced by 3%. Using a December 1982 cash price of 30 cents/kg for bulk soybean meal containing 44% protein indicated a cost of $34.00 to replace the 50 kg of protein represented by a 3% reduction in protein of an average 1.6 tonne harvest. Assuming a $19.00 cost for monitoring, insecticide and application, the $15.00 net return indicated that control measures were warranted.

Pests on regrowths of established alfalfa caused economic damage only 10% of the time in this study in 1979 and 1980. Infrequent damage had led growers to gamble on not spraying their fields. In the Welland region, where *E. fabae* approached 2 leafhoppers/

Table I. Chlorosis, plant height, leaf area, dry weight, and protein content of second- and third-harvest alfalfa infested with *Adelphocoris lineolatus* from 6 August to 4 September 1980 and 30 June to 20 July 1981 at Guelph, Ontario

Infestation (no./plant)	Mortality (%)	No. stems/ plant	Corrected infestation (no./stem)	Average chlorosis plant (%)*	Mean plant ht. (cm)	Leaf area/ plant (cm²)	Dry wt./ plant (g)	Average protein/ plant (%)*
				Third harvest (1980)				
0	–	12.6	0.0	2.0a**	26.5a	335.6a	2.64a	31.4a
25	99.5	15.0	0.01	9.0a	11.4a	111.7a	0.69b	29.1b
				Second harvest (1981)				
0	–	12.3	0.0	10.0a	48.3a	924.8a	7.75a	19.9a
10	93.0	12.2	0.06	41.7b	24.7b	358.1b	3.01b	22.3a
25	94.0	13.0	0.12	48.3b	23.2b	390.5b	3.37b	21.9a

*Analysis based on means transformed by log ($\bar{X}$ + 0.001).
**Means followed by the same letter in the same year are not significantly different at the 0.05 level as determined by Duncan's New Multiple Range Test.

Table II. Chlorosis, plant height, leaf area, dry weight, and protein content of second-harvest, Vernal alfalfa infested at a plant height of 10 cm with adults of *Empoasca fabae* and nymphs of *Philaenus spumarius* from 23 June to 14 July 1980, at Guelph, Ontario

Infestation (no./plant)		Mortality (%)		No. stems/ plant	Corrected infestation (no./stem)		Chlorosis/ plant (%)	Mean plant ht. (cm)	Leaf area/ plant (cm²)	Dry wt./ plant (g)	Average protein/ plant (%)*
E. fabae	*P. spumarius*	*E. fabae*	*P. spumarius*		*E. fabae*	*P. spumarius*					
0	0	–	–	10.4a	0	0	7a**	41.8a	510.3ab	3.22ab	27.6a
1	0	60	–	10.7a	0.04	0	13a	39.1a	584.9a	4.06a	–
3	0	78	–	10.1a	0.07	0	34bc	29.0c	401.6bc	2.69bc	–
0	6	–	69	10.6a	0	0.2	20ab	36.9ab	523.2ab	3.17ab	–
0	18	–	66	9.9a	0	0.6	33bc	29.5bc	407.3bc	2.04cd	–
1	6	60	57	11.8a	0.03	0.2	37bc	30.5bc	392.1bc	1.91cd	–
1	18	72	67	10.8a	0.16	0.6	42c	28.3c	394.8bc	2.05cd	–
3	6	67	70	9.1a	0.1	0.2	44c	25.3cd	335.5c	2.01cd	–
3	18	66	68	10.6a	0.09	0.6	61d	19.9c	298.7c	1.42d	27.2a

*Analysis based on means transformed by log ($\bar{X}$ + 0.001).
**Means followed by the same letter are not significantly different at the 0.05 level as determined by Duncan's New Multiple Range Test.

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Table III. Chlorosis, plant height, leaf area, dry weight, and protein content of third-harvest, Vernal alfalfa infested at a plant height of 10 cm with adults of both *Empoasca fabae* and *Philaenus spumarius* from 29 July to 19 August 1980, at Guelph, Ontario

Infestation (no./plant)		Mortality (%)		No. stems/ plant	Corrected infestation (no./stem)		Chlorosis/ plant (%)	Mean plant ht. (cm)	Leaf area/ plant (cm^2)	Dry wt./ plant (g)	Average protein/ plant (%)*
E. fabae	*P. spumarius*	*E. fabae*	*P. spumarius*		*E. fabae*	*P. spumarius*					
0	0	–	–	8.3a	0	0	5a**	34.9a	350.9a	5.06a	30.2a
1	0	83	–	8.4a	0.02	0	8a	30.9ab	318.5a	4.67a	–
3	0	78	–	9.3a	0.08	0	16ab	23.3cd	259.5a	4.57a	29.4bc
0	6	–	56	10.1a	0	0.3	7a	28.5bc	349.4a	4.89a	–
0	18	–	70	8.0a	0	0.7	15ab	25.8cd	255.7a	4.21a	31.0a
1	6	80	50	8.8a	0.02	0.3	26bc	28.5bc	308.8a	4.54a	–
1	18	70	57	8.3a	0.04	0.9	38cd	24.2cd	246.4a	4.18a	30.3ab
3	6	80	47	9.7a	0.06	0.3	30bcd	24.6cd	278.0a	4.52a	29.2bc
3	18	84	59	9.8a	0.05	0.8	50d	21.7d	277.8a	4.35a	28.4c

*,**See footnotes Table II.

Table IV. Chlorosis, plant height, leaf area, dry weight, and protein content for second-harvest, Vista alfalfa infested at a plant height of 10 cm with adult *Empoasca fabae* from 23 June to 14 July 1981 at Guelph, Ontario

Infestation (no./plant)	Mortality (%)	No. stems/ plant	Corrected infestation (no./stem)	Chlorosis plant (%)*	Mean plant ht. (cm)	Leaf area/ plant (cm^2)	Dry wt./ plant (g)	Average protein/ plant (%)*
0	–	10.8a	0	3.3a**	38.3a	604.2a	4.66ab	21.8a
0.5	0	11.3a	0.04	21.0ab	34.8ab	559.8ab	4.76ab	21.3a
1.0	20	8.5a	0.09	45.0c	28.7bc	456.7abc	4.73ab	20.4ab
1.5	12	12.3a	0.11	35.0bc	31.6b	542.7abc	4.95a	19.8b
2.0	25	8.7a	0.17	64.0d	22.5d	380.1cd	3.49bc	19.4b
2.5	0	12.2a	0.21	72.0d	24.7dc	391.6bcd	3.81abc	17.7c
3.0	0	10.1a	0.30	94.0e	20.6d	278.7d	3.15c	16.8c

*,**See footnotes Table II.

Table V. Maximum mean insect populations and the reduction in numbers following the second cutting in established alfalfa fields averaged for each site, Woodstock, Welland, and Guelph, Ontario in 1979 and 1980

		Maximum mean no. of insects/50 sweeps					
Site	No. of fields	*Empoasca fabae*	*Philaenus spumarius*	*Hypera postica* (larvae)	*Acyrthosiphon pisum*	*Lygus lineolaris*	*Adelphocoris lineolatus*
Woodstock	3	17.4[2]	23.5[1]	17.3[1]	758.8[1]	58.1[2]	42.9[2]
Welland	3	52.5[2]	115.4[1]	59.8[1]	235.3[1]	33.7[2]	22.0[2]
Guelph	4	7.3[2]	56.9[1]	48.9[1]	372.8[1]	50.1[1]	33.2[2]
Mean reduction following 2nd cutting (%)*	10	42.2	89.5	40.0	85.2	81.7	69.7

[1,2]Maximum populations were found on second and third harvest, respectively.
*Mean for all fields. Reduction measured within 5 days of harvest.

Table VI. Plant height, number of plants, dry weight, and protein at harvest in non-treated and treated alfalfa fields averaged for both 1979 and 1980 at Woodstock, Welland, and Guelph, Ontario

		Plant ht. (cm) ($\bar{x} \pm$ S.E.)				Dry wt. (t/ha) ($\bar{x} \pm$ S.E.)				Protein (%) ($\bar{x} \pm$ S.E.)				No. of plants ($\bar{x} \pm$ S.E.)			
No. of fields	Treatment	2nd har.		3rd har.		2nd har.		3rd har.		2nd har.		3rd har.		Fall		Spring	
	Woodstock																
3	Non-treated	69.5	3.8	54.3	2.8	3.9	0.1	3.5	2.0	20.9	0.4	21.7	1.2	68.2†		47.3†	
3	Dimethoate	79.5	5.0	58.1	2.2	3.1	0.4	3.2	0.3	21.9	0.7	23.2	3.0	57.4†		46.7†	
2	Dimethoate & endosulphan	71.3	5.2	59.0	2.7	3.5	2.3	2.9	0.2	21.5	0.7	22.9	0.4	–		–	
	Welland																
3	Non-treated	60.7	3.7	55.0	7.6	3.2	0.3	2.3	0.3	24.7	0.5	22.0	0.7*	59.3	7.4	68.7	0.9
3	Dimethoate	62.8	2.7	58.2	8.3	3.2	0.2	2.0	0.2	23.9	1.1	23.0	0.3*	88.8	3.8	69.9	2.3
2	Dimethoate & endosulphan	64.5	0.7	48.0	9.9	2.7	0.2	2.0	0.2	25.6	0.2	25.8	1.3*	61.5	2.5	74.2	8.6
	Guelph																
4	Non-treated	55.6	3.6	44.9	14.0	2.7	0.2	2.2	0.4	21.7	0.5	22.9	0.4	74.3†		70.9†	
4	Dimethoate	58.5	3.5	49.1	3.9	3.3	0.2	2.3	0.4	22.3	0.2	24.4	0.3	76.7†		68.5†	
2	Dimethoate & endosulphan	53.7	9.4	48.0	14.3	3.7	0.1	2.5	0.8	22.2	1.2	24.6	0.1	–		–	

*Significant differences ($P \leqslant 0.05$) were observed at one field on the third harvest between non-treated and treated areas: Protein content on non-treated 21.0 ± 0.8; dimethoate 23.9 ± 1.0; and dimethoate and endosulphan 27.6 ± 0.8.
†Only one field sampled at site.

Table VII. The fraction of the economic threshold of destructive insects at maximum populations found on second-year alfalfa in southwestern Ontario, in 1979 or 1980

Species	Site	Maximum population	Economic threshold		Actual population as fraction of the threshold
Hypera postica (larvae)	Welland	0.07/stem	3/stem	(Wilson 1973)	1/43
Acyrthosiphon pisum	Woodstock	0.6/stem	103/stem	(Burkhart 1959)	1/170
Philaenus spumarius	Welland	0.04/stem	1/stem	(Anonymous 1978)	1/25
Lygus lineolaris	Guelph	16/m^2	143/m^2	(O'Neal and Peterson 1971)	1/9
Adelphocoris lineolatus	Woodstock	7/m^2	143/m^2	(O'Neal and Peterson 1971)	1/20
Empoasca fabae	Welland	1.9/pendulum sweep	1/pendulum sweep	(Blair 1975)	2/1

sweep and a loss in protein occurred, it could pay growers to monitor and spray young regrowths for control of this species. Unfortunately, populations were generally lower than average during the 2 years of this project and damaging populations are undoubtedly more widespread some years than the data would indicate.

If hypothetical fields were infested with maximum populations reported in this 2-year study (Table VII), and the effects of each species were considered additive (as seen in the cage studies with *E. fabae* and *P. spumarius*), the combined levels of all pests except *E. fabae* would still be less than half the total economic threshold. On this basis, assuming that the reported economic thresholds are realistic, too much emphasis is placed on the complex of insect pests. There is a danger then of the uninformed overreacting to the abundant insect life on regrowth alfalfa. Insecticides thus could be promoted on established alfalfa for combined populations when their use is not indicated for a single pest species. Data presented here suggest that even though insecticides would reduce various species including *P. spumarius*, *H. postica*, *A. pisum*, and *A. lineolatus*, they are not warranted. In Ontario, these species account for only a small percentage of the threshold and are insignificant when compared with the threshold of *E. fabae*, the primary pest. Integrated pest managers must recognize this particular species of the complex so insecticides can be used discriminately. Disruption of current biological control agents for *H. postica* and *A. frontella* will then be minimized.

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