Effect of burning alfalfa stubble for insect pest control on seed yield[1]

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ABSTRACT

Burning alfalfa (*Medicago sativa* (L.)) stubble in the spring has been shown to be effective in reducing some insect pest populations. A study was conducted to determine the long-term effect of this practice on seed yield. Plots were established at Lethbridge, Alberta, and burned in the spring or fall at various heights of plant growth from 1983 to 1989, with one half of each plot treated annually with insecticides when the pest insects were in their most vulnerable stage. Yields from burned treatments were not significantly different from unburned ones for the years 1983 to 1986, and 1988. In 1987, treatments burned in the fall had significantly higher yields than other treatments. Burning at 15-20 cm of growth significantly reduced yield compared to burning before spring growth. In 1989, yields from plots burned at 15-20 cm of growth were significantly lower than those burned every fall or spring. Insecticide treated plots had significantly higher yields in all years except 1983. Burning in the fall, or in the spring before growth, increased gross economic returns, but insecticide treatment gave the highest returns.

INTRODUCTION

Burning alfalfa stubble is widely used by commercial growers of seed alfalfa (*Medicago sativa* (L.)) as a method of controlling insect pests. Increased yields of alfalfa seed have been reported from various cultivation and sanitation practices (burning) attempted by commercial seed growers in Alberta and Saskatchewan (Lilly and Hobbs 1962; Bolton and Peck 1946). In the short term, burning has been reported to reduce pest insect populations and increase seed yields (Carlson 1940; Bolton and Peck 1946; Lilly and Hobbs 1962; Schaber and Entz 1988; Tippens 1964). Despite lack of long term studies, alfalfa seed producers on the Canadian prairies generally burn their seed fields in the spring of every second year.

An Integrated Pest Management (IPM) program was initiated and implemented in alfalfa seed production areas of southern Alberta in 1978 (Schaber and Richards 1979). Such a system should enable producers to increase the sustainability of their operations by reducing dependence on costly pesticides which may also have adverse effects on the environment. Accurate targeting of pesticides to control only damaging stages of insects, combined with other cultural practices, should increase profits and reduce chemical use. Although this system has been in use for some time, its scientific basis and practical merits had not been tested. This study was conducted to assess the long-term effects on seed yield of annual or biennial burning of alfalfa stubble in the fall, in the spring before growth, and at 5-10 cm and 10-15 cm of growth in the spring.

MATERIALS AND METHODS

Experiments were conducted for 7 years (1983-1989) at Lethbridge, Alberta, in an alfalfa seed field (cv. Beaver), grown on a Dark Brown Chernozemic Lethbridge silty clay-loam soil. The plots were seeded in 70 cm rows at 1.21 kg/ha. A split-plot design was used with five burn treatments (12 X 15 m main plots) and two insecticide treatments (split-plots) with four replicates. These small plots were established in order to have a high degree of control and uniformity. Factors that we attempted to control were: irrigation, fertility, weeds, plot distance from shelters for pollinating alfalfa leafcutter bees, and burning. Burn treatments were chosen as representative of local seed producers' management practices as follows: burned every fall (BEF) (in October after harvest); burned every spring before growth (BES); burned alternate springs before growth (BAS); burned alternate springs at 5-10 cm of new growth (BA2); burned alternate springs at 15-20 cm of new growth (BA4); and control, no burn (UNB). The alternate burn treatments occurred in 1983, 1985, 1987, and 1989. The plots were set aflame on the windward side by a propane torch. To control the fire, one quarter of each plot was burned at a time.

Each burn treatment plot was divided in half and the same half was treated annually with insecticides when the pest insects were most vulnerable. To control the plant bugs, *Lygus spp.*, and *Adelphocoris lineolatus* (Goeze), trichlorfon (1150 g AI/ha per 110 l H_20) was applied two or three times during the growing season when these bugs were in the fourth or fifth nymphal instars, and their numbers had reached the economic threshold of 2/90° sweep. Phosmet (1125 g AI/ha per 110 l H_2O) was applied in early June for control of the alfalfa weevil, *Hypera postica* (Gyll.), when most of the larvae were in the third- or fourth-instars, and the numbers had reached the economic threshold of 25/90° sweep. All treatments were randomly assigned at the start of the experiment in 1983, and each plot received its assigned treatment for the 6 years of the study.

The whole field received an application of 11-48-0 fertilizer (110 kg/ha) each year. The plots were irrigated by sprinkler (12 hr at 12 mm/hr) twice during the growing season, once in late May, and again about 1 wk before alfalfa leafcutter bees (*Megachile rotundata* F.) were placed in the alfalfa fields, which was just as bloom commenced in late June. The stocking rate was approximately 60,000 bees/ha. In mid-September, fields were desiccated with diquat (0.6 kg AI/ha per 200 l H_20, plus 0.1% of the total volume of the superfactant, Agral 90). About 7-10 d later, two 2.45 m-wide cuts were straight combined using a Massey Harris combine (1963 model Super 35, Brantford, ON). Alfalfa seed samples were cleaned before weighing.

Table 1

Alfalfa seed yields in kg/ha for each year from plots treated and not treated with insecticides at Lethbridge, Alberta.

Treatment	1983	1984	1986	1987	1988	1989
Insecticide:	161 ± 13a*	427 ± 16.2a	390 ± 22.8a	267 ± 25.9a	477 ± 19.7a	276 ± 12.6a
No-insecticide:	150 ± 15a	105 ± 11.8b	266 ± 20.7b	210 ± 19.9b	247 ± 8.3b	212 ± 8.7b

a,b Means within a given year followed by the same letter are not significantly different ($P = 0.05$, Ryan's Q test).

* Mean and standard error of the mean.

Table 2

Alfalfa seed yields in kg/ha for each year from plots variously treated at Lethbridge, Alberta.

Treatment*	1983	1984	1986	1987	1988	1989
UNB	156 ± 15.0a@	265 ± 60.0a	278 ± 50.3a	201 ± 28.9a	325 ± 35.0a	230 ± 17.2abc
BES	153 ± 22.6a	315 ± 76.6a	336 ± 47.2a	274 ± 45.9b	348 ± 50.7a	272 ± 24.2ab
BEF	212 ± 33.6a	269 ± 51.6a	334 ± 30.0a	404 ± 28.0c	402 ± 56.7a	295 ± 22.5a
BAS†	138 ± 30.3a	251 ± 66.7a	407 ± 42.2a	260 ± 18.1b	352 ± 54.8a	264 ± 18.5abc
BA2†	148 ± 19.8a	227 ± 66.3a	266 ± 29.5a	166 ± 16.2ab	327 ± 47.4a	218 ± 18.5bc
BA4†	124 ± 12.3a	269 ± 68.0a	346 ± 49.2a	134 ± 20.9a	416 ± 50.0a	196 ± 14.3c

a,b,c Means within a given year followed by the same letter are not significantly different ($P = 0.05$, Ryan's Q test).

† Burned in 1983, 1985, 1987, and 1989.

* UNB = control; BES = burned every spring; BEF = burned every fall; BAS = burned alternate springs; BA2 = burned alternate springs 5-10 cm; BA4 = burned alternate springs 15-20 cm.

@ Mean and standard error of the mean.

The data were analyzed as a split-plot design. The GLM procedure from SAS (SAS Institute Inc., 1985) was used to perform analyses of variance, and Ryan's Q test (Ryan 1960) was used to evaluate differences among treatment means. Separate analyses were performed for each year. Seed prices from each year were used to calculate the gross income per ha for each burn treatment. The average alfalfa seed selling prices per kg were: in 1983, $2.20; 1984, $2.20; 1986, $3.19; 1987, $2.97; 1988, $2.31; and 1989, $1.98 (Gold Medal Seeds, Brooks, Alberta). Seed yield data for 1985 are not included because very strong winds, up to 125 km/h, 1 wk after desiccation caused excessive shattering, and the amount of seed harvested was too small to be included in the analysis.

RESULTS

The interaction between burning and insecticide treatment was significant only in 1983 ($P = 0.02$). Because the interaction occurred only in the year of stand establishment, the insecticide and burn treatment effects are interpreted independently.

Insecticide treated plots had significantly higher yields for all years except 1983 (Table 1). Seed yields increased from 1983 to 1986 (Table 2). Yields from burned treatments did not differ significantly from unburned, control treatments for 1983 to 1986, and 1988. In 1987, the BEF treatment had a significantly higher yield than all other treatments, while plots burned at 15-20 cm of growth (BA4) had significantly lower yield than those burned before growth (BEF, BES, BAS). In 1989, BA4 treatment yielded significantly less than BES and BEF treatments. However, there was a consistent trend in the burn treatments as economic returns were higher in the plots burned in the fall or before spring growth (Table 3).

DISCUSSION

Significant differences from burning were detected only in 1987 and 1989, however, the long-term economic implications are still important. The mean economic returns for 6 of the 7 years are presented in Table 3 for the treatments with and without insecticides, so the economic returns due to burning can be calculated. Maximum economic gain was from BEF; $188/ha over UNB, $461 vs $649, (Table 3). Thus, the economic returns from BEF were 41% higher than those from UNB. This is even more evident when burning and insecticides are applied to seed alfalfa fields. No economic gains were realized from the BA2 and BA4 treatments. The difference in economic return between the insecticide and no insecticide treatments for UNB was $282, indicating a substantial economic gain from insecticide application.

The fall burn treatment resulted in the highest yield (Table 2), but the average yield for the unburned insecticide treatment was 14% higher than that for the BEF treatment (Table 3). However, if the cost of insecticide treatments is considered ($20-25/ha per application, usually two treatments per year), then the returns from the BEF treatments are quite comparable ($649 vs $700/ha). The average income was similar for the BES and BAS treatments, which may explain why seed growers in this area generally burn their alfalfa seed fields in the spring before growth once every two years. Although the BEF treatment produced the highest economic returns over the 6 years, seed producers in southern Alberta generally don't burn alfalfa stubble in the fall because of the possibility of soil erosion during the winter.

Insecticide treatments were applied when the damaging threshold for each pest species was approached, but after early August insecticides were not applied, because it was believed that late season (those occurring in alfalfa fields in mid- to late-August) pest insects did not cause economic damage to alfalfa. Subsequently Schaber *et al.* (1990), showed that plant bugs can indeed cause economic damage in late August and need to be controlled. It is possible that these late-season populations were responsible for the lack of consistent differences in yields between treatments.

Schaber and Entz (1988) showed that small plots in a commercial seed alfalfa field, in Alberta, burned before growth in the spring had a significantly higher yield than unburned plots. However, our experimental plots were surrounded by unburned untreated plots which provided a ready supply of pest insects which moved into the treated plots within weeks after the insec-

Table 3

Gross income per ha (mean and standard error) from alfalfa grown for seed in six years* on plots treated and not treated with insecticides.

Burn Treatment@	No Insecticide	Insecticide
UNB	$461 ± 48ab	$743 ± 69ab++
BES	518 ± 59ab	889 ± 84ab
BEF	649 ± 59a	982 ± 82a
BAS	528 ± 69ab	892 ± 86ab
BA2	422 ± 41b	697 ± 67b
BA4	448 ± 65ab	791 ± 91ab

* 1985 data not included because of high winds and excessive shattering before harvest.

@ UNB = control; BES = burned every spring; BEF = burned every fall; BAS = burned alternate springs; BA2 = burned alternate springs 5-10 cm; BA4 = burned alternate springs 15-20 cm.

+, ++ burn treatment means not followed by the same letter are significantly different at $P = 0.10$ and $P = 0.15$, respectively, (Ryan's Q test).

ticide treatment (Schaber and Entz 1991). Despite this, differences in yield were observable in our small plots where immigration of pest insects readily occurred. Much greater yield differences might be expected in producers' fields where immigration is less rapid. Likewise, Bacon *et al.* (1983) and Kogan (1984) reported no strong correlations between alfalfa seed yields and observed insect populations in experiments conducted on the control of pest insects.

Yield is only one factor of IPM, and focusing only on maximizing yield can result in excessive costs and potentially detrimental environmental effects. Therefore, an IPM strategy that stabilizes yield over time and is associated with acceptable profit might be preferred to one that maximizes yield or profit in any one year. Thus, the cultural method of fall or spring burning of alfalfa stubble before growth, as we have shown herein, is compatible with IPM principles and sustainable agriculture.

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NOTE

1. LRS Contribution no. 3879143.

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Phytoseiid mites associated with spider mites on hops in the Willamette Valley, Oregon

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ABSTRACT

Densities and damage by twospotted spider mites, *Tetranychus urticae* Koch and levels of phytoseiid mites on hops were assessed in 34 commercial fields and at 11-19 sites of escaped hops in the Willamette valley of western Oregon in 1991-1992. *Amblyseius fallacis* (Garman), *Typhlodromus pyri* Scheuten, *Amblyseius andersoni* Chant and *Metaseiulus occidentalis* (Nesbitt) were most common. On escaped hops, *T. pyri* was more common than other phytoseiids. It occurred widely on plants surrounding commercial hops including blackberry and other rosaceous plants and probably is a vagrant on escaped hops. *A. fallacis* was most common in commercial hops making up 88% of all specimens, followed by many fewer *M. occidentalis* and *T. pyri*. Early spring survival of *A. fallacis* in commercial hops was poor because of certain cultural practices used in the spring. Means to improve biological control of spider mites on hops are discussed including amended methods of hop culture, use of selective pesticides and inoculative releases of predaceous mites.

Additional keywords: *Amblyseius fallacis, Metaseiulus occidentalis, Typhlodromus pyri, Amblyseius andersoni, Tetranychus urticae*

INTRODUCTION

Two-spotted spider mite (*Tetranychus urticae* Koch) (TSSM) is a major pest of hops and associated crops in the Willamette valley, Oregon. It overwinters in dead plant materials or on the hop crown, emerging in early spring to feed on weeds and new hops shoots (Cone *et al.* 1986, Cranham 1985). Control of TSSM usually requires from one to several miticide sprays each summer. Other pesticides such as aphicides sprayed for hop aphid (*Phorodon humuli* (Shrank)) and fungicides used for disease control may also affect TSSM and its predators. Because of pesticide resistance in TSSM on hops (Campbell 1985), chemical control has been difficult. A biological control program for TSSM would be a desirable alternative to replace pesticides or to augment their use.

Several biological control agents against TSSM have been reported from hops in arid regions of western North America, but their usefulness has been limited because of non-selective pesticide use (Pruszynski & Cone, 1972). These agents include several insect predators and phytoseiid mites. In central Washington, *Metaseiulus occidentalis* (Nesbitt) was the most common phytoseiid; it emerged from the subterrenian crowns of hops in early April and then became sparse, reappearing in July (Pruszynski & Cone, 1973). Although there appeared to be some pesticide tolerance in the central Washington strain of *M. occidentalis,* it did not control TSSM to low levels.

Little is known about biological control on hops in the milder, more humid regions of western North America. This study was conducted to determine the beneficial species composition and incidence of phytoseiids and spider mites on escaped and commercial hops in the more hu-