8-1980

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Research Bulletin
293

August 1980

The Agricultural Experiment Station
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln
Roy G. Arnold, Director

ACKNOWLEDGMENT

This is a cooperative study between the Nebraska Agricultural Experiment Station and Agricultural Research, Science and Education Administration, U.S. Dept. of Agriculture. This study was conducted under experiment station projects 17-027, 15-005 and 12-005.

The authors thank the following persons who helped in the technical aspects of these studies (laying out plots, applying insecticides, counting insects and harvesting plots): Henry J. Stevens, Jr. and J. R. Garl, Agr. Res. Technicians, USDA-SEA-AR; L. E. Klostermeyer, former graduate research assistant, Department of Entomology, University of Nebraska; Terry Brogen, former technician, Department of Entomology, University of Nebraska; Montana Bennet, former student assistant, University of Nebraska; Janet Bartels, former student assistant, University of Nebraska; and Kurt Seevers, student assistant, University of Nebraska.

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Issued August 1980, 1,200

## SUMMARY AND CONCLUSIONS

Three tests in southwestern Nebraska during 1971 and 1972 evaluated insecticides against the army cutworm. Endosulfan was the most effective material tested; however, this insecticide is not presently registered for use on alfalfa.

There is a lack of evidence that the army cutworm causes serious damage to vigorous established stands of alfalfa (Manglitz *et al.* 1973). However, severe plant mortality was caused by this insect in seedling alfalfa. Therefore, stands of alfalfa less than one year old should be carefully monitored during the early spring in areas where the army cutworm is a threat and treatments applied when the first plant mortality (<1%) occurs.

Adult alfalfa weevils did not damage new second growth alfalfa in a small plot study during a 3-year period (1973-1975) at Gothenburg, NE. However, excellent control of larval alfalfa weevils was obtained. Despite visual differences in damage between treated and untreated plots, there was no increase in yield due to treatment in any year. Cothran and Summers (1974) reported that visual estimates were unreliable as a means of estimating yield of alfalfa damaged by the Egyptian alfalfa weevil (*Hypera brunnipennis* (Boheman)) and we found a similar situation with the alfalfa weevil. Dickason and Every (1968) cautioned that with the alfalfa weevil, "Percent leaf loss is an estimate of reduction of quality of hay and not necessarily an estimate of decrease in yield of hay." Qualitative, not quantitative, increases in yield also resulted from the Nebraska insect control studies. These results indicated a need to establish economic threshold levels for the alfalfa weevil in Nebraska to prevent unnecessary use of insecticides.

Four tests to control the alfalfa weevil with registered insecticides verified the efficacy of these materials under Nebraska conditions. Also, control was achieved without unduly increasing numbers of other pests, although pea aphid numbers did increase temporarily after some treatments. Results also showed the need to establish economic threshold levels for the alfalfa weevil, because yield was not increased even though the weevil was suppressed.

A series of tests conducted during 1975 at the Mead Field Laboratory were designed to evaluate plant resistance, cultural practices and insecticides. The use of alfalfa varieties with resistance to various insect pests of alfalfa appeared to be an ideal control method. Studies showed a reduction in alfalfa weevil damage on the varieties Team, Arc, Gladiator and several Nebraska experimental synthetics. Pea aphid numbers were consistently lower on the resistant varieties Team and Dawson than on the susceptible varieties Cody and Vernal. Spotted alfalfa aphid numbers were lower in Cody and Dawson than on the susceptible varieties Team and Vernal. Suppression of low levels of aphids with resistant varieties can therefore be achieved at no cost in time or money to a grower and should help prevent future increases in aphid populations. Proper cutting management of the crop had a controlling effect on both alfalfa weevil larvae and varigated cutworm larvae.

During 1975-1977, a test was conducted each year at the Mead Field Laboratory to evaluate new experimental insecticides against the alfalfa weevil and other pest insects of alfalfa grown for forage. A number of the new insecticides showed promise against the alfalfa weevil and the pea aphid. The efficacy of several insecticides against two other insects, the alfalfa plant bug and the tarnished plant bug, which are primarily damaging during the production of alfalfa seed, were observed. Carbofurna, leptophos and methidathion significantly reduced tarnished plant bug numbers. Carbofuran and chlorpyrifos significantly reduced numbers when both species of plant bugs were counted together. None of these insecticides had been previously evaluated against plant bugs on alfalfa in Nebraska (Kindler *et al.* 1968).

# Alfalfa Insect Management Studies, 1971-77

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## INTRODUCTION AND LITERATURE REVIEW

Although normally only one or two insect species damage alfalfa at any one time or in any one location, losses for the United States have been estimated at $260 million annually (App and Manglitz 1972). In Nebraska, some species damaging to production of alfalfa forage are: the army cutworm, *Euxoa auxiliaris* (Grote); the alfalfa weevil, *Hypera postica* (Gyllenhal); the pea aphid *Acyrthosiphon pisum* (Harris); the spotted alfalfa aphid, *Therioaphis maculata* (Buckton); and the potato leafhopper, *Empoasca fabae* (Harris). In addition, the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), and the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), are commonly present in alfalfa fields but are primarily pests only when alfalfa is grown for seed production.

The army cutworm is not the most destructive insect pest of alfalfa in Nebraska; however, it does have a unique life history. Moths of the single annual generation mature on the plains in May, migrate shortly

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thereafter to higher elevations in the Rocky Mountains, then return to the plains in the fall to lay eggs (Pruess 1967). Eggs hatch the same fall. The small larvae overwinter and damage alfalfa early in the spring, just as the crop begins to regrow. Established stands of alfalfa generally will recover from the damage after the larvae mature and the moths leave the fields, but in fields seeded the previous fall, heavy infestations of the army cutworm can cause considerable plant mortality (Manglitz *et al.* 1973).

The most destructive insect pest of alfalfa in Nebraska in recent years has been the alfalfa weevil, which was accidentally introduced into the United States at two different times and places. The western strain was first found in the United States near Salt Lake City, Utah about 1904, reached western Nebraska by the late 1920's and continued to move eastward very slowly (Hamlin *et al.* 1949). The eastern strain was discovered in Maryland about 1952, spread rapidly and reached Richardson County in eastern Nebraska by 1970 (Keith *et al.* 1977). The eastern strain spread much faster than its western counterpart and seemed to be somewhat more destructive to alfalfa. By 1976, cross-mating studies (the only reliable method of distinguishing between the strains) indicated that the eastern strain had reached the western part of Dawson County and the western strain had reached the western part of York County (Klostermeyer and Manglitz 1979). Alfalfa weevil populations in Nebraska reached their high point in 1974 and 1975 and damage was evident throughout the state. Populations began declining in 1976 and during 1977, 1978, and 1979 were low and did not seriously damage alfalfa.

The spotted alfalfa aphid migrated into Nebraska during the mid-1950's and for several years was very destructive to alfalfa, particularly in the southern part of the state. During this period, aphids overwintered in warmer areas south of Nebraska and migrated north annually. It was later demonstrated that some aphids laid overwintering eggs in the fall. This egg-laying biotype of the spotted alfalfa aphid soon became widespread in Nebraska and adjacent states (Manglitz *et al.* 1966).

The pea aphid and the spotted alfalfa aphid are similar in life cycles and damage patterns. The last widespread and serious pea aphid outbreak was in 1961 (Manglitz *et al.* 1962). Effective control of both species is through the use of resistant alfalfa varieties. Two varieties, 'Dawson' (Kehr *et al.* 1968) and 'Baker' (Kehr *et al.* 1978), are available to Nebraska growers. Spraying of resistant varieties, which is normally unnecessary, may be beneficial during heavy outbreaks. Insecticides are generally compatible with these varieties (Mueke *et al.* 1978a, 1978b).

The potato leafhopper migrates annually to Nebraska from the southern states and is not known to overwinter here (Medler 1957). It usually does not arrive until mid- or late-May; thus, it is never a pest of the first cutting of alfalfa on established stands. In some seasons potato leafhopper may severely stunt the second and third cuttings of alfalfa, particularly in eastern areas. Spring-seeded stands of susceptible varieties may be damaged extensively in the first season of cutting (Kehr *et al.* 1975).

This paper reports results of studies to improve the tactics available for managing the insect pests of alfalfa grown for forage production in Nebraska. Specific objectives were: (1) to further evaluate insecticidal control of the army cutworm; (2) to evaluate timing of insecticide applications in relation to damage caused by alfalfa weevil adults to second cutting alfalfa; (3) to evaluate, under a variety of Nebraska conditions, insecticides registered for alfalfa weevil control; (4) to evaluate the combined use of resistant alfalfa varieties, cultural practices, and insecticides for controlling alfalfa insects and to observe possible interactions between these methods; and (5) to evaluate promising new insecticides against the alfalfa weevil and other insect pests of alfalfa.

## ARMY CUTWORM STUDIES, 1971-72

Because of the unusual migration of the army cutworm, heavy infestations are most frequently found in western Nebraska near the Rocky Mountains. A 2-year study was conducted to determine the effectiveness of endosulfan, which had been reported as the most effective insecticide tested, but which had been tested only one season (Manglitz *et al.* 1973).

### Materials and Methods

In 1971, test plots were located in an alfalfa field (seeded during the fall of 1970) south of McCook (Figure 1). We used a randomized complete block design with three replications. Plot size was 22 × 82.5 ft (6.7 m × 25.1 m). Insecticides and application rates are listed in Table 1. Insecticides were diluted in water and applied at a rate of 10 gal/acre (93.56 liter/ha) with a jeep-mounted John Bean®[8] sprayer operated at 100 psi (7.03 kg/cm$^2$) and equipped with a 21-ft (6.4-m) boom. Application of insecticides was delayed about 10 days because of rain and wet ground and was finally made on April 28. Temperatures were cool, ca. 60-65° F (15.5-18.3° C), with light to moderate winds. At the conclusion of the applications, a heavy rain fell (0.46 inch (1.17 cm)).

Insecticides were evaluated seven days posttreatment by counting cutworm larvae in 10 randomly selected 1-ft$^2$ (929-cm$^2$) areas in each plot.

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[8]The mention of proprietory products or materials does not imply endorsement of those products or materials by any parties, including the University of Nebraska or the U.S. Dept. of Agriculture.

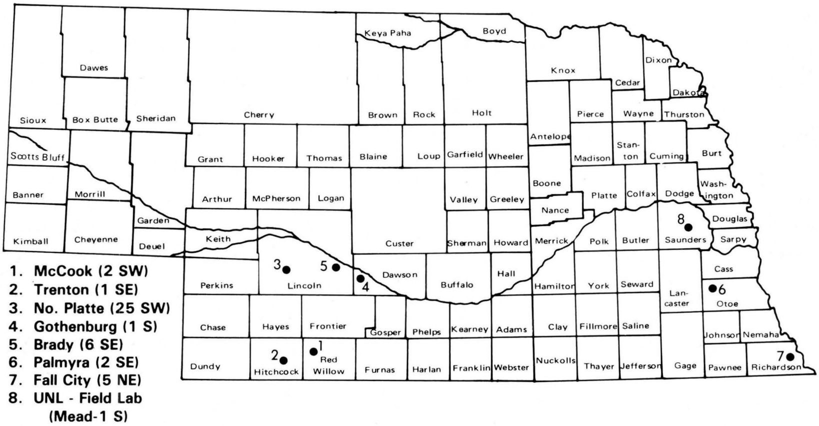


**Figure 1. Approximate locations of field plots used in these studies. The army cutworm studies were conducted at locations 1, 2 and 3. Studies of the timing-of-control of the alfalfa weevil were conducted at location 4. Studies of control of the alfalfa weevil and other insects with registered insecticides were conducted at locations 5, 6, 7 and 8. Studies of control of alfalfa insects with resistant alfalfa varieties, cultural practices and insecticides, and control of the alfalfa weevil and other insects with experimental insecticides were conducted at location 8.**

In 1972, test plots were located in alfalfa fields (seeded during the fall of 1971) located SE of Trenton and SW of North Platte (Figure 1). The experimental design, insecticides, rates of application and sampling techniques used were the same as in 1971. Plot size was 16 × 151 ft (4.9 × 46.0 m). Insecticides were applied with a compressed air sprayer operated at 35 psi (2.46 kg/cm$^2$), equipped with a 16-ft (4.9-m) boom and mounted on a garden tractor. At Trenton, insecticides were applied between 2 and 3 pm on April 10. The weather was bright but hazy with a light wind and temperatures of 60-70° F

**Table 1. Control of the army cutworm by various insecticides at indicated rates of application in tests conducted at McCook, NE in 1971 and at Trenton and North Platte, NE in 1972.**

| Insecticide and rate lb AI/a (kg/ha) | Larvae/ft$^2$ (929 cm$^2$)[a] 1971 McCook[b] | 1972 Trenton[c] | 1972 North Platte[c] |
|---|---|---|---|
| trichlorfon 1 lb (1.12 kg) | 0.40a | 0.40 a | 2.17 a |
| carbofuran 1 lb (1.12 kg) | 0.43 a | 0.43 a | 1.90 ab |
| endosulfan 0.5 lb (0.56 kg) | 0.26 a | 0.27 a | 1.03 abc |
| diazinon 1 lb (1.12 kg) | 0.28 a | 0.47 a | 1.00 bc |
| endosulfan 1 lb (1.12 kg) | 0.13 a | 0.13 a | 0.57 c |
| Control | 0.43 a | 0.43 a | 1.97 ab |

[a]Data shown are actual counts; analysis of variance was performed on square root transformations. Means followed by the same letter do not differ significantly according to Duncan's multiple range test (P = 0.05).

[b]Insecticides were applied on April 28; insects were counted on May 5.

[c]Insecticides were applied on April 10; insects were counted on April 17.

(15.6-21.1° C). At North Platte, insecticides were applied between 6:30 and 7 pm on April 10. The weather was clear with scattered clouds, light wind and temperatures of 50-60° F (10.0-15.6° C).

**Results and Discussion**

In 1971, insecticide treatments were evaluated on May 5. The army cutworm population had declined during the delay of insecticide application and was quite low at the time of the evaluation. Possibly because of this, mean numbers of larvae were not significantly different between any treatments.

In 1972, both tests were evaluated on April 17. At Trenton, the number of cutworm larvae was lower than anticipated, and mean numbers of larvae were not significantly different between any treatment and the control. At North Platte, cutworms were more numerous than in the other tests, and differences were statistically significant between treatments. However, endosulfan at 1 lb AI/a (1.2 kg AI/ha) was the only treatment that reduced numbers of cutworms significantly in comparison to the control. Although results of tests at McCook and Trenton did not differ significantly among treatments, the 1-lb AI/a rate of endosulfan produced the lowest numbers of larvae in every test.

Three tests were conducted in alfalfa stands that were less than 1 year old, and cutworms caused high plant mortality in all fields. Plant mortality is seldom associated with cutworm damage in older stands, although in heavy infestations the first harvest may be delayed. Thus, it appears quite important that young alfalfa stands be closely observed early in the season to ensure adequate protection in areas where the army cutworm is a threat. Research is needed to determine economic thresholds for the army cutworm on seedling alfalfa; however in the absence of more definitive information, it would probably be best to treat alfalfa at the first indications ($<1\%$) of plant mortality.

## ALFALFA WEEVIL: TIMING-OF-CONTROL STUDIES, 1973-1975

The western strain of the alfalfa weevil was not particularly damaging as it slowly migrated eastward through Nebraska. The first serious damage was caused in Dawson County in 1972 by newly emerged adults feeding on very young second growth alfalfa. Weevils damaged, almost exclusively, fields that had been cut at a late growth stage (full bloom or later) in the first cutting cycle. This damage was important to the alfalfa dehydration industry because regrowth was delayed long enough to slow or temporarily halt operation of facilities.

These studies were conducted to determine whether damage could be better controlled by applying insecticide to first growth alfalfa, which would prevent larvae from reaching the adult stage, or by applying insecticide to the regrowth as soon as large numbers of adult weevils were detected.

**Materials and Methods**

Studies were conducted near Gothenburg, NE for three seasons beginning in 1973. Plots of a weevil-susceptible variety of alfalfa were treated on three different dates with carbofuran (0.5 lb AI/a (0.56 kg AI/ha). The first application was an "early pre-harvest", the second was a "late pre-harvest" and the third was a "post-harvest" treatment. The post-harvest treatment was applied to the stubble immediately after the first cutting to control newly developed adult alfalfa weevils. A randomized complete block design with three replications was used. Alfalfa weevils and other abundant insects were counted at about weekly intervals. Plots were harvested during the first and second cuttings, and both yield and quality of forage were determined.

The method of insecticide application, size of plots and number of sweep samples taken to measure the insect population varied from year to year. The 1973 treatments were applied with a jeep-mounted John Bean® sprayer operated at 100 psi (70.3 kg/cm$^2$) and equipped with a 21-ft (6.4-m) boom. Plot size was 66 × 100 ft (20.1 × 30.5 m). The insect population was sampled with a standard 15-inch (38.1-cm) diameter insect net by taking 50 pendulum-type sweeps/plot. Sweep netting is not the most accurate method of comparing insect populations, but is often the method of choice because of ease and speed of sampling (Blickenstaff and Huggans 1969, Armbrust *et al.* 1969).

In 1974 and 1975 insecticides were applied with a knap sack sprayer operated by compressed $CO_2$ at 25 psi (1.76 kg/cm$^2$) and equipped with a 6-ft (1.8-m) boom. Plot size was 40 × 40 ft (12.2 × 12.2 m). Insect populations were sampled by taking 10 pendulum-type sweeps/plot in 1974 and 20 pendulum-type sweeps/plot in 1975.

**Results and Discussion**

Results of the 1973 insect counts are shown in Table 2. The early pre-harvest treatment, applied on May 10 when plants were 12-13 in (30.5-33.0 cm) tall and numbers of larvae averaged 0.08/sweep, controlled larvae throughout the first growth period. The late pre-harvest treatment, applied on May 29 when plants were 24-26 in (61.0-66.00 cm) tall and numbers of larvae averaged 20.1/sweep, was also effective in reducing numbers of larvae. The post-harvest treatment could not have influenced the number of larvae before harvest June 26, but the number in this treatment differed from the control (May 22) by chance. None of the treatments significantly reduced adult numbers until new season adults appeared in early June. By the first cutting (June 12) plots that had been treated pre-harvest could be visually distinguished from those that had not. Treated alfalfa showed no weevil damage and was beginning to bloom, whereas untreated

**Table 2. Insect counts in test of optimal timing of insecticide treatment for alfalfa weevil control. The test insecticide was carbofuran (0.5 lb AI/a (0.56 kg AI/ha)) applied at indicated dates. Gothenburg, NE, 1973.**

| Treatment | Insect | Number per sweep[a] | | | | |
|---|---|---|---|---|---|---|
| | | May 22 | May 29 | June 5 | June 12 | June 26 |
| 1. Early pre-harvest (5/10) | Alfalfa weevil Larvae | 0.06 c | 0.23 b | 0.59 c | 1.93 a | 0 a |
| 2. Late pre-harvest (5/29) | | 19.99 a | 23.09 a | 0.36 c | 0.38 a | 0.03 ab |
| 3. Post-harvest (6/14) | | 0.69 c | 16.57 a | 22.59 b | 2.83 a | 0.04 b |
| 4. Control | | 8.58 b | 20.10 a | 40.69 b | 7.85 a | 0.06 b |
| 1. Early pre-harvest (5/10) | Alfalfa weevil Adults | 0.07 a | 0.09 a | 0.15 a | 0.06 b | 0.01 b |
| 2. Late pre-harvest (5/29) | | 0.13 a | 0.33 a | 0.03 b | 0.05 b | 0 b |
| 3. Post-harvest (6/14) | | 0.19 a | 0.18 a | 0.14 a | 0.05 b | 0 b |
| 4. Control | | 0.26 a | 0.25 a | 0.22 a | 0.15 a | 0.06 a |
| 1. Early pre-harvest (5/10) | Pea aphid | 0.28 b | 0.41 b | 1.73 a | 1.35 a | 1.22 a |
| 2. Late pre-harvest (5/29) | | 6.74 a | 1.70 ab | 0.79 a | 0.49 a | 2.45 a |
| 3. Post-harvest (6/14) | | 5.71 a | 2.30 a | 2.26 a | 0.29 a | 1.85 a |
| 4. Control | | 28.50 a | 2.41 a | 3.29 a | 0.44 a | 1.84 a |
| 1. Early pre-harvest (5/10) | Lady beetles[b] | 0.07 a | 0.02 b | 0.07 a | 0.01 a | 0.03 a |
| 2. Late pre-harvest (5/29) | | 0.18 a | 0.16 a | 0.01 a | 0 a | 0.04 a |
| 3. Post-harvest (6/14) | | 0.20 a | 0.18 a | 0.03 a | 0.01 a | 0.02 a |
| 4. Control | | 0.16 a | 0.14 a | 0.01 a | 0.01 a | 0.01 a |
| 1. Early pre-harvest (5/10) | *Nabis* sp. | 0.14 a | 0.06 a | 0.12 a | 0.04 a | 0.15 a |
| 2. Late pre-harvest (5/29) | | 0.17 a | 0.09 a | 0.17 a | 0.11 a | 0.28 a |
| 3. Post-harvest (6/14) | | 0.18 a | 0.12 a | 0.05 a | 0.19 a | 0.18 a |
| 4. Control | | 0.16 a | 0.07 a | 0.24 a | 0.19 a | 0.19 a |

[a]Means within a column followed by the same letter are not statistically different according to Duncan's multiple range test (P = 0.05).

[b]Adults only. Species composition: *Hippodamia convergens* 86.53%, *H. parenthesis* 7.77%, *Coleomegilla maculata* 5.70%.

plots showed moderate damage and no sign of bloom. Although plots did not differ in dry matter yield, percentage of dry matter or percentage of protein (Table 3), carotene content in 1973 was significantly increased in alfalfa treated either early or late pre-harvest. Data from the second cutting (not shown) revealed no significant differences in any parameter measured, probably because the number of adults was very low.

The pea aphid and two of its predators were also abundant in 1973. Carbofuran effectively reduced numbers of pea aphids, but such reduction was only temporary. No significant reductions were noted in population of either predator in 1973.

Results of 1974 insect counts appear in Table 4. The early pre-harvest treatment, applied on May 7 when plants were 16-18 in (40.6-45.7 cm) tall and numbers of larvae averaged 23.8/sweep, controlled larvae throughout the first cutting. The late pre-harvest treatment, applied on May 15 when plants were 20-22 in (50.8-55.9 cm) tall and number of larvae averaged 36.8/sweep, was also effective in reducing larval numbers. Indication of a corresponding reduction

**Table 3. Yield and quality of hay produced in tests of optimal timing of insecticide treatments for alfalfa weevil control. The test insecticide was carbofuran (0.5 lb AI/a (0.56 kg/ha)) applied at indicated dates. Gothenburg, NE, 1973, 1974 and 1975.**

| Treatment | Yield Tons/a (Metric Tons/ha) | Dry Matter % | Protein % | Cartoene, dry basis mg/lb (mg/kg) |
|---|---|---|---|---|
| *1973 — harvested June 12* | | | | |
| 1. Early pre-harvest (5/10) | 1.7 (3.7) | 25.06 | 15.68 | 88.2 (194) |
| 2. Late pre-harvest (5/29) | 1.4 (3.1) | 25.94 | 15.96 | 92.7 (204) |
| 3. Post-harvest (6/14) | 1.5 (3.4) | 26.23 | 16.29 | 82.7 (182) |
| 4. Control | 1.7 (3.7) | 25.16 | 16.26 | 72.0 (159) |
| $LSD_{0.05}$ | NS | NS | NS | 13.1 |
| *1974 — harvested June 5* | | | | |
| 1. Early pre-harvest (5/7) | 2.3 (5.2) | 24.89 | 16.54 | 92.3 (203) |
| 2. Late pre-harvest (5/15) | 2.1 (4.7) | 25.29 | 16.37 | 96.6 (214) |
| 3. Post-harvest (6/12) | 2.0 (4.5) | 25.98 | 17.08 | 98.4 (217) |
| 4. Control | 2.1 (4.7) | 25.71 | 16.61 | 88.4 (195) |
| $LSD_{0.05}$ | NS | NS | NS | NS |
| *1975 — harvested June 5* | | | | |
| 1. Early pre-harvest (5/7) | 1.6 (3.6) | 24.41 | 19.83 | 112.7 (248) |
| 2. Late pre-harvest (5/15) | 1.6 (3.6) | 26.57 | 19.00 | 112.6 (248) |
| 3. Post-harvest (6/8) | 1.5 (3.3) | 24.93 | 19.29 | 97.9 (216) |
| 4. Control | 1.5 (3.3) | 25.13 | 19.09 | 103.7 (229) |
| $LSD_{0.05}$ | NS | NS | NS | NS |

in numbers of adults was noted by June 5, but no adults were present in any plot by June 25 (post-harvest). In 1974 damage to treated and untreated plots was not as visibly different as in 1973, and no significant differences in yield or quality were noted among treatments (Table 3). Data from the second cutting (not shown) revealed no significant differences in any parameter measured, as would be expected in the absence or near absence of adult weevils during this growth period.

The pea aphid and two of its predators were also abundant in 1974. Numbers of pea aphids were reduced only temporarily by carbofuran, and by May 29 plots treated early pre-harvest contained more than twice as many pea aphids as untreated plots. Presumably, this increase was due to control of predators by the insecticide, even though there were no significant reductions in the numbers of the two predator groups shown in Table 4. However, there could have been the additive effect of slight reductions in numbers of these predators plus reductions in numbers of other less common predators.

Results of the 1975 insect counts appear in Table 5. The early pre-harvest treatment, applied on May 7 when plants were 12 in (30.5 cm) tall and numbers of larvae averaged 0.9/sweep, controlled larvae throughout the first growth period. The late pre-harvest treatment, applied on May 21 when plants were 16-18 in (40.6-45.7 cm) tall and numbers of larvae averaged 13.3/sweep, also reduced number of larvae. No significant differences were noted in the number of adults between treatments. No adults were present in any plot by June 25. No differences in weevil damage could be seen among the plots, and as would be expected with low numbers of adults and lack of visible damage, no significant differences were noted in yield or quality in either the first (Table 3) or second cutting (data not shown).

Pea aphids were not as abundant in 1975 as in 1973 or 1974. No significant differences were noted in pea aphid numbers among treatments. However, the number of coccinelid predators was significantly reduced among treatments on May 29.

In 1973-75, alfalfa was cut in the first or second week of June when about 1/10 of the plants were in bloom. Large numbers of adult weevils did not develop or damage young second growth alfalfa as they did in 1972 when alfalfa was cut at full bloom. Thus, we could not determine whether weevils attacking young second growth alfalfa are better controlled as larvae pre-harvest or as adults. We did deter-

**Table 4. Insect counts in test of optimal timing of insecticide treatments for alfalfa weevil control. The test insecticide was carbofuran (0.5 lb AI/a (0.56 kg AI/ha) applied at indicated dates. Gothenburg, NE, 1974.**

| | | Number per sweep[a] | | | | |
|---|---|---|---|---|---|---|
| Treatment | Insect | May 14 | May 22 | May 29 | June 5 | June 25 |
| 1. Early pre-harvest (5/7) | Alfalfa weevil | 0.90 a | 1.03 b | 5.53 b | 2.67 b | 0.07 a |
| 2. Late pre-harvest (5/15) | Larvae | — | 0.93 b | 2.37 c | 1.93 b | 0.07 a |
| 3. Post-harvest (6/6) | | — | 65.57 a | 53.90 a | 11.30 a | 0.07 a |
| 4. Control | | 53.77 a | 76.77 a | 55.57 a | 11.30 a | 0.07 a |
| 1. Early pre-harvest (5/7) | Alfalfa weevil | 0.03 a | 0.27 a | 0.37 a | 0.07 b | 0 a |
| 2. Late pre-harvest (5/15) | Adults | — | 0.27 a | 1.13 a | 0.70 ab | 0 a |
| 3. Post-harvest (6/8) | | — | 0.33 a | 1.20 a | 0.70 ab | 0 a |
| 4. Control | | 0.33 b | 0.07 a | 0.83 a | 1.60 a | 0 a |
| 1. Early pre-harvest (5/7) | Pea aphid | 1.00 a | 4.33 a | 19.87 a | 13.40 a | 0.57 a |
| 2. Late pre-harvest (5/15) | | — | 2.97 a | 8.43 b | 7.97 b | 0.80 a |
| 3. Post-harvest (6/8) | | — | 6.83 a | 8.43 b | 6.17 b | 0.63 a |
| 4. Control | | 2.40 b | 5.77 a | 8.43 b | 5.70 b | 0.37 a |
| 1. Early pre-harvest (5/7) | Lady beetles[b] | 0 a | 0.20 a | 0 a | 0 a | 0.10 a |
| 2. Late pre-harvest (5/15) | | — | 0.13 a | 0 a | 0.10 a | 0 a |
| 3. Post-harvest (6/8) | | — | 0.27 a | 0 a | 0 a | 0.10 a |
| 4. Control | | 0.20 a | 0.10 a | 0.03 a | 0.03 a | 0.13 a |
| 1. Early pre-harvest (5/7) | *Nabis* sp. | 0.03 a | 0.26 a | 0.53 a | 0.20 a | 0.10 a |
| 2. Late pre-harvest (5/15) | | — | 0.30 a | 0.70 a | 0.70 a | 0.10 a |
| 3. Post-harvest (6/8) | | — | 0.43 a | 0.53 a | 1.00 a | 0.23 a |
| 4. Control | | 0.13 a | 0.50 a | 0.73 a | 1.17 a | 0.10 a |

[a]Means within a column followed by the same letter are not statistically different according to Duncan's multiple range test (P = 0.05).

[b]Adults only. Species composition: *Coleomegilla maculata* 82.25%, *Hippodamia convergens* 16.35%, *H. parenthesis* 1.40%.

**Table 5. Insect counts in test of optimal timing of insecticide treatment for alfalfa weevil control. The test insecticide was carbofuran (0.5 lb AI/a (0.56 kg AI/ha)) applied at indicated dates. Gothenburg, NE, 1975.**

| Treatment | Insect | Number per sweep[a] May 29 | June 5 | June 25 |
|---|---|---|---|---|
| 1. Early pre-harvest (5/7) | Alfalfa weevil Larvae | 2.38 a | 10.26 b | 0 a |
| 2. Late pre-harvest (5/15) | | 0.94 a | 1.98 a | 0.03 a |
| 3. Post-harvest (6/8) | | 9.85 b | 13.33 c | 0 a |
| 4. Control | | 9.35 b | 16.30 d | 0.05 a |
| 1. Early pre-harvest (5/7) | Alfalfa weevil Adults | 0.11 a | 0.23 a | 0 a |
| 2. Late pre-harvest (5/15) | | 0.03 a | 0.23 a | 0 a |
| 3. Post-harvest (6/8) | | 0.25 a | 0.23 a | 0 a |
| 4. Control | | 0.10 a | 0.25 a | 0 a |
| 1. Early pre-harvest (5/7) | Pea aphid | 0.25 a | 0.90 a | 0.03 a |
| 2. Late pre-harvest (5/15) | | 0.11 a | 0.50 a | 0.15 a |
| 3. Post-harvest (6/8) | | 0.58 a | 0.70 a | 0.10 a |
| 4. Control | | 0.45 a | 1.00 a | 0.23 a |
| 1. Early pre-harvest (5/7) | Lady beetles[b] | 0.08 a | 0.51 a | 0.01 a |
| 2. Late pre-harvest (5/15) | | 0.06 a | 0.35 a | 0.01 a |
| 3. Post-harvest (6/8) | | 0.38 b | 0.35 a | 0.01 a |
| 4. Control | | 0.40 b | 0.61 a | 0.06 a |
| 1. Early pre-harvest (5/7) | *Nabis* sp. | 0.13 a | 0.66 a | 0.06 a |
| 2. Late pre-harvest (5/15) | | 0.18 a | 0.38 a | 0 a |
| 3. Post-harvest (6/8) | | 0.33 a | 0.50 a | 0 a |
| 4. Control | | 0.46 a | 0.68 a | 0.06 a |

[a]Means within a column followed by the same letter are not statistically different according to Duncan's multiple range test (P = 0.05).

[b]Adults only of *Coleomegilla maculata.*

mine, however, that treatment of alfalfa is of no economic advantage for alfalfa weevil control when populations are not greater than those encountered in these studies (20 to 36 per sweep) and when these populations occur at no less mature plant growth stages than in these studies (20 to 26 in (50.8 to 66.0 cm)). Hintz *et al.* (1976) showed the importance of plant growth stage in relation to damage by alfalfa weevil larvae. Wilson (1973) reported that low numbers of weevil larvae may slightly increase yield because the larval feeding appears to stimulate lateral bud growth. Possibly such larvae-stimulated growth lessened yield differences in our studies between the shorter weevil-damaged plants and the taller undamaged plants. However, the only increase we noted, that of carotene in treated plants in 1973, was not sufficient to justify treatment cost.

The increase in pea aphid numbers that resulted from treatment with carbofuran (Table 4) is cause for concern, but the increase was not consistent from year to year. Also, Surgeoner and Ellis (1975) did not observe increases in numbers of pea aphids in southern Ontario after treatment of alfalfa with carbofuran during two successive years.

## CONTROL OF THE ALFALFA WEEVIL AND OTHER INSECTS WITH REGISTERED INSECTICIDES, 1974-1976

Before the entry of the eastern strain of the alfalfa weevil into southeastern Nebraska in 1971 (Keith *et al.* 1977), the alfalfa weevil was not an important pest in Nebraska and seldom needed control. Within a few years after arrival of the eastern strain, the pest status of this weevil had changed. These tests were conducted to evaluate selected registered insecticides against the alfalfa weevil and other non-target insects under Nebraska conditions.

### Materials and Methods

The first test was conducted in 1974 near Brady (Figure 1). Insecticides and application rates appear in Table 6. A randomized complete block design with three replications was used. Plot size was 40 × 40 ft (12.2 × 12.2 m). Insecticides were applied in water at the rate of 12 gal/a (113.6 liter/ha) with a knapsack sprayer operated at 25 psi (1.76 kg/cm$^2$) pressure with $CO_2$ as the propellent. The sprayer was equipped with a 5-ft (1.5-m) boom.

The second test was conducted in 1975 at the University of Nebraska Field Laboratory at Mead (Figure 1). Plot size was 20 × 80 ft (6.1 × 24.4 m). Insecticides were applied in water at the rate of 10 gal/a (85.1 liter/ha) with a jeep-mounted John Bean® sprayer operated at 100 psi (70.3 kg/cm$^2$) and equipped with a 21-ft (6.4-m) boom.

The third and fourth tests were conducted in 1976 near Falls City, and near Palmyra (Figure 1). Each year a randomized complete block design with four replications was used. Plot size was 10 × 20 ft (3.1 × 6.1 m). The insecticides were applied in water at the rate of 18 gal/a (168.4 liter/ha) with a knapsack sprayer operated at 30 psi (2.11 kg/cm$^2$) with $CO_2$ as the propellent. The sprayer was equipped with a 3.3-ft (1.0-m) boom.

In 1974, insecticides were applied on May 15 from 6:30 to 8 am. The weather was clear and bright with a very light wind and tempera5ures of 50-60° F (10.0-15.6° C). In 1975, insecticides were applied on May 15 between 9 and 10 am. The weather was clear and bright with a light wind and temperatures of 60-65° F (15.6-18.3° C). The alfalfa was 18-22 in (45.7-55.9 cm) tall, and more than 90% of the plant tips showed signs of weevil feeding. In the Falls City test in 1976, insecticides were applied on May 5. The temperature was 65° F (18.3° C) with moderate winds, and a thunderstorm began immediately after the last insecticide was applied. The alfalfa was about 22 in (55.9 cm) tall and 100% of the plant tips showed weevil feeding. In the Palmyra test in 1976, insecticides were applied on May 7. The temperature was 68-75° F (20.0-23.9° C) with a light wind. Alfalfa was 14-16 in (35.6-40.6 cm) tall and ca. 20% of the plant tips showed weevil feeding.

**Table 6. Insect counts in tests of recommended insecticides applied at indicated rates on May 15, 1974 to control alfalfa weevil in Lincoln Co., NE.**

| Treatment | Rate lb AI/a (kg AI/ha) | Alfalfa weevil larvae per sweep[a] May 23 | May 29 | June 5 | Pea aphids per sweep[a] May 23 | May 29 | June 5 | Lady beetles per sweep[ab] May 23 | May 29 | June 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| methoxychlor + diazinon | 1 (1.12) | 4.37 b | 6.43 b | 3.63 a | 6.20 a | 11.10 bc | 17.50 b | 0.03 b | 0.03 b | 0.17 a |
| dimethoate | 0.5 (0.56) | 3.20 b | 7.36 b | 4.50 a | 2.80 d | 6.30 c | 8.77 b | 0.03 b | 0.03 b | 0.03 a |
| diazinon | 1 (1.12) | 2.67 b | 6.03 b | 4.63 a | 4.37 cd | 10.70 bc | 18.90 ab | 0.03 b | 0.03 b | 0.07 a |
| phosmet | 1 (1.12) | 1.23 b | 2.90 b | 3.87 a | 9.10 b | 15.83 b | 24.17 a | 0.10 b | 0.00 b | 0.17 a |
| methidathion | 0.5 (0.56) | 1.00 b | 2.90 b | 4.13 a | 3.30 d | 9.40 bc | 21.80 ab | 0.00 b | 0.13 a | 0.07 a |
| carbofuran | 0.5 (0.56) | 0.27 b | 1.20 b | 2.43 a | 3.77 cd | 10.87 bc | 20.90 ab | 0.00 b | 0.03 b | 0.07 a |
| Control | --- --- | 12.90 a | 17.77 a | 6.53 a | 16.60 a | 22.37 a | 16.90 b | 0.40 a | 0.17 a | 0.10 a |

[a]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

[b]Species composition: *Hippodamia convergens* 89.6%, *Coleomegilla maculata* 6.9%, *H. parenthesis*, 3.5%.

**Table 7. Insect counts in tests of recommended insecticides applied at indicated rates on May 15, 1974 for alfalfa weevil control in Lincoln Co., NE.**

| Treatment | Rate lb AI/a (kg AI/ha) | Alfalfa plant bugs[ab] per sweep May 23 | May 29 | June 5 | Tarnished plant bugs[ab] per sweep May 23 | May 29 | June 5 |
|---|---|---|---|---|---|---|---|
| methoxychlor + diazinon | 1 (1.12) | 0 b | 0.03 c | 0.13 a | 0.20 a | 0.17 a | 1.90 a |
| dimethoate | 0.5 (0.56) | 0 b | 0.03 c | 0.13 a | 0.03 a | 0.37 a | 1.53 a |
| diazinon | 1 (1.12) | 0 b | 0 c | 0.20 a | 0.07 a | 0.13 a | 1.70 a |
| phosmet | 1 (1.12) | 0 b | 0.23 b | 0.53 a | 0.20 a | 0.53 a | 2.47 a |
| methidathion | 0.5 (0.56) | 0 b | 0.07 bc | 0.07 a | 0 a | 0.13 a | 1.77 a |
| carbofuran | 0.5 (0.56) | 0 b | 0.07 bc | 0.07 a | 0.17 a | 0.23 a | 2.20 a |
| Control | --- --- | 0.37 a | 0.67 a | 0.43 a | 0.57 a | 0.43 a | 2.80 a |

[a]Adults and nymphs.

[b]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

**Results and Discussion**

In 1974, insecticide treatments were evaluated one, two, and three weeks posttreatment (Table 6). Carbofuran produced greatest reduction in numbers of weevil larvae, but results of this treatment were not significantly different from any other treatment. Numbers of weevils in treatments were significantly different from those in the control at one and two week posttreatment, but by week three posttreatment none were statistically different. Control of the pea aphid by the insecticides varied widely. Dimethoate produced the best initial and overall control. Phosmet produced the poorest initial control, and by week three posttreatment these plots contained significantly more aphids than the control. The increase in pea aphid numbers appeared to be associated with a reduction in lady beetle numbers. Moderate populations of plant bugs were noted during this test, and the effects of treatments on their numbers is reported in Table 7. All insecticides were highly effective against the alfalfa plant bug at one week posttreatment, but by week three posttreatment differences among treatments were not significant. No significant reduction in tarnished plant bug numbers were noted. No damage to alfalfa was evident in this test, so alfalfa yield was not measured.

In 1975, we evaluated insecticides one and two weeks posttreatment (Table 8). Carbofuran produced the greatest initial reduction in numbers of alfalfa weevil larvae, although the numbers were not significantly different among insecticide treatments. All treated plots contained significantly fewer larvae than the control. By week two posttreatment, differences were noted in the residual control, and numbers of larvae in several treated plots were not significantly different from those in the control.

When both posttreatment evaluations were considered, the greatest pea aphid control was produced by carbofuran and methidathion. None of the insecticides caused an increase in aphid numbers. All insecticides appeared initially effective against the spotted alfalfa aphid, but the effectiveness of all treatments decreased by week two posttreatment. Forage yields on June 2 (1/10 bloom) did not differ significantly among treatments.

In the Falls City test in 1976, insecticides were evaluated one and two weeks posttreatment (Table 9). Methoxychlor, methidathion and methoxychlor + diazinon produced the greatest weevil control. Malathion and diazinon significantly reduced weevil numbers, but not as much as did the other three insecticides. Methoxychlor + diazinon and diazinon were the only insecticides that significantly reduced pea aphid numbers in the second week posttreatment. Forage yields on May 19 (1/10 bloom) did not differ significantly among treatments.

In the Palmyra test in 1976, insecticides were evaluated one, two and three weeks posttreatment (Table 10). All insecticides produced comparable initial control of weevil larvae. At week three posttreat-

**Table 8. Insect counts and forage yield in tests of recommended insecticides applied on May 15, 1975 for alfalfa weevil and aphid control. Mead, Saunders County, NE.**

| Treatment | Rate lb AI/a (kg AI/ha) | Alfalfa weevil larvae[a] per sweep | | Aphids per sweep[a]: Pea aphid | | Aphids per sweep[a]: Spotted alfalfa aphid | | Yield of forage Tons/a Metric tons/ha) |
|---|---|---|---|---|---|---|---|---|
| | | May 22 | June 2 | May 22 | June 2 | May 22 | June 2 | |
| carbofuran | 0.5 (0.56) | 0.09 a | 0.25 a | 0.04 a | 0.52 a | 0.00 a | 0.15 ab | 2.1 (4.7) a |
| methidathion | 1.0 (1.12) | 0.21 a | 0.83 ab | 0.12 a | 0.61 a | 0.01 ab | 0.12 a | 2.2 (4.9) a |
| Polymer-encapsulated methyl parathion | 0.5 (0.56) | 0.43 a | 1.56 abc | 0.04 a | 0.87 ab | 0.00 a | 0.32 bcd | 2.2 (4.9) a |
| methomyl | 0.9 (1.02) | 1.15 a | 3.44 bc | 0.13 a | 1.28 abc | 0.03 ab | 0.28 abcd | 1.8 (4.0) a |
| phosmet | 0.5 (0.56) | 1.21 a | 1.08 ab | 0.38 a | 1.35 abc | 0.07 bc | 0.37 d | 2.0 (4.5) a |
| azinphosmethyl | 0.5 (0.56) | 1.37 a | 1.73 abc | 0.34 a | 0.91 ab | 0.07 bc | 0.23 abc | 1.6 (3.6) a |
| diazinon | 1.0 (1.12) | 1.60 a | 4.17 c | 0.16 a | 1.37 bc | 0.04 ab | 0.37 cd | 2.0 (4.5) a |
| Control | --- --- | 10.47 b | 4.24 c | 0.86 b | 1.71 c | 0.16 c | 0.44 d | 2.0 (4.5) a |

[a]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).



**Table 9. Insect counts and forage yield in tests of recommended insecticides applied on May 5, 1976 for alfalfa weevil control in Richardson County, NE.**

| Treatment | Rate lb AI/a (kg AI/ha) | Alfalfa weevil larvae per sweep[a] | | Pea aphid per sweep[a] | | Yield of forage Tons/a (Metric tons/ha) |
|---|---|---|---|---|---|---|
| | | May 12 | May 19 | May 12 | May 19 | |
| methoxychlor | 1.5 (1.70) | 0.52 a | 0.57 a | 6.70 c | 3.92 b | 2.1 (4.7) a |
| methidathion | 0.5 (0.56) | 1.12 ab | 1.32 a | 3.52 b | 3.45 b | 2.0 (4.5) a |
| methoxychlor + diazinon | [b] | 2.02 ab | 1.40 a | 1.07 ab | 1.72 a | 1.9 (4.3) a |
| malathion | 1.25 (1.40) | 5.22 bc | 6.22 b | 6.32 c | 4.40 b | 2.1 (4.7) a |
| diazinon | 1.0 (1.12) | 6.47 c | 7.05 b | 0.67 a | 0.62 a | 1.9 (4.3) a |
| Control | -- -- | 22.27 d | 14.40 c | 6.50 c | 4.42 b | 1.8 (4.1) a |

[a]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

[b]2 qts (1.9 liters) of formulated material/a.

**Table 10. Insect counts and forage yield in tests of recommended insecticides applied on May 5, 1976 for alfalfa weevil control in Otoe County, NE.**

| Treatment | Rate lb AI/a (kg AI/ha) | Alfalfa weevil larvae per sweep[a] | | | Pea aphid per sweep[a] | | |
|---|---|---|---|---|---|---|---|
| | | May 14 | May 21 | May 28 | May 14 | May 21 | May 28 |
| Polymer-encapsulated methyl parathion | 0.5 (0.56) | 0.00 a | 0.07 a | 3.10 a | 0.02 a | 1.20 a | 12.32 ab |
| methidathion | 0.5 (0.56) | 0.00 a | 0.85 a | 5.55 abc | 0.02 a | 1.47 a | 13.75 ab |
| malathion | 1.25 (1.41) | 0.10 a | 2.22 a | 9.30 cd | 0.02 a | 2.17 a | 11.47 ab |
| methomyl | 0.9 (1.02) | 0.12 a | 2.02 a | 7.60 bcd | 0.22 a | 2.25 a | 18.32 ab |
| methoxychlor | 1.5 (1.70) | 0.12 a | 0.65 a | 2.37 a | 1.65 b | 17.57 cd | 36.67 de |
| phosmet | 1.0 (1.12) | 0.15 a | 1.07 a | 4.52 ab | 2.17 bc | 19.02 d | 31.95 de |
| carbofuran | 0.5 (0.56) | 0.15 a | 0.25 a | 3.67 ab | 0.20 a | 4.50 a | 15.62 ab |
| azinphosmethyl | 0.5 (0.56) | 0.15 a | 1.52 a | 6.05 abc | 0.57 a | 10.60 b | 21.52 bc |
| methoxychlor + diazinon | [b] | 0.37 a | 1.25 a | 5.97 abc | 0.07 a | 1.77 a | 12.37 ab |
| carbaryl | 1.0 (1.12) | 0.45 a | 2.62 ab | 10.60 d | 2.70 c | 12.82 bc | 29.97 cd |
| diazinon | 1.0 (1.12) | 0.60 a | 5.40 b | 16.95 e | 0.07 a | 1.70 a | 10.67 a |
| Control | --- --- | 5.72 b | 14.07 c | 15.62 e | 1.87 bc | 19.45 d | 38.90 e |

[a]Means followed by the same letter are not statistically different according to Duncan's multiple range test (P = 0.05).

[b]2 qts. (1.9 liters) of mixture as formulated.

ment, methoxychlor, carbofuran, methidathion, Azinphosmethyl, methoxychlor + diazinon, phosmet and polymer-encapsulated methyl parathion still maintained weevils at relatively low numbers, whereas numbers of larvae on plots treated with carbaryl, malathion, methomyl, and diazinon were only slightly reduced from or equal to the control. All insecticides except methoxychlor, phosmet and carbaryl produced moderate reductions in numbers of the pea aphid. Generally, insecticides that provided good initial control were still providing good control three weeks posttreatment. Because weevil damage was relatively light, forage yield was not sampled.

Results of these studies were similar to those obtained for the same insecticides in other parts of the country (Coan *et al.* 1968, Bennett 1968, Dorsey *et al.* 1969, and Campbell *et al.* 1975). Forage yields were sampled in two of our four tests; differences in yields due to treatments were not statistically significant. Thus, although the insecticides tested reduced weevil numbers, their use cannot be justified on the basis of economic return at levels of weevil infestation and plant growth stage similar to those in these tests.

## CONTROL OF INSECT PESTS WITH RESISTANT ALFALFA VARIETIES, CULTURAL PRACTICES AND INSECTICIDES, 1975

Another method of controlling insect pests of alfalfa besides the use of insecticides is the use of resistant alfalfa varieties. The source of alfalfa resistance to feeding of alfalfa weevil larvae in most varieties may be traced to a common ancestry. Tolerance is the mechanism of such resistance and can be measured only under field conditions (Barnes *et al.* 1970, Busbice *et al.* 1977, Devine *et al.* 1977). Resistant varieties are becoming increasingly available to growers. Cultural practices, particularly the time at which the crop is cut, are also important in insect control. Studies were conducted to evaluate the use of resistant alfalfa varieties cut at various times and with or without use of insecticides.

### Materials and Methods

*Alfalfa weevil resistance*—A natural infestation of the alfalfa weevil was observed in an alfalfa nursery at Mead, NE for possible differential damage among cultivars. The nursery had been planted with a V-belt drill in Sharpsburg silty-clay loam on April 23, 1974. A randomized complete block design with four replications was used. Plot size was 3 × 15 ft (0.9 × 4.6 m). Weevil damage was assessed by assigning a visual damage rating (scale of 1 to 5) to each plot; a rating of 1 indicated no damage and a rating of 5 indicated severe damage.

*Cutting management × variety × insecticide*—In this study at Mead, NE we observed the effects, alone and in combination, of the following variables: plant growth stage at time of harvest, alfalfa variety, weevil damage and insecticide treatment on alfalfa weevil numbers. The experimental design was a double split plot with four replications. The main plot treatments were two cutting management systems: (1) an early-cut schedule in which the first harvest was at the bud stage and subsequent harvests at the 1/10 bloom stage; and (2) a late-cut schedule in which the first harvest was at the full bloom stage, the second harvest at 1/10 bloom and the third at full bloom. The subplot treatment was either carbofuran 0.5 lb AI/a (0.56 kg/ha), applied at peak larval infestation or no application. The subplot treatments consisted of four alfalfa varieties, two of which ('Team' and 'Weevlchek') were resistant and two of which ('Dawson' and 'Kanza') were not resistant to the alfalfa weevil. We sampled insect populations immediately before harvest by taking five sweeps/plot with an insect net.

*Variety* × *insecticide*—In this study the effects were observed, alone and in combination, of resistant and susceptible alfalfa varieties and insecticides on the insect complex in eastern Nebraska throughout the growing season. A split-plot design with four replications was used. The main plot treatments were four alfalfa varieties that differed in their resistance to some of the major pest insects (Table 11). The subplot treatments were three insecticides and a control. The alfalfa was seeded during the spring of 1974. Insecticides were applied with a knapsack sprayer operated at 25 psi (1.76 kg/cm$^2$) with $CO_2$ as propellent and equipped with a 5-ft (1.5-m) boom. The insecticides were diluted in water and applied at the rate of 12 gal/a (126.8 liter/ha). Insecticides were applied twice (rates indicated in Table 11) during the season, first on May 13, primarily against the alfalfa weevil, and then on August 23, against aphids and leafhoppers. The alfalfa was cut each time it reached the 1/10 bloom stage (May 27, July

**Table 11. Insecticides, application rates and alfalfa varieties with indicated insect resistance used in the variety X insecticide tests. Mead, NE, 1975.**

| Insecticide | Formulation | Rate lb AI/a (kg AI/ha) |
|---|---|---|
| carbofuran | E.C. 4 lb/gal (479 g/1) | 0.5 (0.56) |
| leptophos | E.C. 2.9 lb/gal (348 g/1) | 0.5 (0.56) |
| methidathion | E.C. 2 lb/gal (240 g/1) | 0.5 (0.56) |

| Variety | Insect resistance[a] Alfalfa weevil | Spotted alfalfa aphid | Pea aphid |
|---|---|---|---|
| Dawson | S | R | R |
| Team | R | S | R |
| Vernal | S | S | S |
| Cody | S | R | S |

[a]S = susceptible; R = resistant

**Table 12. Ratings of damage to alfalfa varieties by the alfalfa weevil and forage yield in an alfalfa nursery at Mead, NE, 1975.**

| Entry | Alfalfa weevil[a] damage ratings | | Forage yield—dry matter: Tons/acre (Metric tons/ha) | | Forage yield—dry matter: Relative[b] |
|---|---|---|---|---|---|
| | 5/21 | 5/27 | Cut 1[c] | 4 cuts | 4 cuts |
| Arc | 2.2*[d] | 2.5* | 2.3 (5.1) | 6.9 (15.4) | 102 |
| A10 | 2.8* | 4.2 | 2.1 (4.7) | 6.2 (13.9) | 92 |
| Bonus | 3.5 | 5.0 | 2.1 (4.7) | 6.8 (15.2) | 102 |
| Citation | 2.5* | 2.8* | 2.5 (5.6) | 7.4 (16.5) | 110 |
| CW/5 | 2.8* | 2.8* | 2.2 (4.9) | 6.9 (15.4) | 104 |
| Dawson DCC72 | 3.5 | 4.5 | 2.1 (4.7) | 6.9 (15.4) | 104 |
| 520 | 3.8 | 5.0 | 2.0 (4.5) | 6.7 (15.0) | 101 |
| 524 | 4.5 | 4.5 | 2.4 (5.4) | 7.6 (17.0) | 114 |
| 530 | 3.0* | 4.2 | 2.1 (4.7) | 6.9 (15.4) | 103 |
| Gladiator | 2.8* | 3.2* | 2.5 (5.6) | 7.5 (16.8) | 112 |
| G-777 | 3.0* | 4.2 | 1.9 (4.2) | 6.5 (14.6) | 97 |
| Kanza KCC72 | 4.2 | 5.0 | 1.8 (4.0) | 6.3 (14.1) | 94 |
| N.S. 76 PPa | 2.8* | 3.2* | 2.4 (5.4) | 7.4 (16.6) | 111 |
| N.S. 77 PPa | 3.0* | 3.2* | 2.4 (5.4) | 7.4 (16.6) | 110 |
| N.S. 77 PaSaP1W | 2.5* | 3.2* | 2.4 (5.4) | 7.4 (16.6) | 110 |
| N.S. 81 | 2.8* | 4.2 | 2.3 (5.1) | 7.1 (15.9) | 106 |
| N.S. 81 PPaSa | 3.2 | 4.0 | 2.1 (4.7) | 6.7 (15.0) | 100 |
| N.S. 82 | 2.5* | 3.2* | 2.4 (5.4) | 7.5 (16.8) | 112 |
| Olympic | 3.2 | 4.2 | 2.2 (4.9) | 7.0 (15.7) | 104 |
| Pacer | 2.8* | 3.5 | 2.4 (5.4) | 7.4 (16.6) | 111 |
| Resistador II | 3.8 | 4.5 | 1.6 (3.6) | 6.2 (13.9) | 93 |
| Saranac SCC72 | 3.2 | 3.8 | 2.2 (4.9) | 6.8 (15.2) | 102 |
| SX-10 | 3.2 | 4.5 | 2.0 (4.5) | 6.0 (13.4) | 90 |
| Team | 2.5* | 2.8* | 2.3 (5.1) | 6.8 (15.2) | 101 |
| Valor | 3.2 | 4.5 | 2.4 (5.4) | 7.1 (15.9) | 106 |
| Vangard | 2.5* | 3.5 | 2.1 (4.7) | 6.8 (15.2) | 101 |
| Vernal VCC72 | 3.2 | 4.5 | 2.3 (5.1) | 6.7 (15.0) | 100 |
| Vista | 2.8* | 4.0 | 2.1 (4.7) | 6.7 (15.0) | 100 |
| WL219 | 3.0* | 4.8 | 2.2 (4.9) | 7.1 (15.9) | 106 |
| WL310 | 3.0* | 4.5 | 2.1 (4.7) | 7.1 (15.9) | 106 |
| WL311 | 3.5 | 4.2 | 2.1 (4.7) | 7.2 (16.1) | 108 |
| C.V. | 22.0% | 14.0% | 4.9% | 4.3% | |
| LSD at .05 | 1.0 | 0.8 | 0.15 | 0.42 | |
| LSD at .01 | 1.3 | 1.0 | 0.19 | 0.55 | |

[a]1 = no damage, 5 = severe damage.

[b]Percent of the average of Dawson, Kanza, Saranac and Vernal.

[c]Cut June 2 at ca. 20% bloom.

[d]*Not significantly different from Arc according to Duncan's multiple range test (P = 0.05).

3, August 5 and September 12, 1975). Insect populations were sampled by taking 10 pendulum sweeps/plot with a 15-inch (38.1-cm) diameter insect net.

## Results and Discussion

*Alfalfa weevil resistance*—Visual differences in damage among the plots were apparent by mid-May, and damage ratings were recorded on May 21 and 27 (Table 12). Damage increased from a mean of 3.1 for all entries on May 21 to a mean of 4.0 on May 27. During this same period the average damage ratings for 'Arc', 'Gladiator' and 'Team' (resistant varieties) increased less (2.5 on May 21 to 2.8 on May 27) than those for the other varieties. Therefore, the damage ratings of May 27 appeared to be a more reliable means of separating resistant and susceptible entries than the ratings of May 21. With Arc as the standard for comparison, only eight entries had damage ratings not significantly different on May 27. Of these eight entries, two were known to be resistant (Team and Gladiator), four were Nebraska entries (NS-76, 2 populations of NS-77, and NS-82) that trace some of their ancestry to Team and two entries ('Citation' and 'CW/5') were not known to contain any Team/Arc germplasm.

All entries with low damage ratings on May 27 yielded more than the average yield for the controls, Dawson, Kanza, Saranac and Vernal. Because many factors besides weevil damage contribute to total yield, it was not possible to say more about the relationship between weevil resistance and forage yield as seen in the results of this test.

*Cutting management × variety × insecticide*—Coincident with these studies the variegated cutworm, *Peridroma saucia* (Hubner), infested eastern Nebraska; larvae reached peak numbers just before the first cutting. Many large larvae remained in fields after crop removal, and their feeding delayed the second growth. Their effect on the alfalfa was similar to that described for alfalfa weevil adults in similar situations (as described earlier).

Insect counts and forage yield from this experiment appear in Table 13. Cutting schedule had a marked effect on insect populations. Weevil larvae were the most abundant just before the early harvest. Adult weevils and variegated cutworm larvae were not counted in this sample because their numbers were extremely low. When the late-cut plots were sampled ca. 2 weeks later, the number of weevil larvae had decreased, and adult weevils were relatively abundant. At the latter sampling, cutworm larvae were present in the untreated plots. Carbofuran reduced numbers of all insects, regardless of cutting schedule. Alfalfa variety had no significant influence on insect numbers, regardless of cutting schedule.

Alfalfa cut early generally produced lower yields of dry matter but higher levels of protein and carotene than alfalfa cut late. Differences in dry matter yield among varieties in the early-cut schedule were not significant, and the only differences in protein and carotene among varieties were in untreated plots. Yield was significantly different among varieties in the late-cut schedule for both the first cut and the total season in both treated and untreated plots. These differences

**Table 13. Insect counts and forage yield from four alfalfa varieties in a three-cut management system in early- and late-maturity cuttings with and without insecticides. The test insecticide was carbofuran (0.5 lb AI/a (0.56 kg AI/ha)). Mead, NE, 1975.**

| Variety | Insects per sweep | | | | | | Forage data | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alfalfa weevil | | | | Varigated cutworms | | Protein, dry basis % | | Carotene, dry basis, mg/kg | | Dry matter yield tons/a (Metric tons/ha) | | | |
| | Larvae | | Adults | | | | | | | | First cut | | Total season | |
| | WI[a] | WO/I[b] | WI | WO/I | WI | WO/I | WI | WO/I | WI | WO/I | WI | WO/I | WI | WO/I |
| *Early cut schedule*[c] | | | | | | | | | | | | | | |
| Dawson | 0.00 | 28.44 | --- | --- | --- | --- | 19.7 | 19.1 | 190 | 194 | 1.8 (4.0) | 1.7 (3.8) | 4.7 (10.5) | 5.1 (11.4) |
| Kanza | 0.00 | 37.70 | --- | --- | --- | --- | 19.7 | 20.0 | 185 | 192 | 1.9 (4.0) | 1.8 (4.0) | 4.6 (10.3) | 5.1 (11.4) |
| Team | 0.04 | 23.60 | --- | --- | --- | --- | 19.8 | 20.7 | 198 | 223 | 1.9 (4.2) | 1.8 (4.0) | 4.5 (10.1) | 5.1 (11.4) |
| Weevlchek | 0.00 | 34.00 | --- | --- | --- | --- | 19.8 | 19.1 | 192 | 190 | 1.9 (4.2) | 1.9 (4.2) | 4.7 (10.5) | 5.2 (11.6) |
| $\bar{X}$ | 0.02 | 30.50 | --- | --- | --- | --- | 19.7 | 19.7 | 192 | 198 | 1.9 (4.1) | 1.8 (4.0) | 4.6 (10.3) | 5.1 (11.4) |
| $LSD_{05.}$ | NS | NS | | | | | NS | 1.2 | NS | 18 | NS | NS | NS | NS |
| *Late cut schedule*[d] | | | | | | | | | | | | | | |
| Dawson | 0.04 | 9.64 | 0.80 | 3.84 | 0.10 | 0.64 | 18.4 | 16.8 | 212 | 161 | 2.2 (4.9) | 2.4 (5.4) | 4.8 (10.7) | 5.6 (12.5) |
| Kanza | 0.24 | 13.20 | 0.76 | 3.70 | 0.00 | 1.36 | 17.5 | 17.8 | 196 | 185 | 2.4 (5.4) | 2.3 (5.1) | 5.1 (11.4) | 5.6 (12.5) |
| Team | 0.00 | 8.24 | 0.84 | 3.40 | 0.00 | 0.80 | 17.6 | 17.2 | 192 | 170 | 2.3 (5.1) | 2.5 (5.6) | 4.9 (11.0) | 5.1 (11.4) |
| Weevlchek | 0.04 | 8.64 | 0.36 | 2.36 | 0.00 | 0.50 | 18.0 | 17.9 | 201 | 181 | 2.7 (6.1) | 2.5 (5.6) | 5.7 (12.8) | 5.7 (12.8) |
| $\bar{X}$ | 0.08 | 9.94 | 0.68 | 3.32 | 0.02 | 0.82 | 17.9 | 17.4 | 201 | 174 | 2.4 (5.4) | 2.4 (5.4) | 5.1 (11.4) | 5.5 (12.3) |
| $LSD_{.05}$ | NS | NS | NS | NS | NS | NS | NS | 0.7 | NS | 18 | 0.1 | 0.11 | 0.15 | 0.35 |

[a]WI = insecticide applied May 15, 1975.

[b]WO/I = no insecticide.

[c]Insecticide-treated plots were cut May 21 in bud stage, June 25 at 1/10 bloom and July 28 at 1/10 bloom. Untreated plots were cut May 21 in bud stage, July 1 in 1/10 bloom and August 5 at full bloom.

[d]Insecticide-treated and untreated plots were cut June 3 in the full bloom stage, July 3 in the 1/10 bloom stage and August 5 in full bloom.

**Table 14. Effects of application of leptophos, carbofuran and methidathion on insect populations, forage yield at 1st-cutting and protein and carotene contents of indicated alfalfa varieties. Treatments were applied on May 13, and plots were harvested on May 27. Mead, NE, 1975.**

| Variety | Treatment | Mean number per sweep: Tarnished plant bug | Alfalfa plant bug | Pea aphid | Potato leaf-hopper | Alfalfa weevil larvae | Dry matter yield tons/a (Metric tons/ha) | Protein % | Carotene mg/kg |
|---|---|---|---|---|---|---|---|---|---|
| Dawson | leptophos | 0.45 | 0.68 | 1.23 | 1.08 | 6.55 | 2.1 (4.8) | 18.2 | 154.7 |
| | carbofuran | 0.38 | 0.93 | 0.65 | 0.48 | 0.15 | 2.3 (5.2) | 18.4 | 176.4 |
| | methidathion | 0.55 | 0.93 | 0.93 | 0.78 | 5.75 | 2.3 (5.2) | 18.3 | 163.6 |
| | Control | 1.20 | 0.90 | 0.70 | 0.95 | 29.00 | 2.2 (5.0) | 17.4 | 148.4 |
| Team | leptophos | 0.50 | 1.25 | 0.83 | 0.50 | 1.98 | 2.3 (5.2) | 17.6 | 156.4 |
| | carbofuran | 0.35 | 0.65 | 0.30 | 0.35 | 0.18 | 2.3 (5.2) | 17.8 | 160.0 |
| | methidathion | 0.45 | 0.80 | 0.53 | 0.33 | 0.80 | 2.4 (5.4) | 17.5 | 170.2 |
| | Control | 1.20 | 0.83 | 0.95 | 1.25 | 13.08 | 2.2 (5.0) | 17.6 | 153.3 |
| Vernal | leptophos | 0.33 | 0.63 | 8.18 | 0.60 | 3.58 | 2.4 (5.4) | 17.0 | 153.8 |
| | carbofuran | 0.33 | 0.68 | 1.78 | 0.73 | 0.20 | 2.5 (5.7) | 17.8 | 164.9 |
| | methidathion | 0.20 | 0.83 | 2.60 | 1.23 | 1.88 | 2.4 (5.4) | 17.7 | 153.8 |
| | Control | 1.03 | 1.00 | 3.75 | 0.75 | 24.63 | 2.4 (5.4) | 16.8 | 152.9 |
| Cody | leptophos | 0.43 | 1.03 | 4.03 | 0.83 | 3.63 | 1.8 (4.1) | 18.2 | 171.6 |
| | carbofuran | 0.38 | 1.15 | 0.65 | 0.63 | 0.10 | 2.0 (4.5) | 18.5 | 176.4 |
| | methidathion | 0.44 | 1.20 | 1.48 | 0.90 | 4.63 | 1.8 (4.1) | 19.0 | 182.4 |
| | Control | 0.93 | 1.15 | 4.10 | 1.75 | 20.60 | 1.8 (4.1) | 17.7 | 168.2 |
| $LSD_{.05}$ | Varieties | NS | NS | 1.36 | NS | NS | NS | 1.3 | 18.7 |
| Values | Insecticides | 0.44 | NS | NS | NS | 6.05 | NS | NS | NS |

did not appear to be related to insect control.

Although the numbers of insects that developed in this nursery in 1975 were not great enough to seriously damage the alfalfa, the early-cut schedule controlled populations of adult alfalfa weevils and possibly larval variegated cutworms.

*Variety × insecticides*—Insect counts and dry matter yield of the alfalfa at the first cutting appear in Table 14. Numbers of alfalfa weevil larvae were significantly reduced by all insecticides but not significantly by any variety. Numbers of pea aphids were significantly reduced by resistant varieties (Dawson and Team) but not by any insecticide. Alfalfa plant bug numbers were not significantly reduced by any insecticide or variety. Tarnished plant bug numbers were significantly reduced by all insecticides but not significantly by any variety. Dry matter yield was not different among varieties or insecticides. Differences in protein and carotene contents were small, but significant among some varieties but not among insecticides.

Pea aphid numbers for the remainder of the season are reported in Table 15. Strangely, insecticides seemed to influence aphid numbers on July 1, although the only previous treatment was on May 13. Aphid numbers on July 1 were lower in the plots of Vernal treated with carbofuran and higher in the plots of Cody treated with lep-

**Table 15. Counts of pea aphids on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the 2nd through 4th growth periods. Mead, NE, 1975.**

| | | Mean number of pea aphids per sweep | | | | | |
|---|---|---|---|---|---|---|---|
| Variety | Treatment | June 17 | July 1 | July 23 | August 4 | Sept.[a] 6 | Seasonal mean |
| Dawson | leptophos | 0.53 | 0.75 | 0.25 | 0.93 | 0.58 | 0.71 |
| | carbofuran | 0.30 | 0.85 | 0.30 | 0.58 | 0.33 | 0.50 |
| | methidathion | 0.23 | 0.88 | 0.10 | 0.58 | 0.25 | 0.49 |
| | Control | 0.33 | 0.78 | 0.25 | 0.75 | 0.55 | 0.56 |
| Team | leptophos | 0.30 | 0.63 | 0.10 | 0.60 | 0.50 | 0.49 |
| | carbofuran | 0.20 | 0.88 | 0.18 | 0.53 | 0.45 | 0.42 |
| | methidathion | 0.23 | 0.98 | 0.13 | 0.48 | 0.38 | 0.45 |
| | Control | 0.08 | 0.75 | 0.15 | 0.58 | 0.43 | 0.49 |
| Vernal | leptophos | 1.10 | 5.38 | 0.45 | 4.00 | 1.23 | 3.39 |
| | carbofuran | 0.70 | 3.75 | 0.63 | 2.93 | 0.68 | 1.74 |
| | methidathion | 0.88 | 5.15 | 0.33 | 4.10 | 0.75 | 2.19 |
| | Control | 1.00 | 5.38 | 0.53 | 3.23 | 1.28 | 2.52 |
| Cody | leptophos | 0.85 | 3.45 | 0.50 | 2.68 | 1.20 | 2.12 |
| | carbofuran | 1.10 | 2.05 | 0.45 | 2.88 | 0.80 | 1.32 |
| | methidathion | 0.73 | 2.10 | 0.40 | 2.65 | 0.90 | 1.37 |
| | Control | 1.08 | 2.70 | 0.35 | 2.83 | 1.10 | 2.02 |
| $LSD_{.05}$ | Varieties | 1.09 | 3.19 | 0.39 | 1.07 | 0.52 | |
| Values | Insecticides | NS | 0.57 | NS | NS | 0.28 | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

**Table 16. Counts of spotted alfalfa aphids on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the entire growing season. Mead, NE, 1975.**

| | | Mean number of spotted alfalfa aphids per sweep [a] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variety | Treatment | May[b] 27 | June 17 | July 1 | July 23 | August 4 | Sept.[b] 6 | Seasonal mean |
| Dawson | leptophos | 0.08 | 0.07 | 0.08 | 0.18 | 0.20 | 0.30 | 0.15 |
| | carbofuran | 0.07 | 0.07 | 0.07 | 0.18 | 0.25 | 0.30 | 0.15 |
| | methidathion | 0.11 | 0.07 | 0.07 | 0.16 | 0.33 | 0.29 | 0.17 |
| | Control | 0.11 | 0.07 | 0.07 | 0.15 | 0.26 | 0.28 | 0.16 |
| Team | leptophos | 0.11 | 0.08 | 0.11 | 0.29 | 0.74 | 0.55 | 0.31 |
| | carbofuran | 0.07 | 0.07 | 0.08 | 0.18 | 0.60 | 0.53 | 0.26 |
| | methidathion | 0.10 | 0.07 | 0.17 | 0.24 | 0.87 | 0.51 | 0.33 |
| | Control | 0.22 | 0.07 | 0.13 | 0.26 | 0.96 | 0.57 | 0.37 |
| Vernal | leptophos | 0.10 | 0.07 | 0.10 | 0.20 | 0.92 | 0.54 | 0.32 |
| | carbofuran | 0.12 | 0.07 | 0.10 | 0.20 | 0.62 | 0.53 | 0.27 |
| | methidathion | 0.09 | 0.07 | 0.11 | 0.23 | 0.90 | 0.50 | 0.32 |
| | Control | 0.09 | 0.07 | 0.19 | 0.28 | 0.86 | 0.50 | 0.33 |
| Cody | leptophos | 0.07 | 0.07 | 0.07 | 0.11 | 0.20 | 0.22 | 0.12 |
| | carbofuran | 0.11 | 0.07 | 0.07 | 0.14 | 0.24 | 0.22 | 0.14 |
| | methidathion | 0.07 | 0.07 | 0.07 | 0.12 | 0.23 | 0.20 | 0.13 |
| | Control | 0.07 | 0.07 | 0.07 | 0.19 | 0.26 | 0.23 | 0.15 |
| $LSD_{.05}$ | Varieties | NS | NS | 0.12 | 0.29 | 0.76 | 0.59 | |
| Values | Insecticides | NS | NS | NS | NS | NS | NS | |

[a]Transformed data ($\sqrt{X + 0.05}$)

[b]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

tophos than in controls. Leptophos has been reported to increase aphid numbers (Mueke *et al.* 1978), but the time lag was unusual. On September 6, after treatments in late August, pea aphid numbers were significantly reduced in plots of the susceptible varieties Vernal and Cody treated with carbofuran and methidathion. Resistant varieties (Dawson and Team) had significantly fewer aphids than susceptible varieties (Vernal and Cody) throughout the season.

Spotted alfalfa aphid numbers for the entire season are presented in Table 16. Numbers of this aphid were low throughout the season, and particularly before July 1. The influence of resistance in the varieties Dawson and Cody was apparent by July 1 and throughout the rest of the season. Aphid numbers were too low, however, to infer any influence of insecticide treatments at any time of the season.

Potato leafhopper numbers for the remainder of the season, after the first cutting, are presented in Table 17. Variety had no influence on leafhopper numbers at any time. Significant differences due to insecticides were noted on July 1. For all varieties except Dawson, treated plots contained more insects than untreated plots. Such an effect could have been caused by an earlier reduction in numbers of parasites and predators of the potato leafhopper, but such influences

**Table 17. Counts of potato leafhoppers on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the 2nd through 4th growth periods. Mead, NE, 1975.**

| | | Mean number of potato leafhoppers per sweep | | | | | |
|---|---|---|---|---|---|---|---|
| Variety | Treatment | June 17 | July 1 | July 23 | August 4 | Sept.[a] 6 | Seasonal mean |
| Dawson | leptophos | 4.38 | 14.70 | 6.18 | 14.48 | 0.78 | 6.92 |
| | carbofuran | 5.13 | 11.73 | 6.10 | 9.40 | 0.55 | 5.56 |
| | methidathion | 4.70 | 13.45 | 6.65 | 9.45 | 0.90 | 5.99 |
| | Control | 4.60 | 16.05 | 7.73 | 14.13 | 0.85 | 7.38 |
| Team | leptophos | 4.53 | 15.68 | 4.93 | 6.28 | 0.53 | 5.40 |
| | carbofuran | 5.15 | 13.73 | 5.03 | 7.28 | 0.23 | 5.29 |
| | methidathion | 3.85 | 13.05 | 4.40 | 7.88 | 0.40 | 4.98 |
| | Control | 5.00 | 10.13 | 5.58 | 8.23 | 0.75 | 5.15 |
| Vernal | leptophos | 3.78 | 10.23 | 4.18 | 6.88 | 0.73 | 4.40 |
| | carbofuran | 3.78 | 11.45 | 4.53 | 6.15 | 0.38 | 4.50 |
| | methidathion | 4.98 | 13.58 | 5.45 | 9.33 | 0.30 | 5.81 |
| | Control | 3.63 | 9.05 | 5.23 | 7.98 | 0.85 | 4.58 |
| Cody | leptophos | 5.10 | 18.15 | 6.45 | 9.58 | 0.63 | 6.79 |
| | carbofuran | 3.15 | 13.93 | 6.35 | 7.88 | 0.38 | 5.38 |
| | methidathion | 4.90 | 18.60 | 5.53 | 8.83 | 0.43 | 6.53 |
| | Control | 5.93 | 13.80 | 6.65 | 9.23 | 0.60 | 6.32 |
| $LSD_{.05}$ | Varieties | NS | NS | NS | NS | NS | |
| Values | Insecticides | NS | 4.25 | NS | NS | 0.53 | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

have not been studied. The only other influence of insecticides noted was on September 6, but at that time leafhopper numbers were very low in all plots. Although differences in mean numbers are statistically significant, they are not pronounced or easy to interpret.

Lady beetle numbers for the entire season are presented in Table 18. Numbers of these predators were influenced at times by both insecticides and plant varieties. On May 27 and August 4, the one variety susceptible to both aphids (Vernal) had the highest numbers of lady beetles. Carbofuran and methidathion appeared to reduce numbers of these beneficial insects the most. Numbers of another predator, *Orius insidiosus* (Say), appeared to follow the same trends as numbers of lady beetles, although the influence of insecticides and varieties did not appear to be so pronounced with *Orius insidiosus* (Table 19). Numbers of another group of predaceous insects, damsel bugs. (Nabis spp), were influenced less by insecticides and varieties (Table 20).

Plant bug numbers after 1st cutting appear in Tables 21 and 22. Significant differences were noted for alfalfa plant bugs among alfalfa varieties on July 23. But because this was the only date differences were significant, and plant bug populations were at about the

Table 18. **Counts of lady beetles on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the entire growing season. Mead, NE, 1975.**

| Variety | Treatment | Mean number of lady beetles per sweep | | | | | | Seasonal mean |
|---|---|---|---|---|---|---|---|---|
| | | May[a] | June | July | | August | Sept.[a] | |
| | | 27 | 17 | 1 | 23 | 4 | 6 | |
| Dawson | leptophos | 0.13 | 0.10 | 0.13 | 0.03 | 0.08 | 0.15 | 0.10 |
| | carbofuran | 0 | 0.10 | 0.10 | 0.03 | 0.05 | 0.20 | 0.08 |
| | methidathion | 0.20 | 0.25 | 0.08 | 0 | 0.13 | 0.13 | 0.13 |
| | Control | 0.20 | 0.10 | 0.05 | 0.03 | 0.05 | 0.25 | 0.11 |
| Team | leptophos | 0.10 | 0.13 | 0.10 | 0 | 0.23 | 0.13 | 0.12 |
| | carbofuran | 0.08 | 0.25 | 0.18 | 0.03 | 0.15 | 0.10 | 0.13 |
| | methidathion | 0.20 | 0.20 | 0.10 | 0.15 | 0.18 | 0.10 | 0.16 |
| | Control | 0.25 | 0.20 | 0.10 | 0.05 | 0.20 | 0.35 | 0.19 |
| Vernal | leptophos | 0.65 | 0.20 | 0.18 | 0.03 | 0.30 | 0.33 | 0.28 |
| | carbofuran | 0.25 | 0.20 | 0.20 | 0.10 | 0.28 | 0.03 | 0.18 |
| | methidathion | 0.20 | 0.25 | 0.08 | 0.03 | 0.23 | 0.28 | 0.18 |
| | Control | 0.63 | 0.18 | 0.05 | 0.10 | 0.33 | 0.25 | 0.26 |
| Cody | leptophos | 0.58 | 0.18 | 0.20 | 0.08 | 0.05 | 0.23 | 0.22 |
| | carbofuran | 0.18 | 0.20 | 0.15 | 0.08 | 0.03 | 0.13 | 0.13 |
| | methidathion | 0.33 | 0.23 | 0.13 | 0.03 | 0.10 | 0.18 | 0.17 |
| | Control | 0.40 | 0.23 | 0.18 | 0.05 | 0.15 | 0.28 | 0.22 |
| $LSD_{.05}$ | Varieties | 0.44 | NS | NS | NS | 0.21 | NS | |
| Values | Insecticides | 0.26 | NS | NS | NS | NS | 0.21 | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

same magnitude before and after the observation date, little importance can be ascribed to the differences. Tarnished plant bug numbers were not significantly influenced by either insecticides or varieties (Table 22).

Yields from the second, third and fourth cuttings appear in Table 23. There were no significant differences in mean dry matter yields among varieties or insecticides for these cuttings.

## CONTROL OF THE ALFALFA WEEVIL AND OTHER INSECTS WITH EXPERIMENTAL INSECTICIDES, 1975-77

Even though a number of registered insecticides effectively control the alfalfa weevil, new candidate insecticides were evaluated because resistance could develop in alfalfa weevil populations to any of the recommended insecticides.

### Materials and Methods

General methods were the same all three years. 'Dawson' alfalfa was used in a randomized complete block design with four replica-

**Table 19. Counts of *Orius insidiosus* on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the entire growing season. Mead, NE, 1975.**

| Variety | Treatment | Mean number of *Orius insidiosus* per sweep | | | | | | Seasonal mean |
|---|---|---|---|---|---|---|---|---|
| | | May[a] 27 | June 17 | July 1 | July 23 | August 4 | Sept.[a] 6 | |
| Dawson | leptophos | 1.23 | 0.95 | 0.58 | 0.85 | 1.75 | 3.35 | 1.45 |
| | carbofuran | 0.68 | 0.78 | 0.68 | 1.00 | 1.38 | 2.48 | 1.17 |
| | methidathion | 1.05 | 1.55 | 0.23 | 1.20 | 1.25 | 1.93 | 1.20 |
| | Control | 0.78 | 1.10 | 0.65 | 0.95 | 1.50 | 2.05 | 1.17 |
| Team | leptophos | 0.68 | 0.75 | 0.73 | 0.80 | 2.38 | 1.73 | 1.18 |
| | carbofuran | 0.45 | 0.73 | 0.55 | 0.65 | 2.00 | 1.45 | 0.97 |
| | methidathion | 0.63 | 0.58 | 0.60 | 0.83 | 2.43 | 1.65 | 1.12 |
| | Control | 0.65 | 0.88 | 0.48 | 0.95 | 2.35 | 1.73 | 1.17 |
| Vernal | leptophos | 0.95 | 1.43 | 0.70 | 0.98 | 3.85 | 2.85 | 1.79 |
| | carbofuran | 0.65 | 1.30 | 0.70 | 0.88 | 2.53 | 1.48 | 1.26 |
| | methidathion | 0.75 | 1.48 | 0.65 | 1.30 | 2.40 | 1.75 | 1.39 |
| | Control | 0.83 | 1.20 | 0.65 | 0.95 | 2.90 | 2.25 | 1.46 |
| Cody | leptophos | 0.88 | 1.50 | 0.75 | 0.78 | 2.43 | 3.20 | 1.59 |
| | carbofuran | 0.50 | 1.23 | 0.48 | 0.75 | 2.15 | 2.60 | 1.29 |
| | methidathion | 0.55 | 1.18 | 0.65 | 0.78 | 2.45 | 2.50 | 1.35 |
| | Control | 0.68 | 1.40 | 0.63 | 1.35 | 2.03 | 3.05 | 1.52 |
| $LSD_{.05}$ Values | Varieties | 0.65 | 0.61 | NS | NS | 1.65 | NS | |
| | Insecticides | 0.40 | NS | NS | NS | NS | 0.97 | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

tions. Plot size was 12 × 15 ft (3.7 × 4.6 m). Insecticides and application rates are listed in Tables 24, 25 and 26. Insecticides were diluted in water and applied at a rate of 12 gal/a (112.2 liter/ha) to first cutting alfalfa. Applications were made with a knapsack sprayer operated at 25 psi (1.76 kg/cm$^2$) and equipped with a 5-ft (1.5-m) boom. The sprayer used compressed $CO_2$ as the propellent. An application of carbofuran and an untreated control were checks in each test.

Treatments were evaluated by taking five sweeps/plot with a 15-in (38.1-cm) diameter insect net at one or two weeks posttreatment. All insects collected were placed in 70% alcohol for later sorting and counting. We counted all insects collected in sufficient numbers for proper evaluation of insecticide effects.

In 1975, insecticides were applied on May 15. The weather was clear and bright with a light wind and temperatures of 60-65° F (15.6-18.3° C). The alfalfa was 18-22 in (45.7-55.9 cm) tall and weevil damage was evident on slightly less than 50% of the plant tips.

In 1976, insecticides were applied on May 14. The weather was overcast to partly cloudy with light wind and a temperature of 60° F (15.6° C). The alfalfa was 18-22 in (45.7-55.9 cm) tall, and weevil damage was evident on 35% of the plant tips.

**Table 20. Counts of damsel bugs on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the entire growing season. Mead, NE, 1975.**

| Variety | Treatment | Mean number of damsel bugs per sweep | | | | | | Seasonal mean |
|---|---|---|---|---|---|---|---|---|
| | | May[a] 27 | June 17 | July 1 | July 23 | August 4 | Sept.[a] 6 | |
| Dawson | leptophos | 0.38 | 0.88 | 0.58 | 1.28 | 1.08 | 0.78 | 0.83 |
| | carbofuran | 0.13 | 0.85 | 0.33 | 1.48 | 0.78 | 0.43 | 0.67 |
| | methidathion | 0.35 | 0.90 | 0.55 | 1.48 | 0.95 | 0.58 | 0.80 |
| | Control | 0.45 | 0.88 | 0.45 | 1.33 | 0.93 | 0.68 | 0.79 |
| Team | leptophos | 0.33 | 0.78 | 0.60 | 0.93 | 1.43 | 0.30 | 0.73 |
| | carbofuran | 0.18 | 0.78 | 0.58 | 1.25 | 1.28 | 0.35 | 0.74 |
| | methidathion | 0.13 | 0.88 | 0.38 | 0.78 | 1.48 | 0.38 | 0.67 |
| | Control | 0.23 | 0.83 | 0.55 | 1.25 | 1.03 | 0.30 | 0.70 |
| Vernal | leptophos | 0.48 | 0.83 | 0.65 | 1.33 | 1.70 | 0.70 | 0.95 |
| | carbofuran | 0.18 | 0.80 | 0.45 | 1.08 | 1.25 | 0.45 | 0.70 |
| | methidathion | 0.40 | 0.58 | 0.73 | 1.45 | 1.95 | 0.50 | 0.94 |
| | Control | 0.35 | 0.78 | 0.55 | 1.10 | 1.68 | 0.78 | 0.87 |
| Cody | leptophos | 0.48 | 0.60 | 0.70 | 1.53 | 1.25 | 0.53 | 0.85 |
| | carbofuran | 0.25 | 0.78 | 0.50 | 1.73 | 1.20 | 0.55 | 0.84 |
| | methidathion | 0.43 | 0.60 | 0.88 | 1.60 | 1.08 | 0.25 | 0.81 |
| | Control | 0.25 | 0.78 | 0.48 | 1.73 | 1.48 | 0.38 | 0.85 |
| $LSD_{.05}$ | Varieties | 0.27 | NS | NS | NS | 0.78 | NS | |
| Values | Insecticides | 0.28 | NS | NS | NS | NS | NS | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

Two tests were conducted in 1977. For the first test, insecticides were aplied on May 9. The weather was partly cloudy with a light wind and temperatures of 60-65° F (15.6-18.3° C). The alfalfa was 25-27 in (63.5-68.6 cm) tall and weevil damage was evident on 53% of the plant tips. In the second test, insecticides were applied on May 12. The weather was clear and bright with a light wind and temperatures of 70-75° F (21.1-23.9° C). The alfalfa was 28-30 in (71.1-76.2 cm) tall and weevil damage was evident on 56% of the plant tips.

## Results and Discussion

In 1975, alfalfa weevil larvae were the only insects counted (Table 24). All treated plots contained significantly fewer larvae than untreated plots on both sampling dates (one and two weeks posttreatment). At one week posttreatment, larval numbers in several treatments (phosalone + malathion, phosmet, phosmet + carbophenothion, and phosalone at 1.5 lb/a (1.86 kg/ha)) were not significantly different from those in the carbofuran treatment. By the second week posttreatment only TH 6042 at 0.125 lb/a (0.14 kg/ha) produced larval numbers significantly different from the carbofuran treatment.

In 1976, both the alfalfa weevil and the pea aphid were counted

**Table 21. Counts of the alfalfa plant bug on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the 2nd through 4th growth periods. Mead, NE, 1975.**

| Variety | Treatment | Mean number of alfalfa plant bugs per sweep | | | | | Seasonal mean |
|---|---|---|---|---|---|---|---|
| | | June 17 | July 1 | July 23 | August[a] 4 | Sept. 6 | |
| Dawson | leptophos | 0.68 | 0.78 | 0.85 | 0.85 | 0.40 | 0.70 |
| | carbofuran | 0.93 | 0.63 | 0.98 | 0.38 | 0.05 | 0.65 |
| | methidathion | 0.93 | 0.95 | 1.10 | 0.60 | 0.03 | 0.76 |
| | Control | 0.90 | 0.45 | 0.83 | 0.65 | 0.08 | 0.63 |
| Team | leptophos | 1.25 | 0.58 | 0.43 | 0.25 | 0.03 | 0.63 |
| | carbofuran | 0.65 | 0.60 | 0.48 | 0.23 | 0.08 | 0.45 |
| | methidathion | 0.80 | 0.50 | 0.35 | 0.30 | 0.10 | 0.47 |
| | Control | 0.03 | 0.60 | 0.60 | 0.50 | 0.13 | 0.45 |
| Vernal | leptophos | 0.63 | 0.95 | 0.58 | 0.48 | 0.05 | 0.55 |
| | carbofuran | 0.68 | 0.60 | 0.93 | 0.30 | 0 | 0.53 |
| | methidathion | 0.83 | 0.65 | 0.95 | 0.50 | 0.08 | 0.64 |
| | Control | 1.00 | 0.75 | 0.88 | 0.50 | 0.10 | 0.70 |
| Cody | leptophos | 1.03 | 0.45 | 1.00 | 0.48 | 0.13 | 0.68 |
| | carbofuran | 1.15 | 0.73 | 0.73 | 0.43 | 0.03 | 0.70 |
| | methidathion | 1.20 | 0.73 | 0.68 | 0.35 | 0 | 0.69 |
| | Control | 1.15 | 0.60 | 1.30 | 0.48 | 0.08 | 0.79 |
| $LSD_{.05}$ | Varieties | NS | NS | 0.49 | NS | NS | |
| Values | Insecticides | NS | NS | NS | NS | NS | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

(Table 25). At one week posttreatment, mean numbers of weevil larvae were not significantly different among treatments but means of all insecticide treatments were significantly different from the control. Mean numbers of weevil larvae had increased for all treatments by the second week posttreatment. Fenvalerate produced the least difference between the two observations and provided the best control of all insecticides at two weeks posttreatment. At one week posttreatment all insecticides controlled the pea aphid except SD-41706 and phosmet. At two weeks posttreatment several insecticides (fenitrothion at 1 lb/a /1.12 kg/ha) and 0.75 lb/a /0.84 kg/ha), M-4105 and fenvalerate) maintained good aphid control. Dry matter yield and protein and carotene contents were not different among treatments.

In 1977, in the first test, one week posttreatment all treated plots contained significantly fewer alfalfa weevil larvae than the untreated plot. Results with chlorpyrifos were not significantly different from those with carbofuran (Table 26). By two weeks posttreatment the weevil population was greatly reduced, and differences among treatments were no longer significant, thus obscuring any possible residual effects of the compounds tested. In general, those compounds most effective against the alfalfa weevil were also most effective against the

**Table 22. Counts of the tarnished plant bug on four alfalfa varieties after treatment with leptophos, carbofuran and methidathion during the 2nd through 4th growth periods. Mead, NE, 1975.**

| Variety | Treatment | Mean number of tarnished plant bugs per sweep | | | | | Seasonal mean |
|---|---|---|---|---|---|---|---|
| | | June 17 | July 1 | July 23 | August 4 | Sept.[a] 6 | |
| Dawson | leptophos | 4.45 | 2.28 | 2.18 | 2.03 | 0.88 | 2.04 |
| | carbofuran | 3.33 | 1.63 | 2.20 | 2.33 | 1.00 | 1.81 |
| | methidathion | 3.63 | 4.05 | 2.10 | 1.88 | 0.80 | 2.17 |
| | Control | 2.80 | 2.30 | 2.05 | 2.10 | 1.03 | 1.91 |
| Team | leptophos | 3.93 | 4.13 | 2.08 | 1.48 | 0.73 | 2.14 |
| | carbofuran | 4.15 | 2.35 | 1.45 | 1.68 | 1.03 | 1.83 |
| | methidathion | 3.93 | 2.28 | 1.30 | 2.23 | 0.90 | 1.85 |
| | Control | 4.18 | 1.83 | 1.95 | 1.93 | 0.05 | 1.86 |
| Vernal | leptophos | 3.40 | 2.30 | 2.35 | 2.63 | 1.00 | 2.00 |
| | carbofuran | 3.25 | 2.50 | 1.85 | 2.23 | 0.83 | 1.83 |
| | methidathion | 4.43 | 2.95 | 2.35 | 2.50 | 0.65 | 2.18 |
| | Control | 4.28 | 2.50 | 1.83 | 2.05 | 0.93 | 2.10 |
| Cody | leptophos | 4.03 | 1.24 | 1.73 | 1.98 | 1.10 | 1.75 |
| | carbofuran | 4.03 | 1.35 | 2.20 | 2.63 | 0.88 | 1.91 |
| | methidathion | 4.33 | 2.30 | 2.50 | 1.93 | 0.75 | 2.04 |
| | Control | 3.78 | 4.05 | 2.75 | 1.98 | 1.20 | 2.44 |
| $LSD_{.05}$ | Varieties | NS | NS | NS | NS | NS | |
| Values | Insecticides | NS | NS | NS | NS | NS | |

[a]Sampling followed insecticide treatments by 14 days. No other treatments were applied.

plant bug and the pea aphid at one week posttreatment. Plant bug numbers increased and pea aphid numbers decreased before the second sampling date, but significant differences were not detected.

In the second test, at one week posttreatment UC-54229 (at both rates) reduced numbers of weevil larvae as much as the carbofuran treatment. Weevil numbers had decreased greatly by the date of the second sample, so any residual effects of the insecticides were obscured. Pea aphid and plant bug numbers were very low and did not differ among treatments.

**Table 23. Effect of application of leptophos, carbofuran and methidathion on forage yield of indicated alfalfa varieties at 2nd through 4th harvests. Mead, NE, 1975.**

| | | Tons/a (Metric tons/a) | | |
|---|---|---|---|---|
| Variety | Treatment | July 3 | August 5 | Sept. 12[a] |
| Dawson | leptophos | 1.5 (3.4) | 1.2 (2.7) | 1.8 (4.0) |
| | carbofuran | 1.6 (3.6) | 1.3 (2.9) | --- |
| | methidathion | 1.5 (3.4) | 1.3 (2.9) | 1.1 (2.5) |
| | Control | 1.4 (3.1) | 1.2 (2.7) | 1.8 (4.0) |
| Team | leptophos | 1.4 (3.1) | 1.1 (2.5) | 1.2 (2.7) |
| | carbofuran | 1.2 (2.7) | 0.9 (2.0) | --- |
| | methidathion | 1.3 (2.9) | 1.1 (2.5) | 1.1 (2.5) |
| | Control | 1.4 (3.1) | 1.1 (2.5) | 1.2 (2.7) |
| Vernal | leptophos | 1.5 (3.4) | 1.2 (2.7) | 1.2 (2.7) |
| | carbofuran | 1.3 (2.9) | 1.2 (2.7) | --- |
| | methidathion | 1.5 (3.4) | 1.2 (2.7) | 1.1 (2.5) |
| | Control | 1.5 (3.4) | 1.1 (2.5) | 1.2 (2.7) |
| Cody | leptophos | 1.3 (2.9) | 1.3 (2.9) | 1.2 (2.7) |
| | carbofuran | 1.3 (2.9) | 1.4 (3.1) | --- |
| | methidathion | 1.4 (3.1) | 1.4 (3.1) | 1.3 (2.9) |
| | Control | 1.3 (2.9) | 1.3 (2.9) | 1.3 (2.9) |
| $LSD_{.05}$ | Varieties | NS | NS | NS |
| Values | Insecticides | NS | NS | NS |

[a]Sampling followed insecticide treatments by 20 days. No other treatments were applied.

**Table 24. Counts of larval alfalfa weevils and forage yield after applications of experimental insecticides. Treatments were applied at Mead, NE on May 15, 1975.**

| Treatment | Rate lb AI/a | (kg/ha) | Number of larvae per sweep[a] May 22 | June 2 | Forage yield tons/a (Metric tons/ha) |
|---|---|---|---|---|---|
| carbofuran | 0.5 | (0.56) | 0.40 a | 0.44 a | 2.4 (5.3) a |
| phosmet | 1.0 | (1.12) | 1.00 ab | 0.50 a | 2.3 (5.1) a |
| phosalone 1.5 + malathion .067 | 0.75 | (0.84) | 1.90 ab | 1.04 a | 2.2 (5.1) a |
| phosmet + carbophenothion | 0.5/0.5 | (0.56/0.56) | 2.64 ab | 0.70 a | 2.6 (5.9) a |
| phosalone | 1.5 | (1.68) | 4.00 abc | 1.84 ab | 2.5 (5.6) a |
| phosalone | 0.75 | (0.84) | 6.30 bc | 2.14 ab | 2.5 (5.6) a |
| permethrin | 0.20 | (0.22) | 6.30 bc | 2.74 ab | 2.5 (5.6) a |
| TH 6042[b] | 0.25 | (0.28) | 8.60 c | 2.70 ab | 2.5 (5.6) a |
| TH 6042[b] | 0.125 | (0.14) | 9.16 c | 4.64 b | 2.3 (5.2) a |
| permethrin | 0.1 | (0.11) | 9.64 c | 1.50 a | 2.2 (5.1) a |
| Contol | ---- | | 29.60 d | 17.14 c | 2.4 (5.4) a |

[a]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

[b]1-8-Pyrazole-1-carboxamide, N, 3-bis(4-chlorophenyl)-4-phenyl-

**Table 25. Insect counts and forage yield of 'Dawson' alfalfa after application of experimental insecticides. Treatments were applied at Mead, NE on May 14, 1976**

| Treatment | Rate lb AI/a (kg/ha) | Alfalfa weevil larvae per sweep[a] | | Pea aphids per sweep[a] | | Forage yield—1st cut, May 26[a] | | |
|---|---|---|---|---|---|---|---|---|
| | | May 20 | May 26 | May 20 | May 26 | Protein % db | Carotene mg/kg db | Tons/a dry matter (Metric tons/ha) |
| permethrin, 2E | 0.06 (0.07) | 7.40 b | 17.04 b | 2.20 b | 4.90 bc | 19.1 a | 161 a | 2.1 (4.7) a |
| fenitrothion | 1.00 (1.12) | 7.04 b | 10.40 bc | 2.84 b | 2.40 c | 19.7 a | 174 a | 2.2 (4.9) a |
| permethrin, 2E | 0.09 (0.10) | 5.74 b | 12.94 bc | 1.30 b | 2.90 bc | 19.2 a | 161 a | 2.3 (5.1) a |
| chlorpyrifos | 0.50 (0.56) | 5.04 b | 7.44 bc | 0.64 b | 2.34 c | 19.4 a | 163 a | 2.3 (5.1) a |
| fenitrothion | 0.75 (0.84) | 4.84 b | 11.50 bc | 1.08 b | 2.20 c | 19.4 a | 157 a | 2.3 (5.1) a |
| SD-41706, 2.4EC[b] | 0.05 (0.06) | 3.80 b | 5.24 bc | 8.74 a | 10.94 a | 19.0 a | 186 a | 2.0 (4.6) a |
| fenvalerate, 2.4 EC | 0.05 (0.06) | 2.64 b | 3.10 c | 0.60 b | 1.04 c | 18.9 a | 170 a | 2.2 (4.9) a |
| chlorpyrifos | 0.25 (0.28) | 2.14 b | 14.14 bc | 1.10 b | 4.04 bc | 19.5 a | 159 a | 2.3 (5.2) a |
| A-47171, 2 EC[c] | 1.00 (1.12) | 1.84 b | 9.40 bc | 3.60 b | 5.04 abc | 19.4 a | 163 a | 2.3 (5.2) a |
| phosmet[R] 70 WP | 1.00 (1.12) | 1.24 b | 5.90 bc | 7.90 a | 8.60 ab | 19.0 a | 161 a | 2.2 (4.9) a |
| A-47170, 2 EC[d] | 1.00 (1.12) | 1.10 b | 5.64 bc | 2.94 b | 3.60 bc | 19.7 a | 168 a | 2.1 (4.7) a |
| carbofuran | 0.50 (0.56) | 0.54 b | 7.04 bc | 2.40 b | 4.70 bc | 19.6 a | 174 a | 2.2 (4.9) a |
| Control | --- | 22.10 a | 29.80 a | 11.10 a | 10.70 a | 19.1 a | 184 a | 2.2 (4.9) a |

[a]Means followed by the same letter are not significantly different according to Duncan's multiple range test (P + 0.05).

[b]Cyclopropanecarboxylic acid, 2, 2, 3, 3-tetramethyl-alpha-cyano-3-phenoxy-benzyl ester.

[c]Benzene, 1, 1,'-(2-methylproplidene)bis [4-ethoxy-

[d]Benzene, 1, 1,'-(2-chloropropylidene)bis [4-ethoxy-

**Table 26. Insect counts and forage yield of 'Dawson' alfalfa after application of experimental insecticides at Mead, NE, 1977.**

| Treatment | Rate lb AI/a (Kg-ha) | Mean number of insects per sweep[a] | | | | | | Dry matter yield tons/a (Metric tons/ha) |
|---|---|---|---|---|---|---|---|---|
| | | Alfalfa weevil larvae | | Plant bugs[b] | | Pea aphids | | |
| | | 1 wk[c] | 2 wk[d] | 1 wk | 2 wk | 1 wk | 2 wk | |
| | *Test 1–applied May 9* | | | | | | | |
| carbofuran | 0.50 (0.56) | 0.34 a | 1.40 a | 1.44 a | 5.40 a | 1.94 a | 2.80 a | 2.0 (4.5) a |
| chlorpyrifos | 0.50 (0.56) | 0.54 a | 2.20 a | 1.04 a | 3.90 a | 2.10 a | 4.24 a | 1.7 (3.8) a |
| chlorpyrifos | 0.25 (0.28) | 2.00 ab | 1.80 a | 0.90 a | 4.74 a | 4.24 ab | 4.20 a | 1.9 (4.3) a |
| permethrin[e] | 0.50 (0.56) | 5.14 bc | 3.44 a | 6.50 b | 7.14 a | 2.10 a | 3.14 a | 2.1 (4.7) a |
| permethrin[f] | 0.01 (0.01) | 6.14 bc | 1.74 a | 5.40 b | 6.50 a | 3.74 a | 3.24 a | 2.1 (4.7) a |
| permethrin[f] | 0.02 (0.02) | 8.14 c | 2.80 a | 5.64 b | 6.70 a | 3.70 a | 3.64 a | 2.1 (4.7) a |
| permethrin[e] | 0.01 (0.01) | 8.30 c | 3.64 a | 6.60 b | 8.04 a | 4.54 ab | 3.80 a | 1.8 (4.2) a |
| Control | --- | 12.54 d | 2.70 a | 5.44 b | 6.90 a | 7.64 b | 3.40 a | 2.1 (4.7) a |
| | *Test 2–applied May 12* | | | | | | | |
| UC 54229[g] | 0.25 (0.28) | 0.0 a | 0.14 a | 6.64 a | 6.00 a | 2.30 a | 0.24 a | 1.8 (4.1) a |
| UC 54229[g] | 0.50 (0.56) | 0.20 a | 0.10 a | 8.84 a | 9.10 a | 3.14 a | 0.74 a | 2.0 (4.5) a |
| carbofuran | 0.50 (0.56) | 0.34 ab | 1.10 a | 7.74 a | 10.00 a | 2.74 a | 0.64 a | 1.9 (4.3) a |
| EL 494[h] | 0.50 (0.56) | 1.30 bc | 0.50 a | 7.24 a | 10.60 a | 2.74 a | 0.90 a | 1.9 (4.3) a |
| Control | --- | 1.54 c | 0.40 a | 6.64 a | 10.14 a | 2.14 a | 0.80 a | 1.9 (4.3) a |

[a]Means followed by the same letter are not statistically different according to Duncan's multiple range test (P = 0.05).

[b]Mixture of species (*Lygus* spp. and *Adelphocoris* spp.), adults and nymphs.

[c]One week observation for test 1 was made on May 16, one week observation for test 2 was made on May 22.

[d]Two weeks observation for test 2 was made on May 19, two weeks observation for test 2 was made on May 26.

[e]Tested as FMC 33 297.

[f]Tested as PP 557.

[g]Information on composition not available.

[h]*N*-[[[5-(4-bromophenyl)-6-methyl-2-pyrazinyl]amino]=carbonyl]-2, 6,-dichlorobenzamide.

## LITERATURE CITED

App, B.A. and G. R. Manglitz. 1972. Insects and related pests. Chap 24, *In* Alfalfa Science and Technology, Monograph 15. Am Soc of Agronomy, Madison, Wisc. 812 pp.

Armbrust, E. J., H. D. Niemczyk, B. C. Pass, and M. C. Wilson. 1969. Standardized procedures adopted for cooperative Ohio Valley States alfalfa weevil research. J. Econ. Entomol. 62:250-51.

Barnes, D. K., C. H. Hanson, R. H. Ratcliffe, T. H. Busbice, J. A. Schillinger, G. R. Buss, W. V. Campbell, R. W. Hemken and C. C. Blickenstaff. 1970. The development and performance of Team alfalfa: A multiple pest resistant alfalfa with moderate resistance to the alfalfa weevil. U.S. Dept. Agric., ARS34-115, 41 pp.

Bennett, S. E. 1968. A decade with the alfalfa weevil in Tennessee. Tenn. Bull 446, 33 pp.

Blickenstaff, C. C. and J. L. Huggans. 1969. Four methods of sampling to measure populations of alfalfa weevil larvae. J. Econ. Entomol. 62:556-57.

Busbice, T. H., W. V. Campbell, L. V. Bunch and G. Y. Gurgis. 1977. Breeding alfalfa cultivars resistant to the alfalfa weevil. Euphytica 27:343-352.

Campbell, W. V., T. H. Busbice, J. M. Falter and J. W. Glover. 1975. The alfalfa weevil and its management in North Carolina. North Car. Tech. Bull. 234, 36 pp.

Coan, R. M., V. E. Adler, C. C. Blickenstaff and A. L. Steinhauer. 1968. Field evaluation of insecticides for control of the alfalfa weevil in Maryland, 1962-66. USDA, ARS33-127, 20 pp.

Cothran, W. R. and C. G. Summers. 1974. Visual economic thresholds and potential pesticide abuse: alfalfa weevils, an example. Environ. Entomol. 3:891-894.

Devine, T. E., R. H. Ratcliffe, T. H. Busbice, J. A. Schillinger, L. Hofmann, G. R. Buss, R. W. Cleveland, F. L. Lukezic, J. E. McMurtrey and C. M. Rinker. 1977. ARC, a multiple pest-resistant alfalfa. U.S. Dept. Agric., Tech. Bull. 1559, 27 pp.

Dickason, E. A. and R. W. Every. 1968. Alfalfa weevil larval injury in Oregon. J. Econ. Entomol. 61:860-861.

Dorsey, C. K., L. P. Stevens and J. E. Weaver. 1969. Experiments to control the alfalfa weevil with hydraulic spray and granular applications. West. Va. Bull. 578T, 26 pp.

Hamlin, J. C., W. C. McDuffie and F. V. Lieberman. 1949. Alfalfa weevil distribution and crop damage in the United States. USDA Cir. No. 815, 21 pp.

Hintz, T. R., M. C. Wilson and E. J. Armbrust. 1976. Impact of alfalfa weevil larval feeding on the quality and yield of first cutting alfalfa. J. Econ. Entomol. 69:749-754.

Kehr, W. R., G. R. Manglitz, and R. L. Ogden. 1968. Dawson alfalfa—a new variety resistant to aphids and bacterial wilt. Nebr. Agric. Exp. Sta., Sta Bull 497, 23 pp.

Kehr, W. R., R. L. Ogden, and S. D. Kindler. 1975. Management of four alfalfa varieties to control damage from potato leafhoppers. Nebr. Agric. Expt. Sta. Res. Bull. 275, 42 pp.

Kehr, W. R., G. R. Manglitz, and R. L. Ogden, 1978. Registration of Baker alfalfa (Reg. No. 87). Crop Sci. 18:692.

Keith, D. L., G. R. Manglitz and W. R. Kehr. 1977. The alfalfa weevil. Neb Guide G73-30, 4 pp. Univ. of Nebr. Coop. Ext. Svc.

Kindler, S. D., G. R. Manglitz and J. M. Schalk. 1968. Insecticides for control of insects attacking alfalfa seed in Eastern Nebraska. J. Econ. Entomol. 61:1636-1639.

Klostermeyer, L. E. and G. R. Manglitz. 1979. Distribution of eastern and western alfalfa weevil in Nebraska determined by cross-mating. J. Kansas Entomol. Soc. 52:209-214.

Manglitz, G. R., W. R. Kehr, and C. O. Calkins. 1962. Pea-aphid resistant alfalfa now in sight. Nebr. Expt. Sta. Quart. 9:5-6, 24.

Manglitz, G. R., C. O. Calkins, R. J. Walstrom, S. D. Hintz, S. D. Kindler and L. L. Peters. 1966. Holocyclic strain of the spotted alfalfa aphid in Nebraska and adjacent states. J. Econ. Entomol. 59:636-639.

Manglitz, G. R., J. M. Schalk, L. W. Anderson, and K. P. Pruess. 1973. Control of the army cutworm on alfalfa in Nebraska. J. Econ. Entomol. 66:299.

Medler, J. T. 1957. Migration of the potato leafhopper - a report on a cooperative study. J. Econ. Entomol. 50:493-497.

Mueke, J. M., G. R. Manglitz and W. R. Kehr. 1978a. Pea aphid: interaction of insecticides and alfalfa varieties. J. Econ. Entomol. 77:61-64.

Mueke, J. M., G. R. Manglitz and W. R. Kehr. 1978b. Effect of insecticides applied to resistant and susceptible varieties of alfalfa on spotted alfalfa aphid and alfalfa weevil. University of Nebraska - Department of Entomology Rpt. No. 7, 11 pp.

Pruess, K. P. 1967. Migration of the army cutworm, *Chorizagrotis auxiliaris* (Lepidoptera: Noctuidae). I. Evidence for a migration. Ann. Entomol. Soc. Amer. 60:910-920.

Surgeoner, C. A. and C. R. Ellis. 1975. Effect on non-target organisms of field applications of carbofuran for control of *Hypera postica* (Coleoptera: Curculionidae). Proc. Entomol. Soc. Ontario 106:13.

Wilson, M. C. 1973. Damage from alfalfa weevil infestations. Proc. No. Central Br.-ESA 28:28-31.