EFFECTS OF ALFALFA CULTIVAR DORMANCY
ON POPULATION LEVELS OF
THE ALFALFA WEEVIL

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PREFACE

In Oklahoma, there is potential for increased production of alfalfa if less-dormant cultivars are used. However, the potential also exists that more alfalfa weevil, (*Hypera postica*), habitat will be available over the winter months because of the greater growth in late fall and new growth in early spring. These studies were conducted to determine the population dynamics of egg and larval stages of the alfalfa weevil on cultivars with different dormancies.

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CHAPTER I

INTRODUCTION

The alfalfa weevil, Hypera postica (Gyllenhal), is one of the most destructive insect pest of alfalfa, Medicago sativa L. It is found throughout the United States and with high infestation levels it causes severe damage when not controlled. Since 1972, this insect has caused serious damage to alfalfa in Oklahoma resulting in extensive economic losses (Berberet et al. 1980).

An integrated pest management program has been implemented in Oklahoma and involves the use of a combination of four types of control measures (Berberet 1982). These include winter grazing of stands, release of biological agents, chemical insecticides, and use of tolerant cultivars. Several studies have been conducted in Oklahoma to better understand the life history of the alfalfa weevil using these control measures.

In Oklahoma, winter grazing by livestock was found to reduce H. postica egg numbers by over 60% and resulted in lower larval populations in spring (Senst and Berberet 1980). Release of the biological agent, Bathyplectes curculionis (Thomson), has contributed to a reduction in weevil populations (Berberet and Gibson 1976). Insecticides have been important in controlling larval populations and guidelines have been published in Oklahoma for proper timing of applications (Berberet and Coppock 1985). Use of tolerant alfalfa cultivars that are able to withstand feeding by the alfalfa weevil is another possible control that could provide yield-savings to producers. Cultivars with moderate levels of tolerance to _H. postica_ have been developed. They include 'Team' (Barnes et al. 1973), 'Arc' (Devine et al. 1975), 'Liberty' and 'Cimarron'.

One of the most important decisions alfalfa producers must make is cultivar selection because this will influence stand longevity and yield. One aspect of choosing a cultivar is determining what dormancy is needed. Dormancy in alfalfa is manifested by a slowing or ceasing of growth with shorter day length and cooler temperatures in the fall (McKenzie et al. 1988). Cultivars that are very dormant are able to survive extremely cold winter weather. Less dormant cultivars generally have a shorter cessation period and may grow actively all year where winters are less severe.

Currently, both dormant and moderately dormant alfalfa cultivars are recommended for use in Oklahoma (Gray et al. 1985). Due to their vigorous spring and fall growth, less dormant cultivars have the possibility of providing an additional harvest per season. However, production potential of nondormant cultivars will not be realized if water is limited. Dormant types may be more drought tolerant because they stop growing during dry periods

(Melton et al. 1988).

Less dormant alfalfa may have more fall growth and provide favorable overwintering habitats and ovipositional sites for weevil adults. The result is a possibility for more eggs over the winter in these cultivars vs. the more dormant ones. Larger egg populations have been reported for plants with increased growth than in alfalfa with less fall growth (Norwood et al. 1967 and Busbice et al. 1968).

If cultivars with increased fall growth attract more ovipositing females, then it is probable that greater larval populations as well as increased damage may occur. According to Burbutis (1967), larval damage to alfalfa is a function of egg numbers. However, tall, rapidly growing alfalfa cultivars are known to be less susceptible to damage by alfalfa weevil larvae (Dogger and Hanson 1963). Similarly, mature alfalfa is not damaged as much from larval feeding as early stage alfalfa (Mathur and Pienkowski 1967). Thus, it is not clear whether semi-dormancy will result in more or less damage to alfalfa.

Relative amounts of fall and spring growth as well as plant response to weevil injury are important criteria to be considered when evaluating cultivars in Oklahoma. The objectives of this study were:

I. To determine the effects that alfalfa cultivars with a wide range of winter dormancy have on population levels of the alfalfa weevil.

II. To determine the population dynamics of alfalfa weevil eggs in fall and spring growth among cultivars with varying degrees of winter dormancy.

III. To determine the preferred ovipositional locations for alfalfa weevils within alfalfa stems.

IV. To estimate the ability of the cultivars to tolerate feeding by the alfalfa weevil.

V. To evaluate the productivity of the cultivars under weevil infested and uninfested conditions.

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CHAPTER II

LITERATURE REVIEW

Alfalfa is a major crop in Oklahoma and is the second or third most important in the state (Sholar et al. 1982). It was first introduced in the mid-1800's by pioneers who brought in seed mainly from Kansas and Colorado (Chaffin 1950). Since its introduction into the state, the acreage has steadily increased. By 1924, alfalfa occupied 97,128 ha in Oklahoma. From 1945 to 1973, harvested alfalfa increased from 148,930 to 234,726 ha (Collins and Ray 1975).

Alfalfa hectareage has also increased in Oklahoma due to improved pest resistant cultivars and better management. According to Collins and Ray (1975), average yield/ha fluctuated from 4483 kg/ha in 1945 to 7397 kg/ha in 1973. A total of 667,552 metric tons of alfalfa was produced statewide in 1945. Production increased from that to 1,735,998 metric tons of alfalfa in 1973.

Although alfalfa cultivars have improved production since introduction into the United States, none has immunity to any of the important diseases or insect pests. Disease and insect pests reduce yield by decreasing plant vigor, causing leaf-drop, and killing plants (Caddel et al. 1982). Several cultivars have been developed that offer resistance to some disease and insect pests. These plants survive and yield better in the presence of pests than susceptible cultivars under mostly moderate infestation levels.

Of the 100 insect species known to be injurious to alfalfa (App and Manglitz 1972), only 10 cause serious damage over large areas of the United States. Barnes et al. (1974) outlined procedures for evaluating alfalfa cultivars for resistance to these pests. One of the most important is the alfalfa weevil, *Hypera postica* (Gyllenhal). It has caused annual losses averaging $57 million to alfalfa producers (App and Manglitz 1972).

The alfalfa weevil was first discovered in the United States in Utah in 1904 (Titus 1910). It was not until 1907 that populations increased to levels that caused serious injury to alfalfa. By 1916 it was estimated that the weevil had caused over $3 million damage to the alfalfa crop in Utah (Manglitz and App 1958).

The alfalfa weevil continued to spread to other regions in the West. This western strain, as it was later called, infested 12 states in nearly 50 years (Evans 1959). In 1951, populations of *H. postica* were found in Maryland and became known as the eastern strain (Poos and Bissell 1953). Since then the eastern strain spread rapidly so that now it occupies virtually all of the 48 contigious states.

In 1968, the eastern strain of alfalfa weevil was first collected in eastern Oklahoma, where it entered the state from Arkansas and Missouri (Berberet et al. 1980). The throughout the state and by 1971 had been recorded from all counties. Since 1972, the alfalfa weevil has caused serious damage to alfalfa and great economic loss in Oklahoma (Berberet et al. 1980).

Young larvae confine their feeding within alfalfa terminals and leaf buds at the tops of plants (Evans 1959). "Ragging" occurs as leaves grow from the damaged terminal buds. As the larvae mature, they feed on leaves causing skeletonization and often complete defoliation of plants. Heavily infested fields have a grayish appearance due to severe defoliation and drying of the damaged leaves.

A majority of the yield reduction in alfalfa is due to defoliation by larvae. The feeding reduces both the yield and quality of the first crop and residual effects of feeding reduces the yield of the second crop in the Southern Plains (Berberet et al. 1981). Reductions in both leaf and stem components become apparent as damage from larval feeding increases (Berberet and McNew 1986). Alfalfa growth, yield, moisture content, rate of maturity, and stem density are reduced if heavy weevil infestations occur prior to first harvest (Wilson et al. 1979; Wilson and Quisenberry 1986; Godfrey and Yeargan 1987). In Oklahoma, yield of the first alfalfa crop can be expected to decrease approximately 188 kg/ha for each larva/stem in the population (Berberet et al. 1981). Hintz et al. (1976) attributed stunting to a decrease of meristematic growth and photosynthesis resulting from defoliation and damage to terminal buds. Fick and Liu

(1976) reported that weevil defoliation delayed normal morphological development and reduced canopy height. Losses of approximately 160 kg/ha can occur in the second crop for each larva/stem due to residual effects of infestation on the first crop.

Generally, adults do relatively little damage to alfalfa. Bjork and Davis (1984) found that each adult weevil consumes 4.5 times more than a larva. However, damage is reported less frequently for adults in Oklahoma because their populations are usually lower and feeding is extended over a shorter time period than the concentrated feeding period of the larvae. Adults often feed on the stem epidermis of alfalfa causing water loss, disruption in translocation, and retarding of growth (Mathur and Pienkowski 1967). They also sever side shoots and leaf petioles and feed upon margins of leaves. Adult females also damage main stems during oviposition.

Poinar and Gyrisco (1960) reported that adults were more active during the night than during the day. Bass (1967) reported that 87% of his adult collections were made with sweep nets between 6 P.M. and 6 A.M. In early morning, adults retreat to the bases of alfalfa plants and remain hidden throughout the day. Southwick and Davis (1968) reported similar activity in Utah during summer and suggested that this behavior was related to light intensity.

Ovipositional activity begins in southern regions when mature adults migrate back to alfalfa fields after summer and early fall aestivation. The majority of weevil egg lay occurs from late fall to early spring in Oklahoma (Berberet et al. 1980). Litsinger and Apple (1973a) reported that fall oviposition never surpassed 2% of the yearly egg output for the alfalfa weevil in Wisconsin. Less than 37% of the females were sexually mature before spring. However, Armbrust et al. (1966) found that a considerable amount of fall oviposition does take place in New York. The percentage of successfully overwintering eggs varied according to field location, snow cover, severity of winter, and the condition of the alfalfa.

Alfalfa weevil eggs have a higher degree of winter survival and are more cold-hardy than larvae, pupae, or adults (Armbrust et al. 1969). Townsend and Yendol (1968) studied the survival of overwintering eggs in Pennsylvania and found that the percentage of viable eggs decreased as winter progressed. Alfalfa weevil eggs become more susceptible to low temperatures when the larval head capsule becomes visible through the chorion (Morrison and Pass 1974). Similarly, the mortality of embryos increases with more advanced development (Shade and Hintz 1983). Koehler and Gyrisco (1961) reported that prepupal and pupal stages do not overwinter because low temperatures and dessication were lethal.

In southern United States, females continue to oviposit in winter if temperatures above 50^{o}C occur. Adult weevils are able to respond to periodic warm temperatures as they have immediate ovipositional responses to oscillating daily temperatures (LeCato and Pienkowski 1970). Adult weevils tend to lay more eggs at alternating temperatures of 4 to 16 °C than at constant temperatures (LeCato and Pienkowski 1972). As the season progresses, weevils begin laying eggs in growing stems and less in litter as the stems reach a height of 15 to 20 cm (Hamlin et al. 1949).

Some eggs hatch during warmer periods in winter when the temperature is above the developmental threshold of 10°C (50°F) and sufficient degree day accumulations have occurred (Litsinger and Apple 1973b). However, the larvae usually die from freezing temperatures and lack of food. Egg numbers normally decrease by March and April as warmer temperatures stimulate hatching. Koehler and Gyrisco (1961) reported that humidity levels are important for hatching. High humidity is more favorable for egg survival than low humidity at temperatures ranging from 12 to 35 °C.

The developmental threshold for larvae is 8.9°C (Hsieh et al. 1974). Larvae usually occur simultaneously with new alfalfa growth in the spring. Larval populations continue to increase as warmer temperatures occur. In Oklahoma, peak larval densities usually occur in April but varies according to weather conditions. Peak numbers occur after the accumulation of approximately 500 degree days (DD) from January 1 with a developmental threshold of 8.9°C in northern Oklahoma (Berberet et al. 1980). In southern Oklahoma, accumulation of approximately 700 DD occurs for peak larval numbers. Larval populations usually begin declining by late April.

The pupal stage is found from late March to May in Oklahoma (Berberet et al. 1980). Newly emerged adults are generally seen 10 days after pupation and become numerous around late April. New adults begin to aestivate usually by late May. Weevils remain inactive throughout the summer and early fall. Activity of the adults begin again as cooler temperatures return in the fall.

In the early 1960's, the USDA Agricultural Research Service started a program in the eastern United States to develop resistant cultivars to the alfalfa weevil (Lehman and Stanford 1971). It was theorized that it would be a sure and inexpensive means of controlling this pest. Several workers began screening many alfalfa cultivars and related species of *Medicago* for alfalfa weevil resistance. Barnes et al. (1974) considered nonpreference to adult feeding and oviposition and tolerance to larval feeding to be the principle selection factors for resistance. Lehman and Stanford (1971) thought reduced egg laying was associated with sources of a low level of weevil resistance. Sorensen et al. (1972) measured resistance by estimating insect numbers and damage to plants. Several annual *Medicago* spp. with glandular hairs are known to be resistant to feeding and oviposition by alfalfa weevil larvae and adults (Barnes and Ratcliff 1969; Shade et al. 1975; Johnson et al. 1980a,b,c; Danielson et al. 1986; and Danielson et al. 1987). However, these resistant annuals are unable to hybridize with perennial alfalfas. Currently, only small differences in the levels have been found among perennial *M. sativa* tested for resistance to the alfalfa weevil.

Stem diameter was found to influence egg deposition of the weevil (Busbice et al. 1968; Dhaliwal and Grewal 1983; Norwood et al. 1967; Sweetman 1929; and VanDenburgh et al. 1966). Larger stems were preferred over smaller stems and this attractiveness seemed to be related to body size of weevils as mature, larger females oviposit in late winter and early spring (Norwood et al. 1967). Stem diameter and shape tended to be correlated, as smaller stems were usually round while larger stems were more rectangular in shape. Campbell and Dudley (1965) reported that reduction in egg numbers in some cultivars was associated with an increase in stem solidness and a decrease in stem pith. This limited the size of the cavity for egg deposition.

Dively (1970) reported that egg populations were greater in new growth of alfalfa than in stubble. Vigorous plants having upright growth with large stems and leaves received the greatest egg deposition (Busbice et al. 1968 and Norwood et al. 1967). Plants with decumbent growth, wide crowns, and small stem diameters had a tendency to receive fewest eggs.

Summers and Lehman (1976) conducted field tests with several nondormant alfalfa cultivars to evaluate their resistance to *H. brunneipennis* (Boheman), the Egyptian alfalfa weevil. Nonpreference by adult females was not evident because the total number of eggs deposited was not different among the cultivars. This suggested that resistance to oviposition by H. brunneipennis was not a factor to be considered when evaluating these cultivars (Summers and Lehman 1976).

Mathur and Pienkowski (1967) found that the ability of alfalfa plants to withstand larval feeding damage was related to the stage of plant growth at the time of infestation. The effect of feeding on the quality of alfalfa was dependent upon the stage of growth of the plant and its growth rate. Hintz et al. (1976) found that early larval feeding caused greater damage.

'Team', 'Arc', 'Liberty', and 'Cimarron' are cultivars that are adapted to Oklahoma and exhibit some tolerance to the alfalfa weevil. Their moderate levels of tolerance are attributed to vigorous spring growth and lateral branching.

Higher yields in the Midwest are more often attained with less dormant cultivars (Elliot et al. 1972). Cultivars that initiate spring growth at an early date and continue growth late in fall often make possible an additional cutting in areas where the length of the growing season and soil moisture are not limiting. Buller and Pitner (1954) reported that less dormant alfalfa had a greater annual production than moderately dormant alfalfa grown in extreme southern regions. However, the longevity of the moderately dormant cultivars exceeded that of the less dormant by several years and was less affected by disease.

Fall dormancy of alfalfa is a useful indicator of a plant's ability to survive winter stress (Viands and Tueber 1985). Peltier and Tysdal (1931) noted that winter-hardy alfalfa had a more vigorous growth earlier in the season than the non-winter hardy following a severe winter. Westgate (1908) reported that winter-hardy alfalfas survive cold temperatures but they do not produce good yields. Elliot et al. (1972) reported that better yielding alfalfa has usually been associated with a greater risk of winter mortality.

In Oklahoma, there is potential for increased production of alfalfa if less dormant cultivars are used. They grow earlier in spring and later in fall and can produce more forage on a seasonal basis. However, potential also exists for more alfalfa weevil habitats over the winter months due to greater growth in late fall or new growth in early spring. Higher weevil populations could mean more damage or higher control costs, thus the profit to be made from greater production with less dormant cultivars may be reduced.

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CHAPTER III

EFFECTS OF ALFALFA DORMANCY ON EGG AND LARVAL POPULATION LEVELS OF THE ALFALFA WEEVIL (COLEOPTERA: CURCULIONIDAE)

Introduction

The growing season for alfalfa (Medicago sativa L.) in Oklahoma typically extends from early March to late October. Theoretically, the alfalfa cultivars that would produce the highest seasonal yields would be those that take maximum advantage of this growing season by beginning growth soon after the last killing freeze in spring and initiating regrowth rapidly after each harvest. Less-dormant alfalfa cultivars have these characteristics in a more pronounced manner than those which maintain complete dormancy in winter. Traditionally, recommendations for alfalfa cultivars in Oklahoma have included dormant cultivars developed in the North Central states, such as 'Dawson', 'Perry', and 'Baker' (Caddel et al. 1982). More recent recommendations in Oklahoma suggest using cultivars with less dormancy, such as 'WL 318', 'Cimarron', '555' (Pioneer), and 'Pike' (Gray et al. 1985).

With the increased production associated with less-dormant alfalfa, the potential exists for increased alfalfa weevil, Hypera postica (Gyllenhal), habitat through the winter months. The majority of alfalfa weevil oviposition occurs from November to April in Oklahoma, and egg population densities are dependent on the amount of living or dead top growth of alfalfa that is available (Berberet et al. 1980). In a greenhouse study, Busbice et al. (1968) placed adult weevils on alfalfa four times from November through January and allowed to oviposit. Taller alfalfa had higher egg counts. Similar results were obtained by Norwood et al. (1967) who reported that alfalfa with upright growth received more eggs than intermediate and decumbent alfalfas. Senst & Berberet (1980) found lower egg numbers in grazed areas compared with plots that were not grazed in winter.

Evidence is accumulating from several published sources that indicates the presence of more plant material during the principal ovipositional period may result in greater egg accumulations over the winter. With higher egg populations, the potential exists for greater damage to nondormant cultivars compared with dormant ones. The objective of this study was to determine the extent to which alfalfa dormancy influences egg and larval population densities of the alfalfa weevil.

Materials and Methods

Experiment I, 1981-1983

Alfalfa was planted at the Agronomy Research Station at Perkins, Oklahoma on 24 September 1980. Dormancies of the five alfalfa entries ('Riley', 'Arc', 'WL 318', 'OK 10', and 'UC-176') were estimated based on the amount of growth after the last harvest in September (fall growth). Measurement of fall growth is a standard agronomic procedure for estimating fall dormancy (Kohel & Davis 1960, Smith 1961, Viands & Teuber 1985, Perry et al. 1987), and was used to determine how the selected entries related to each other. The entries that had the least fall growth ('Riley' and 'Arc') were classified as the most dormant, and the entry with intermediate growth ('WL 318') was estimated as moderately dormant. The entries with the greatest amount of fall growth ('OK 10' and 'UC-176') were grouped as nondormant. 'OK 10' is a selection from the Oklahoma Agricultural Experiment Station; 'UC-176' is a germplasm release from the California Agricultural Experiment Station.

Entries were planted in five rows, 1 by 5 m plots set in a randomized complete block design with six replications. The experiment was designed as a free choice test where naturally occurring adults could travel short distances to each entry. Sampling for alfalfa weevils began when the stands were 1 yr old and continued for 2 yr. Irrigation was used as needed to maintain growth of alfalfa throughout each season. Plots were sprayed with carbofuran at 1.12 kg (AI)/ha after peak larval infestation if weevils threatened complete destruction of foliage. Alfalfa was harvested when it reached the early bloom stage.

Density estimates of weevil eggs were determined on each sampling date by random collections of four samples (each 0.025 m^2) of alfalfa plant material per plot. Estimates of fall egg lay were made on 28 January 1982 and 14 January 1983 to determine which entries were more attractive to females as ovipositional sites after return from summer aestivation during October and November. Additional egg samples were collected on 8 March 1982 and 10 March 1983 to estimate population density at the period of maximum hatching in late winter. Plant material was cut at ground level and bagged for each sample. The blender extraction method developed by Pass & VanMeter (1966) was used to separate eggs from the alfalfa. Egg viability was estimated from the samples taken in January and March to evaluate differences in survival related to alfalfa dormancy. Three samples of 100 eggs from each entry were incubated at 23 ± 2°C for 10 d for percentage hatch of eggs.

A 25-stem sample was collected from each plot for larval density estimates on 26 March 1982 and 11 April 1983 at first appearance of damage. Samples taken on 22 April 1982 and 29 April 1983 gave estimates of peak larval populations. Standard berlese funnels were used to retrieve weevil larvae from foliage for counting.

Heights of 10 stems per plot were measured at each egg or larval sampling date. Stems were measured when egg samples were taken to estimate the amount of fall growth available for oviposition by adult weevils. Measurements of height were taken during larval sampling to estimate the mean height of spring growth in each entry.

Experiment II, 1983-1985

Alfalfa was planted on 3 September 1982 at the Agronomy Research Station at Stillwater, Oklahoma. Dormancy was again estimated for five alfalfa entries ('Riley', 'K81-7', 'WL 318', 'OK 10', and 'KS 157') based on fall plant height. In relation to each other, 'Riley' and 'K81-7' were classified as the most dormant entries, 'WL 318' as somewhat less dormant, and 'OK 10' and 'KS 157' as nondormant. 'K81-7' and 'KS 157' are selections from the USDA and Kansas Agricultural Experiment Station. Planting procedures, irrigation, and harvest management were the same as those for Experiment I.

Egg and larval population densities were determined as in Experiment I; estimates of fall egg numbers were made on 6 January 1984 and 7 January 1985. Egg density estimates were taken on 24 February 1984 and 6 March 1985. Larval populations were determined from samples collected on 26 March and 14 April 1984 and 19 March and 16 April 1985.

Monthly temperatures (^{o}C) were obtained from the weather stations at the Oklahoma Agricultural Experiment Station in Perkins and Stillwater to describe low temperature conditions to which overwintering alfalfa weevils and alfalfa entries were subjected. The weather stations were located approximately 0.5 km from Experiments I and II. Degree-day (DD) accumulations were calculated for the alfalfa weevil in Oklahoma based on the egg developmental threshold of 10°C from January 1 (Litsinger & Apple 1973) to compare yearly seasonal development of the alfalfa weevil.

All data were subjected to analysis of variance (SAS Institute 1985) and differences between means were tested for significance ($\underline{P} < 0.05$) with Duncan's Multiple Range Test (Duncan 1955).

Results

Experiment I, 1981-1983

The winter of 1981-1982 was moderate; the average low temperature in January was -7.8°C (Table I). Height of fall (1981) growth in the nondormant entries, 'OK 10' and 'UC-176', was significantly ($\underline{F} = 27.84$; df = 4, 20; $\underline{P} < 0.05$) greater than in 'Riley' and 'Arc' (Fig. 1). The population densities of alfalfa weevil eggs ranged from 45.5 eggs in 'Arc' to 101.9 eggs/0.025 m^2 in 'UC-176' in January and a similar trend among dormant compared with nondormant entries existed in the March egg samples (Table II). 'Arc' and 'Riley' had significantly lower egg numbers than 'UC-176' on 28 January ($\underline{F} = 8.30$; df = 4, 90; $\underline{P} < 0.05$) and on 8 March ($\underline{F} = 7.93$; df = 4, 90; $\underline{P} < 0.05$). Egg populations on 8 March were reduced for all entries as a result of hatching. Egg viability was not significantly different among entries on either date and ranged from 47 to 56 % in

TABLE I

MONTHLY MEANS FOR LOW TEMPERATURES (C) AND DEGREE-DAY (DD) ACCUMULATIONS FOR ALFALFA WEEVIL DEVELOPMENT FROM DECEMBER-MARCH IN OKLAHOMA, 1981-1985.

	December		January		February		March	
Season	C	DD	C	DD	C	DD	C	DD
1981-1982	-1.1(-11.7)[a]	44	-7.8(-20.0)	42	-3.3(-18.9)	69	3.9(-7.8)	233
1982-1983	-0.6 (-8.9)	89	-2.8 (-7.8)	25	-0.6(-11.7)	42	2.2(-6.7)	126
1983-1984	-8.9(-22.8)	10	-4.4(-23.9)	51	1.7(-5.0)	123	3.3(-3.9)	106
1984-1985	0.0(-12.2)	103	-5.8(-18.9)	1	-3.6(-18.9)	41	6.1(-2.8)	223
Average[b]	-2.4(-13.0)	51	-5.7(-16.3)	32	-1.6(-13.7)	82	3.4(-6.7)	199

[a] Coldest low temperature recorded during each month given in parentheses.
[b] Long term average from 1972-1987.

Figure 1. Heights of Alfalfa Growth in Entries Ranging from Dormant (Riley) to Nondormant (UC-176), Oklahoma, 1981-1982.

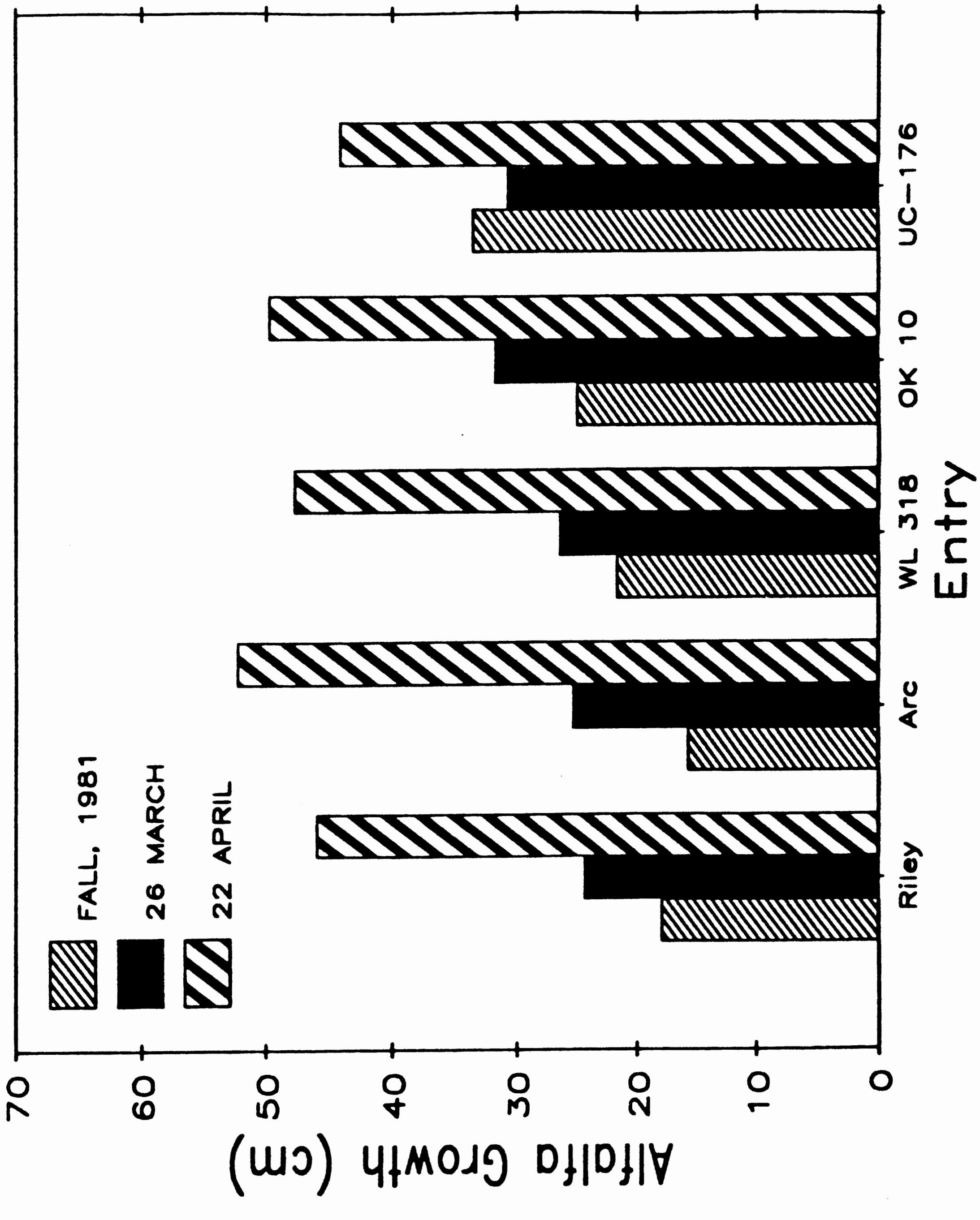
Alfalfa Growth (cm)
0
10
20
30
40
50
60
70
FALL, 1981
26 MARCH
22 APRIL
Riley
Arc
WL 318
OK 10
UC-176
Entry

TABLE II

INFLUENCE OF ALFALFA DORMANCY ON OVERWINTERING POPULATIONS OF ALFALFA WEEVIL EGGS AND LARVAE IN OKLAHOMA, 1982.

	Eggs/0.025 m^2		Larvae/25 stems	
Entry	28 January	8 March	26 March	22 April
Riley[a]	56ab	17a	50ab	77ab
Arc	46a	24ab	47a	82ab
WL 318	65ab	36bc	43a	111c
OK 10	81bc	37bc	77b	95bc
UC-176	102c	46c	78b	68a
S.E.	8	4	9	7

[a] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

January and 49 to 58 % in March.

'Riley', 'Arc', and 'WL 318' had significantly ($\underline{F}$ = 51.36; df = 4, 20; $\underline{P} < 0.05$) less spring growth than 'OK 10' and 'UC-176' when measured on 26 March (Fig. 1). Measurements on 22 April showed that 'Arc' had attained significantly ($\underline{F}$ = 15.17; df = 4, 20; $\underline{P} < 0.05$) more growth than the other entries as first harvest approached. Larval samples taken on 26 March indicated that the most dormant and moderately dormant entries had significantly ($\underline{F}$ = 3.33; df = 4, 20; $\underline{P} < 0.05$) fewer larvae than the nondormant ones (Table II). By 22 April, there had been an increase in larval densities in all entries except 'UC-176', with 'WL 318' having a significantly ($\underline{F}$ = 5.83; df = 4, 20; $\underline{P} < 0.05$) higher larval population density than 'Arc' or 'Riley' and 'UC-176'. There is no logical explanation for the decline in larval numbers in 'UC-176', which was not expected based on egg densities.

In 1982-1983, the winter was mild; low temperatures rarely fell below $-6.7^{o}C$. However, DD accumulations were lower from January through March than in 1981-1982 (Table I). Fall growth of the most dormant entries in 1982 was again significantly ($\underline{F}$ = 122.01; df = 4, 20; $\underline{P} < 0.05$) less than in the others, with 'UC-176' having the greatest growth (Fig. 2). There had been little fall egg lay in any of the entries as indicated from the 14 January sample; however, numbers had increased greatly by 10 March. The most dormant entries had significantly ($\underline{F}$ = 8.73; df = 4, 90; $\underline{P} < 0.05$)

Figure 2. Heights of Alfalfa Growth in Entries Ranging from Dormant (Riley) to Nondormant (UC-176), Oklahoma, 1982-1983.

fewer eggs than 'OK 10' or 'UC-176'. Viability of eggs in March was not significantly different among entries and ranged from 73 to 80 %. Viability was higher than the previous year as the average low temperature during January, in particular, was just -2.8°C (Table I).

On 11 April, spring growth of the least dormant entries was significantly ($F = 57.75$; df = 4, 20; $P < 0.05$) greater than that of the dormant entries (Fig. 2). Spring growth by 29 April was significantly ($F = 24.50$; df = 4, 20; $P < 0.05$) lower in 'UC-176' than in other entries and greatest in 'Arc' and 'OK 10'. The inability of 'UC-176' to sustain rapid spring growth may indicate that some loss of vigor had occurred because of poor adaptation to subfreezing temperatures during winter. Larval numbers were highest in 'OK 10' and 'WL 318' on 11 April (Table III). Apparently as a result of extensive oviposition in spring that was not detected in our sampling, larval numbers were much higher by 29 April. Despite the fact that differences in spring growth were not great among the entries on 29 April, 'OK 10' and 'UC-176' had significantly ($F = 9.29$; df = 4, 20; $P < 0.05$) greater larval populations than 'Riley' or 'Arc'. Unlike the 1981 and 1982 season, larval numbers in 'UC-176' were highest among the entries and compared well with expectations based on relative egg numbers.

Experiment II, 1983-1985

Record cold temperatures occurred during December of

TABLE III

INFLUENCE OF ALFALFA DORMANCY ON OVERWINTERING POPULATIONS OF ALFALFA WEEVIL EGGS AND LARVAE IN OKLAHOMA, 1983.

	Eggs/0.025 m^2		Larvae/25 stems	
Entry	14 January	10 March	11 April	29 April
Riley[a]	9ab	36a	36a	139a
Arc	8ab	27a	40ab	134a
WL 318	7a	46ab	58b	161ab
OK 10	12b	60bc	60b	190b
UC-176	10ab	75c	49ab	247c
S.E.	2	7	7	15

[a] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

1983 and the average low for the month was -8.9°C (Table I). Temperatures were more moderate in February and March as DD accumulations were above average in February. The least dormant entries, 'OK 10' and 'KS 157', had significantly ($F = 74.65$; df = 4, 20; $P < 0.05$) more growth in fall of 1983 (Fig. 3). The first egg sample on 6 January indicated that 'WL 318', 'OK 10', and 'KS 157' had significantly ($F = 7.18$; df = 4, 90; $P < 0.05$) greater fall egg deposition than the more dormant entries (Table IV). Egg numbers were highest in 'OK 10' on 24 February. The low temperature for the month (-23.9°C) on 19 January contributed to egg mortality, and there was some decomposition of inviable eggs after this date. Morrison & Pass (1974) reported that eggs may be inviable after being exposed to temperatures of -20.5°C or lower for 24 h. Eggs collected on 24 February had a relatively high viability (58 to 78 %) because of additional ovipositional activity that occurred after 19 January.

The least dormant entries, 'OK 10' and 'KS 157', had significantly more spring growth on 26 March ($F = 163.82$; df = 4, 20; $P < 0.05$) and 14 April ($F = 73.81$; df = 4, 20; $P < 0.05$) (Fig. 3). As expected, larval numbers were fairly uniform among entries on 26 March because many eggs had been killed by cold weather (Table IV). By 14 April, larval numbers were not significantly ($F = 0.89$; df = 4, 20; $P < 0.05$) different among entries.

Temperatures were relatively mild in December of 1984. However, January of 1985 was the coldest month during this

Figure 3. Heights of Alfalfa Growth in Entries Ranging from Dormant (Riley) to Nondormant (KS 157), Oklahoma, 1983-1984.

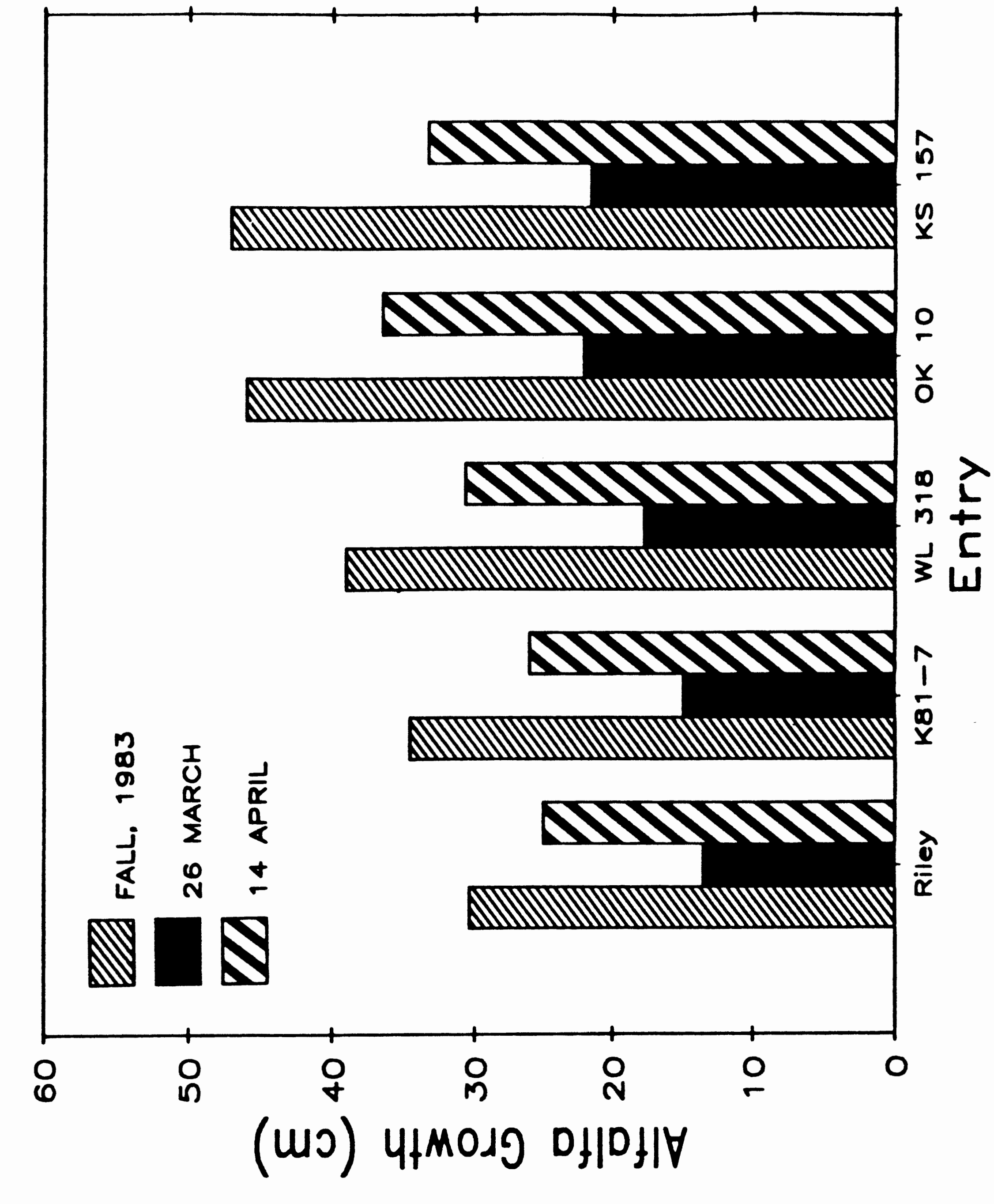
Alfalfa Growth (cm)
0
10
20
30
40
50
60
Entry
Riley
K81–7
WL 318
OK 10
KS 157
FALL, 1983
26 MARCH
14 APRIL

TABLE IV

INFLUENCE OF ALFALFA DORMANCY ON OVERWINTERING POPULATIONS OF ALFALFA WEEVIL EGGS AND LARVAE IN OKLAHOMA, 1984.

	Eggs/0.025 m^2		Larvae/25 stems	
Entry	6 January	24 February	26 March	14 April
Riley[a]	43a	66ab	67a	146a
K81-7	51a	46a	64a	138a
WL 318	80b	58a	78ab	155a
OK 10	96b	85b	90b	132a
KS 157	89b	66ab	64a	135a
S.E.	9	8	7	10

[a] Means within columns followed by the same letter are not significantly (_P_ > 0.05) different.

research (January DD = 1) (Table I). The height of fall 1984 growth was significantly ($F = 122.74$; df = 4, 20; $P < 0.05$) lower in the most dormant entries than in 'WL 318', 'OK 10', or 'KS 157' (Fig. 4). Weevils were evidently more attracted to the moderately dormant and nondormant entries for ovipositional sites in fall; these had significantly ($F = 12.48$; df = 4, 90; $P < 0.05$) higher egg numbers on 7 January than 'Riley' or 'K81-7' (Table V). Egg numbers were reduced by 6 March due to hatching. Egg numbers were significantly ($F = 9.54$; df = 4, 90; $P < 0.05$) lower in the most dormant entries. Because temperatures remained well above the lower lethal limit, egg viability ranged from 90 to 93 % on 7 January and 56 to 81 % on 6 March. No significant differences in viability occurred among entries on either date.

Spring growth was significantly greater in the nondormant entries on 19 March ($F = 71.03$; df = 4, 20; $P < 0.05$) and 16 April ($F = 27.57$; df = 4, 20; $P < 0.05$) (Fig. 4). Samples on 19 March indicated that larval populations early in the season were lowest in 'OK 10' ($F = 1.82$; df = 4, 20; $P < 0.05$) (Table V). Lower larval numbers in the nondormant entries were not expected and did not relate well to egg densities. Numbers of larvae increased in all entries so that at peak larval density they exceeded 200 eggs/25 stems in all except 'WL 318'. The population level in 'OK 10' was significantly ($F = 3.85$; df = 4, 20; $P < 0.05$) higher than in the other entries on 16 April.

Figure 4. Heights of Alfalfa Growth in Entries Ranging from Dormant (Riley) to Nondormant (KS 157), Oklahoma, 1984-1985.

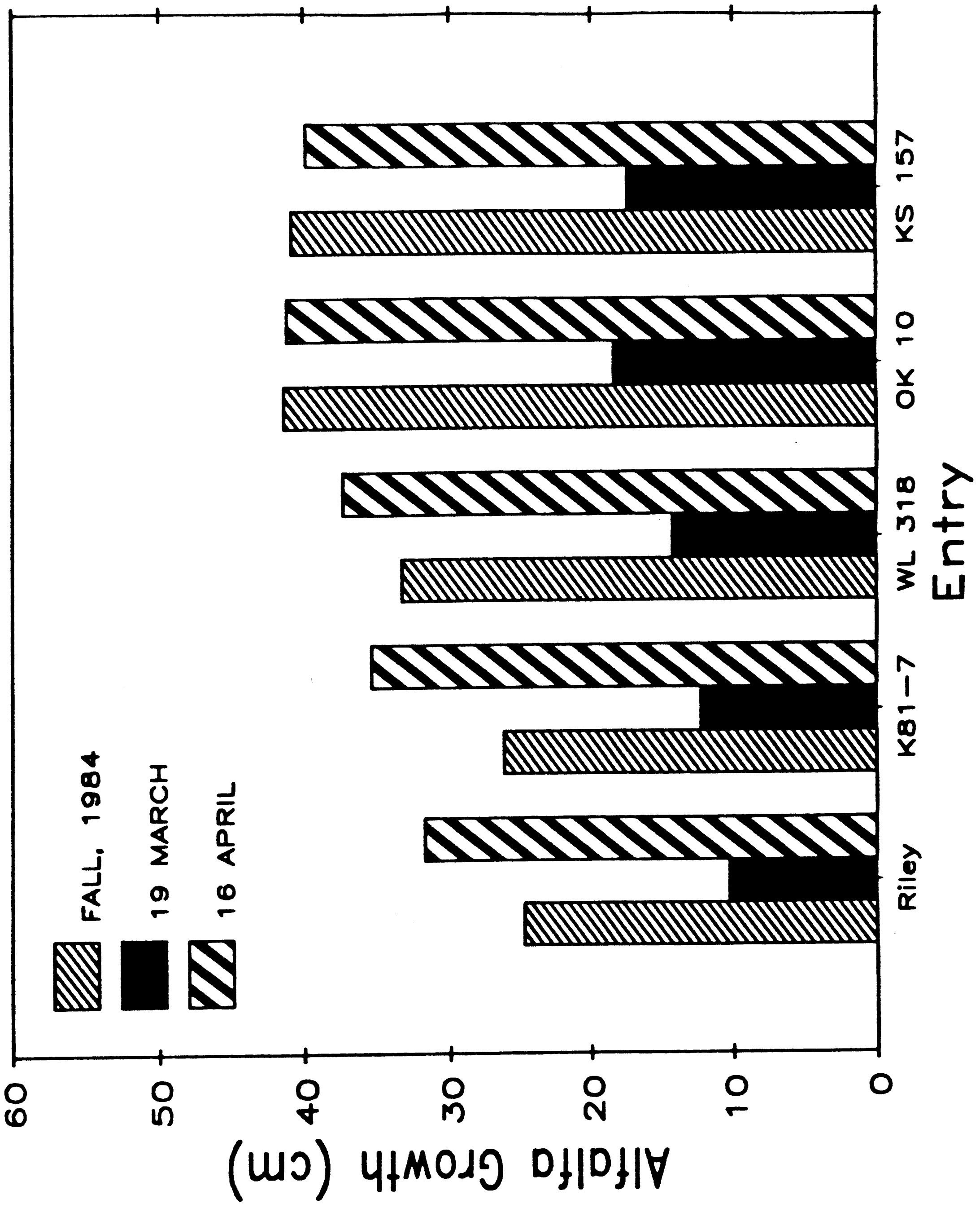
FALL, 1984
19 MARCH
16 APRIL
Alfalfa Growth (cm)
0
10
20
30
40
50
60
Riley
K81–7
WL 318
OK 10
KS 157
Entry

TABLE V

INFLUENCE OF ALFALFA DORMANCY ON OVERWINTERING POPULATIONS OF ALFALFA WEEVIL EGGS AND LARVAE IN OKLAHOMA, 1985.

	Eggs/0.025 m^2		Larvae/25 stems	
Entry	7 January	6 March	19 March	16 April
Riley[a]	176a	132a	77ab	209a
K81-7	212a	158a	71ab	209a
WL 318	331b	242b	93b	188a
OK 10	306b	217b	52a	281b
KS 157	338b	261b	60ab	249ab
S.E.	21	17	12	20

[a] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

Discussion

A gradient in alfalfa weevil ovipositional habitat availability was evident among the alfalfa entries used in these experiments. Varying degrees of dormancy resulted in considerably taller fall growth in the least dormant entries compared with dormant entries. Alfalfa dormancy may regulate growth characteristics that influence weevil infestations. Results from egg population samples from 1982-1985 strongly suggest that alfalfa weevil adults were more attracted to the nondormant entries in fall and winter for ovipositional sites. Although other properties of the entries could have attracted the weevils, evidence seems to indicate that dormancy had the primary effect on the weevils.

Temperatures of 1.7°C are necessary to cause alfalfa weevil adults to break diapause and return to alfalfa fields from summer aestivation sites and initiate ovipositional activity (Hsieh & Armbrust 1974). This occurred by mid-October in each year of the study. Hard killing frosts usually occurred by mid-December. In 1982 and 1983, 'OK 10' and 'UC-176' had more eggs than the dormant entries. Adult alfalfa weevils deposited more eggs in 'WL 318', 'OK 10', and 'KS 157' in 1984 and 1985. Fall growth was greater in these entries and provided more abundant ovipositional sites. Similar results were reported by Dively (1970) in New Jersey where three stages of growth were available as ovipositional sites for the alfalfa weevil. He found significantly lower egg densities during fall and winter in alfalfa with stubble 5 to 8 cm tall than in growth of 15 to 18 cm. Berberet (unpublished data) found that on a field-to-field basis (field size >10 ha), the same relationship existed in fall growth and alfalfa weevil oviposition. Egg deposition was greater in fields with more fall growth. Egg deposition rates are apparently different between fields (or plots) because adult weevils fly or crawl to areas that they find more attractive for feeding or oviposition.

Although differences in the height of fall growth were evident, there was no significant differences in egg viability. Dively (1970) attributed greater egg survival in stubble alfalfa to higher moisture content and less exposure to extreme cold than occurred in taller alfalfa. Dry, windy conditions common to Oklahoma caused desiccation and lower viabilities of eggs in all entries. Cold temperatures also made many eggs inviable, apparently with little differential due to plant height.

Larval numbers were generally higher on nondormant entries. In Experiment I, the most dormant entries usually had significantly fewer larvae than those estimated as being nondormant. An exception, in which larval densities did not compare well with egg densities, occurred in Experiment II in March 1984 when cold temperatures in January caused inviability of eggs and contributed to lower larval numbers.

Conclusions

Alfalfa dormancy appeared to regulate plant growth characteristics which influenced weevil infestations. Dormant alfalfa entries with less fall growth had significantly lower egg numbers than nondormant ones. As a result, nondormant entries were more heavily infested by weevil larvae in spring. Thus, the use of nondormant entries may lead to a greater risk of larval damage when compared with dormant entries.

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CHAPTER IV

INFLUENCE OF FALL AND SPRING GROWTH OF SEVERAL ALFALFA CULTIVARS ON EGG AND LARVAL DENSITIES OF THE ALFALFA WEEVIL (COLEOPTERA: CURCULIONIDAE)

Introduction

In southern regions of the United States where adult alfalfa weevils (*Hypera postica* (Gyllenhal)) are active from October through March (Berberet 1980), both living and dead alfalfa (*Medicago sativa* L.) growth is available as ovipositional sites. Growth after the last fall harvest is available to alfalfa weevils returning from aestivation sites. As freezing weather causes a cessation of growth usually in December, new growth begins from crowns and is available from January through the spring. Because nondormant cultivars have more crown growth in winter than more dormant ones, they may be more highly preferred as ovipositional sites for alfalfa weevils.

Essig and Michelbacher (1933) summarized the reports of several early workers from Western states who studied the biology of alfalfa weevils of the western strain. This strain actively oviposits in the spring and early summer. It has been generally believed that alfalfa weevil eggs were first deposited in dead alfalfa stems with later oviposition in growing stems. Manglitz and App (1957) also reported this in Maryland.

In Wyoming, Sweetman (1929) reported that the majority of weevil eggs were deposited in green growth. He examined 150 green and 150 dead brown alfalfa stems collected from fields during early May to mid-June. In 1928, 20% of eggs were found in dead stems while 80% were in green stems. In contrast, Wakeland (1924) noted that a greater proportion of eggs were deposited in dry stems thoughout the season in lower, warmer localities in Utah than in higher, cooler ones. Similarly, Niemczyk and Flessel (1970) studied the population dynamics of alfalfa weevil eggs in Ohio and reported that dead alfalfa stems were important oviposition sites, even when green alfalfa stems were available. Most spring laid eggs were found in dead stems until new alfalfa stems were at least 25 cm tall. After this, 50 to 95 % of eggs were found in green stems.

In Oklahoma, there may be a period during December and January when the only ovipositional sites available to alfalfa weevils are in dead fall growth. During this period, temperatures below -10°C that can cause eggs to be inviable are common. As new growth appears, it is not clear what impact this additional ovipositional area has on the population dynamics of alfalfa weevil eggs and whether larval populations found in March and April result from eggs laid in this new growth. The objectives of this study were to determine population densities of alfalfa weevil eggs in fall and spring growth in alfalfa cultivars having different dormancy levels and estimate the effects of those growth stages on egg viability and subsequent larval density.

Materials and Methods

Alfalfa was planted in two sites at the Agronomy Research Station at Stillwater, Oklahoma on 18 September 1984 (Port soil) and 17 September 1985 (Pulaski fine sandy soil). Six cultivars that had a wide range of dormancies were selected. The dormant cultivars selected were 'Advantage' (Moutray et al. 1983a) and 'WL 318' (Beard and Kawaguchi 1978). 'Baron' (Moutray et al. 1983b) and 'WL 515' (Kawaguchi et al. 1982) were used as moderately dormant cultivars while 'Granada' (Moutray et al. 1983c) and 'CUF 101' (Lehman et al. 1983) were those least dormant. Dormancies of the cultivars were estimated based on the relative amount of fall growth after a last harvest in September. The plots were 3.4 X 5 m and arranged in a randomized complete block design with six replications.

Growth characteristics were quite different among the alfalfa cultivars and may have influenced habitat selection of returning aestivating weevils in fall. Ten alfalfa stems per plot were measured in late fall before a killing frost to estimate the habitat available for returning adult females. Measurements of new spring growth (10 stems/plot) were taken from January through April at every date of egg or larval sampling.

Preferences for oviposition in dead stems from late fall and winter versus new spring growth were determined. Fall egg lay in each cultivar was estimated from 30 stem samples per plot taken monthly from November through March. Egg populations in new spring growth were estimated from 30 stems per plot taken from late January through March. Weevil eggs were extracted from alfalfa samples using methods by Pass and VanMeter (1966) and classified according to embryonic development by color. Differences in densities among cultivars indicated whether preferences for habitat and ovipositional sites occurred.

Viabilities were estimated for eggs from fall and spring growth to determine if differences occurred depending on type of growth or dormancy. Three to six samples of ca. 100 eggs were incubated from each cultivar for 10 d at $23 \pm 2^{o}C$.

Larval populations were sampled at the first sign of damage to determine if possible effects of alfalfa dormancy on egg deposition would influence larval numbers. Samples were taken at 100 degree day (DD) intervals above the developmental threshold of $10^{o}C$ ($50^{o}F$) accumulated from 1 January. A 30 stem sample was pulled from each plot on each date. Larvae were retrieved with Standard berlese funnels and stored in 50% ethyl alcohol for counting and separation into instars by head capsule size.

All data were subjected to analysis of variance (SAS Institute 1985) and significant ($\underline{P} < 0.05$) differences between means were determined with Duncan's Multiple Range Test (Duncan 1955).

Results

1985-1986

By mid-December, low temperatures (to $-17^{\circ}C$ ($2^{\circ}F$)) occurred and 3.8 cm of snow had fallen. However, after December the winter was quite mild as DD accumulations in January, February, and March were well above average (Table VI). In November 1985, the dormant cultivars had significantly ($F = 125.53$; df = 5, 25; $P < 0.05$) less fall growth than 'Granada' and 'CUF 101' (Fig. 5). Once this growth was killed, it was present as dead brown stems and used as an ovipositional site by the alfalfa weevil throughout the winter.

Egg population results from the fall growth in December 1985 strongly indicate that adult alfalfa weevils were less attracted to dormant cultivars when they reentered the alfalfa fields after aestivation. Densities ranged from 154 eggs/30 stems in 'Advantage' to a high of 269 eggs/30 stems in 'CUF 101' (Table VII). Egg populations by January were again significantly ($F = 4.83$; df = 5, 25; $P < 0.05$) lower in the dormant cultivars; thus, cultivars with less dormancy were used more during fall egg lay. The majority of eggs found in the fall growth by March were inviable as a result of dessication.

Egg viability was high in all cultivars in December,

TABLE VI

MONTHLY MEANS FOR LOW TEMPERATURES (°C) AND DEGREE-DAY (DD) ACCUMULATIONS FOR ALFALFA WEEVIL DEVELOPMENT FROM DECEMBER-MARCH IN OKLAHOMA, 1985-1988.

	December		January		February		March	
Season	°C	DD	°C	DD	°C	DD	°C	DD
1985-1986	-6.0(-16.7)[a]	17	-4.6(-12.8)	73	0.3(-16.7)	173	5.4(-3.3)	282
1986-1987	-1.1 (-6.7)	17	-5.3(-15.0)	29	0.0 (-7.2)	85	3.2(-5.2)	187
1987-1988	-2.7(-16.1)	57	-6.6(-23.9)	46	-4.7(-16.7)	79	0.8(-8.9)	170
Average[b]	-2.4(-13.0)	51	-5.7(-16.3)	32	-1.6(-13.7)	82	3.4(-6.7)	199

[a] Coldest low temperature recorded during each month given in parentheses.

[b] Long term average (1972-1987).

Figure 5. Fall growth of alfalfa cultivars in Oklahoma A, 1985; B, 1986; C, 1987.

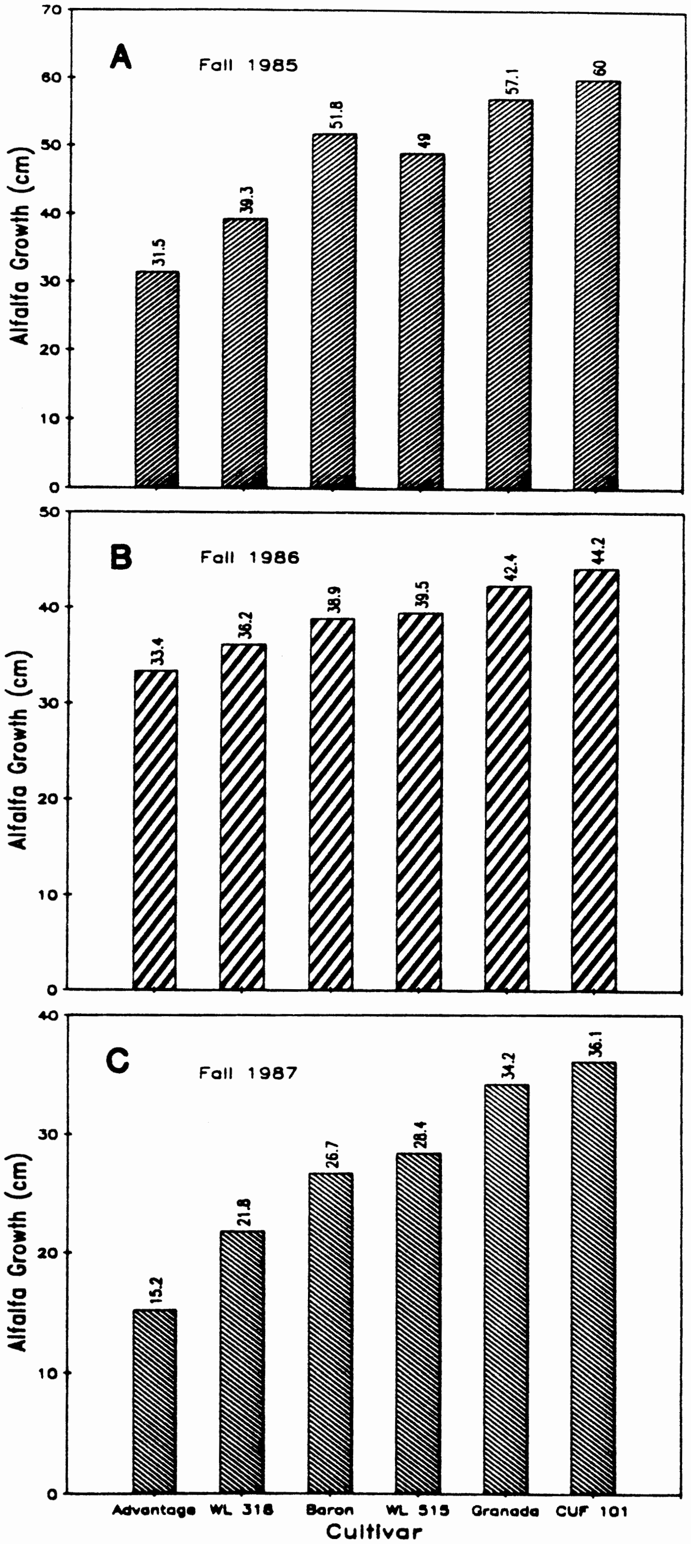
A
Fall 1985
Alfalfa Growth (cm)
0
10
20
30
40
50
60
70
31.5
39.3
51.8
49
57.1
60
B
Fall 1986
Alfalfa Growth (cm)
0
10
20
30
40
50
33.4
36.2
38.9
39.5
42.4
44.2
C
Fall 1987
Alfalfa Growth (cm)
0
10
20
30
40
15.2
21.8
26.7
28.4
34.2
36.1
Advantage
WL 318
Baron
WL 515
Granada
CUF 101
Cultivar

TABLE VII

DENSITIES OF ALFALFA WEEVIL EGGS IN FALL GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
6 Dec.[b]	154a	207ab	261b	249b	247b	269b	± 25
12 Jan.	113a	120a	206b	157ab	177b	181b	± 17
20 March	49ab	65b	39a	50ab	44ab	29a	± 7
			1986-1987				
15 Nov.	18a	14a	24a	24a	22a	37b	± 3
13 Jan.	80a	68a	57a	58a	71a	80a	± 8
12 March	30a	33a	36a	42a	45a	41a	± 6
			1987-1988				
21 Nov.	14a	17a	36a	40ab	70c	67bc	± 9
7 Jan.	53a	63a	86ab	112bc	145c	166d	± 16
22 Feb.	80ab	66a	98abc	96abc	116bc	119c	± 12

[a] Egg numbers per 30 stems.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

with an overall average of 83% (Table VIII). The number of viable alfalfa weevil eggs ranged from 129 to 231 eggs/30 stems (Table IX). By January, viability dropped 4 to 33 % in the fall growth probably because of dessication within stems. Virtually all that remained in the brown growth by March were inviable eggs. The viability of eggs in 'Advantage' was significantly (*F* = 2.05; df = 5, 25; $P < 0.05$) higher than in 'Granada', ranging from 0 to 20 %. 'WL 318' had an average of 11 viable eggs/30 stems.

By mid-January, heights of less dormant cultivars ranged from 4.3 to 5.3 cm (Fig. 6). Differences in heights occurred among the cultivars in March, but were probably not considered biologically significant to the alfalfa weevil.

The density of eggs in the spring growth in mid-January was low, ranging from 10 eggs in 'WL 515' to 21 eggs/30 stems in 'CUF 101'. There was an increase in hatching by March and egg numbers were low, with an overall average of 9/30 stems (Table X). Egg viability in March averaged 41% (Table XI); and numbers of viable eggs ranged from 3 to 15/30 stems (Table XII). Low temperatures (-16.7^{o}C) occurred in February which reduced egg survival.

Larval hatch began early in the season because of mild temperatures that occurred after December. Densities in February ranged from 37 in 'Baron' to 66 larvae/30 stems in 'WL 318' (Table XIII). As egg hatch continued, by 21 March, 'CUF 101' had a significantly (*F* = 4.08; df = 5, 25; $P < 0.05$) greater larval density than the dormant cultivars.

TABLE VIII

PERCENTAGE VIABILITIES OF ALFALFA WEEVIL EGGS IN FALL GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
				1985-1986			
6 Dec.	84ab	80ab	87b	84ab	77a	86b	± 3
12 Jan.	68ab	76b	54a	62ab	72ab	66ab	± 5
20 March	20b	17ab	11ab	4ab	0a	9ab	± 4
				1986-1987			
13 Jan.	86a	86a	86a	82a	87a	87a	± 2
12 March	73a	77a	70a	78a	67a	70a	± 7
				1987-1988			
7 Jan.	69a	79a	83a	80a	80a	78a	± 4
22 Feb.	80a	83a	73a	76a	80a	75a	± 3

[a] Means within rows followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

TABLE IX

ESTIMATE OF THE NUMBER OF VIABLE ALFALFA WEEVIL EGGS IN THE FALL GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101
			1985-1986			
6 Dec.	129	166	227	209	190	231
12 Jan.	77	91	111	97	127	119
20 March	10	11	4	2	0	3
			1986-1987			
13 Jan.	69	58	49	48	62	70
12 March	22	25	25	33	30	29
			1987-1988			
7 Jan.	37	50	71	90	116	129
22 Feb.	64	55	73	73	93	89

[a] Egg numbers per 30 stems.

Figure 6. Heights of alfalfa cultivars in the spring, Oklahoma. A, 1986; B, 1987; C, 1988.

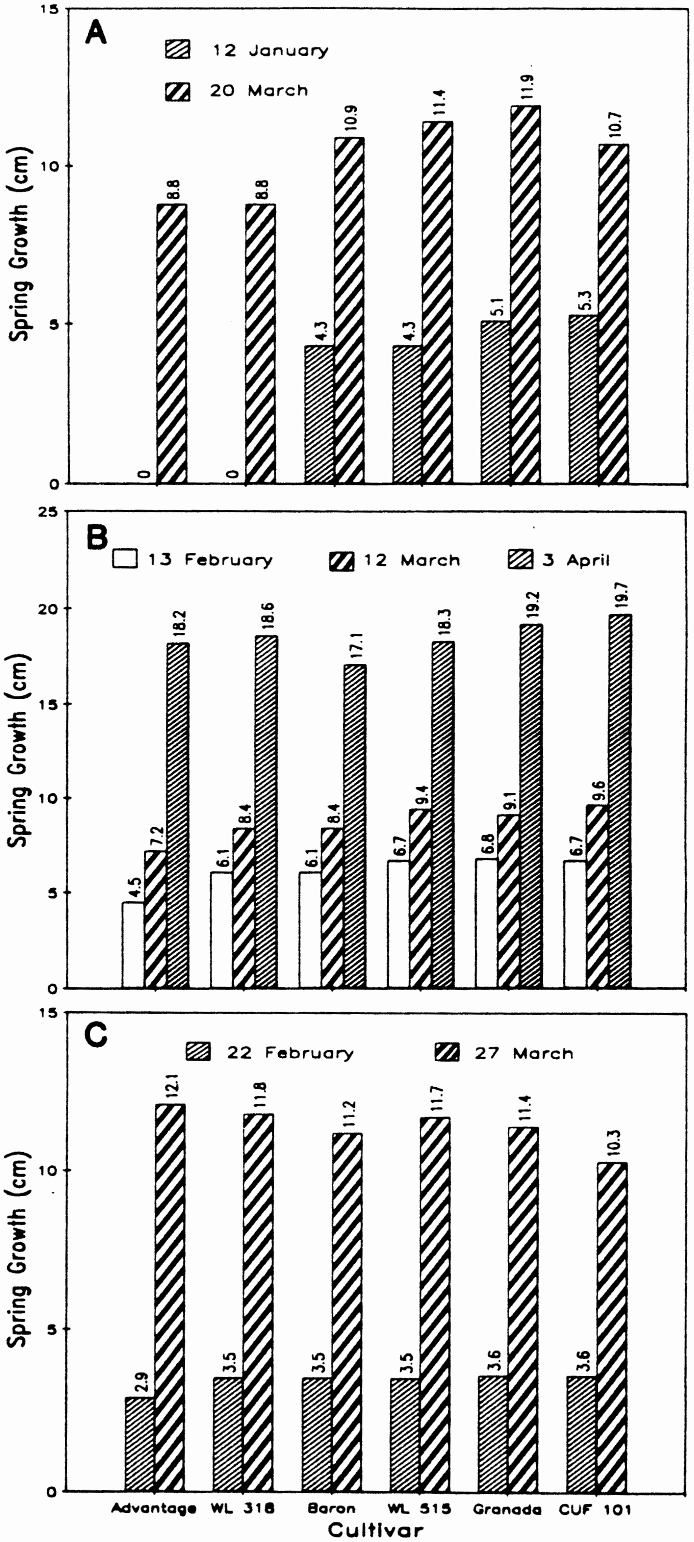
A
12 January
20 March
Spring Growth (cm)
0
5
10
15
0
8.8
0
8.8
4.3
10.9
4.3
11.4
5.1
11.9
5.3
10.7
B
13 February
12 March
3 April
Spring Growth (cm)
0
5
10
15
20
25
4.5
7.2
18.2
6.1
8.4
18.6
6.1
8.4
17.1
6.7
9.4
18.3
6.8
9.1
19.2
6.7
9.6
19.7
C
22 February
27 March
Spring Growth (cm)
0
5
10
15
2.9
12.1
3.5
11.8
3.5
11.2
3.5
11.7
3.6
11.4
3.6
10.3
Advantage
WL 318
Baron
WL 515
Granada
CUF 101
Cultivar

TABLE X

DENSITIES OF ALFALFA WEEVIL EGGS IN SPRING GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[b]	-[c]	-[c]	14ab	10a	14ab	21 b	± 3
20 March	8a	9a	26 b	17ab	12a	12a	± 3
			1986-1987				
13 Jan.	26ab	23a	46ab	42ab	49 b	41ab	± 8
12 March	6a	8a	7a	17ab	15ab	22 b	± 4
3 April	29a	37ab	39ab	39ab	50 b	50 b	± 5
			1987-1988				
22 Feb.	3a	7ab	12 b	6ab	9ab	13 b	± 3
27 March	2a	4ab	8ab	8ab	12 b	7ab	± 3

[a] Egg numbers per 30 stems.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

[c] No growth.

TABLE XI

PERCENTAGE VIABILITIES OF ALFALFA WEEVIL EGGS IN SPRING GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
		1985-1986					
20 Mar.	43a	37a	58a	40a	27a	46a	± 11
		1986-1987					
13 Jan.	75a	83a	72a	77a	78a	80a	± 5
12 March	81a	84a	75a	75a	78a	85a	± 6
3 April	83a	86ab	96b	90ab	89ab	86ab	± 4
		1987-1988					
22 Feb.	99d	91c	86bc	71a	78ab	84bc	± 3
27 March	89a	80a	92a	92a	90a	97a	± 10

[a] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

TABLE XII

ESTIMATE OF THE NUMBER OF VIABLE ALFALFA WEEVIL EGGS IN THE SPRING GROWTH OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1985-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101
			1985-1986			
20 March	3	3	15	7	3	6
			1986-1987			
13 Jan.	20	19	33	32	38	33
12 March	5	7	5	13	12	19
3 April	24	32	37	35	45	43
			1987-1988			
22 Feb.	3	6	10	4	7	11
27 March	2	3	7	7	11	7

[a] Egg numbers per 30 stems.

TABLE XIII

LARVAL POPULATION DENSITIES OF THE ALFALFA WEEVIL ON SEVERAL ALFALFA CULTIVARS IN OKLAHOMA, 1986-1988.[a]

Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1986				
19 Feb.[b]	51b	66b	37a	43ab	44ab	46ab	± 9
21 March	173a	157a	219bc	154a	167ab	253c	± 20
4 April	246a	244ab	292ab	264ab	345b	233a	± 32
			1987				
21 Mar.	137a	167ab	220ab	229ab	256ab	293b	± 41
3 April	123a	98a	131ab	155 b	116a	154b	± 20
13 April	247a	246a	285a	295a	307a	394a	± 47
			1988				
24 March	107a	116a	219bc	173b	218bc	235c	± 16
4 April	180ab	149a	233bc	268cd	298d	271cd	± 18
11 April	70ab	64a	105bc	99abc	124c	102abc	± 12

[a] Larvae per 30 stems.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

Peak numbers occurred by 4 April and ranged from 233 to 345 larvae/30 stems. Unexpectedly, 'Advantage' and 'CUF 101' did not have different population densities.

1986-1987

The winter of 1987 had monthly mean low temperatures of -1.1, -5.3 and 0.0 ^{o}C occurring in December, January, and February, respectively, (Table VI). 'Granada' and 'CUF 101' had significantly (F = 19.76; df = 5, 61; P < 0.05) greater growth than the dormant and moderately dormant cultivars, with heights ranging from 33.4 to 44.2 cm (Fig. 5).

Early egg densities (15 November) were significantly (F = 3.96; df = 5, 61; P < 0.05) higher in 'CUF 101' than in other cultivars, indicating a possible preference for the taller, fall growth (Table VII). Egg numbers increased as the season progressed; overall averages of 69 and 38 eggs/30 stems occurred in January and February, respectively. Egg populations were not as high as in 1985-1986. This may have been because a fungal epizootic of *Erynia* spp. killed 90% of weevil larvae in the Payne County Research Area in April 1986 (Goh 1987), possibly contributing to lower adult populations in 1986-1987. In addition, floods in late September 1986 may have caused some mortality of aestivating adults.

Viabilities in the fall growth were high throughout the season because temperatures were well above the long term average for Stillwater (Table VI). In January and March, viability averaged 86 and 72 %, respectively (Table VIII). The estimated numbers of viable eggs in January and March, averaged 59 and 27 eggs/30 stems, overall (Table IX).

Spring growth was present in all cultivars by January. The amount of growth ranged from 4.5 to 6.8 cm in height (Fig. 6). Freezing temperatures occurred periodically during the spring and killed all new growth in mid-January, mid-February, and late March. In April, cultivars had an average of 18.5 cm of growth.

Egg population densities in the spring growth strongly indicate an ovipositional preference for the nondormant cultivars. In January, egg numbers were significantly (F = 1.76; df = P < 0.05) higher in 'Granada' than in 'WL 318', with a range from 23 to 49 eggs/30 stems (Table X). Egg numbers were lower by March because of increased larval hatch and decreased oviposition; however, 'CUF 101' had three times more eggs than the dormant cultivars. Cold temperatures in late March appeared to increase oviposition and in April, and the nondormant cultivars again had higher egg densities than more dormant ones.

Viability was high in the spring growth from January through April as temperatures were higher than average. Egg survival in January and March had overall means of 77 and 80% (Table XI), representing 29 and 10 viable eggs/30 stems, respectively (Table XII). The percentage and number of viable eggs increased in April because of those recently deposited and ranged from 24 in 'Advantage' to 45 viable eggs/30 stems in 'Granada'.

Larval densities were lowest in the most dormant cultivar and increased as the alfalfa dormancy decreased (Table XIII). In March, 'Advantage' had a significantly (F = 2.27; df = 5, 55; $P < 0.05$) lower density than 'CUF 101'. Because of a week of freezing temperatures in late March that killed many larvae, populations were much lower in April and ranged from 98 to 155 larvae/30 stems. As a result of the increased egg deposition in early April, larval numbers were higher by mid-April.

1987-1988

The winter was unusually cold for northcentral Oklahoma as low temperatures of -16.1, -23.9, and -16.7 ^{o}C occurred in December, January, and February, respectively (Table VI). In December and January, 25 and 23 cm of snow fell and acted as an insulating cover to preserve viability of weevil eggs. The fall growth was shorter than in any other year of this study (Fig. 5). 'Granada' and 'CUF 101' had heights over twice that of 'Advantage', ranging from 36.1 to 15.2 cm.

Alfalfa weevils consistently oviposited less in dormant than in nondormant alfalfas throughout the season and agrees with findings of Reid et al. (1989). In November, 'Granada' and 'CUF 101' had significantly (F = 6.47; df = 5, 25; $P <$ 0.05) higher egg numbers than 'Advantage' and 'WL 318' (Table VII). In early January and February, more eggs were deposited in the nondormant cultivars.

In early January, eggs in the fall growth had viabilities averaging 78% (Table VIII); the estimated number of viable eggs ranged from 37 egg/30 stems in 'Advantage' to 129 viable eggs/30 stems in 'CUF 101' (Table IX). By late February and after low temperatures, egg viability was surprisingly high and ranged from 75 to 83 %. Alfalfa weevil eggs were protected during the periods of low temperatures by large amounts of snow. Overall, the number of viable eggs averaged 75 eggs/30 stems.

The alfalfa cultivars, particularly the nondormants, were stressed during the spring because several killing frosts to alfalfa growth occurred. As a result, 'CUF 101', usually the taller cultivar, was significantly ($\underline{F} = 2.52$; df = 5, 25; $\underline{P} < 0.05$) shorter than the more dormant cultivars by March because it had to regrow from crowns.

Alfalfa weevil egg densities were low in the spring growth in February (Table X). Numbers ranged from 3 to 13 eggs/30 stems. By March, egg numbers had declined due to reduced ovipositional activity of adults and an increase in larval development and eclosion.

Eggs in 'Advantage' and 'WL 318' had significantly ($\underline{F} = 13.68$; df = 5,6; $\underline{P} < 0.05$) higher viabilities in the spring growth than the less dormant cultivars in February (Table XI). By March, viability was high for this late in the season, with an overall average of 90%.

Larval population densities were consistently lower in dormant cultivars and higher in nondormant ones throughout the season; egg population densities in 1988 followed this same trend (Table XIII). Larval numbers in March ranged from 107 larvae in 'Advantage' to a high of 235 larvae in 'CUF 101'. Peak larval densities occurred by early April and the dormant cultivars had significantly (F = 10.08; df = 5,25; $P < 0.05$) lower densities than the less dormant cultivars, ranging from 149 to 298 larvae.

Populations and Viabilities Averaged Across Cultivars

Egg population densities were different from date to date for the fall and spring growth within years (Table XIV). This is expected because eggs are deposited from October to April and hatching of larvae occurs when temperatures increase during the day. In 1985-1986 and 1987-1988, cultivar by date interactions occurred in the fall growth. Block by date and cultivar by date interactions were not significant for egg populations in the spring growth of any year.

Percentage viabilities were different between dates for each year in the fall and spring growth (Table XV). Eggs in the fall growth had a tendency to become less viable as the winter progressed because of lower temperatures and dessication, while eggs deposited in the spring growth, except for 1986, had higher viabilities as warmer temperatures occurred. Cultivar by date interactions were not significant in any year in the fall or spring growth, except for the fall growth in 1988. Block by date

TABLE XIV

EGG POPULATION DENSITIES OF THE ALFALFA WEEVIL AVERAGED ACROSS CULTIVARS IN THE FALL AND SPRING GROWTH.[a]

		Fall Growth			
1985-1986[b]		1986-1987		1987-1988	
6 Dec.	231c	15 Nov.	23a	21 Nov.	40a
12 Jan.	159b	13 Jan.	69b	7 Jan.	104bc
20 Feb.	78a	12 Mar.	38a	22 Feb.	96b
		Spring Growth			
1985-1986		1986-1987		1987-1988	
12 Jan.	15a	13 Jan.	38b	29 Jan.	21b
31 Jan.	25a	12 Mar.	12a	22 Feb.	8a
20 Mar.	14a	3 Apr.	41b	27 Mar.	7a

[a] Egg numbers per 30 stems.

[b] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

TABLE XV

PERCENTAGE VIABILITIES OF ALFALFA WEEVIL EGGS AVERAGED ACROSS CULTIVARS IN THE FALL AND SPRING GROWTH.[a]

Fall Growth					
1985-1986		1986-1987		1987-1988	
6 Dec.	83c	13 Jan.	86b	7 Jan.	78b
12 Jan.	67b	13 Feb.	74a	22 Feb.	79b
20 Feb.	29a	12 Mar.	72a	10 Mar.	64a

Spring Growth					
1985-1986		1986-1987		1987-1988	
31 Jan.	71b	13 Jan.	77a	7 Jan.	78a
20 Feb.	38a	12 Mar.	79ab	22 Feb.	83ab
20 Mar.	42a	3 Apr.	88b	27 Mar.	90b

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[a] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

TABLE XVI

LARVAL POPULATION DENSITIES OF THE ALFALFA WEEVIL AVERAGED ACROSS CULTIVARS.[a]

1986[b]		1987		1988	
19 Feb.	48a	21 Mar.	216b	24 Mar.	178b
21 Mar.	189b	4 Apr.	129a	4 Apr.	233c
4 Apr.	270c	13 Apr.	296c	11 Apr.	94a

[a] Larvae per 30 stems.

[b] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

interactions also were not significant except in the fall growth in 1986. Because viability decreased sharply from date to date in 1986 and was unusually low compared to 1987 and 1988, this interaction would not be unexpected.

Larval population densities within each year were different between dates (Table XVI). This is expected because larval hatching increases as temperatures rise in the spring. Cultivar by date interactions were significant in 1986 and 1988; block by date interactions were significant in 1986 and 1987. Because each cultivar possesses eggs having different developmental ages, larval populations on a particular date would be dependent on the DD accumulations of the eggs, which would be highly variable.

Discussion

The most important ovipositional site for the alfalfa weevil in Oklahoma is the fall growth. Over the season, a greater proportion of eggs were deposited in this growth in each year. Similarly, dead alfalfa stems in Ohio were also reported to be important sites for egg deposition even when green growth was present (Niemczyk and Flessel 1970). This is in contrast to Litsinger and Apple (1973) who reported that fall oviposition of the alfalfa weevil never surpassed 2% of the yearly egg output in Wisconsin. By the time spring growth appeared in January, oviposition was much less in Oklahoma because adults were older. In addition, adult mortality probably contributed to a decline in oviposition as the season progressed. Helgesen and Cooley (1976) reported a 25% overwintering survival of adults in New York, with a marked decrease in January and February. Survival was reduced because fat reserves were expended due to large, rapid temperature fluctuations.

Although weevils continued to oviposit in fall growth after new growth appeared, the majority of egg deposition after January occurred in the spring growth as based on the number of newly deposited yellow eggs. Since this stage is present for a short time, it can only be used as an indicator of weevil activity and preferences for ovipositional sites close to a particular date. The fall growth did have higher numbers of brown eggs at this time but these are assumed to have been deposited in fall. Hamlin et al. (1949) and Niemczyk and Flessel (1970) reported that weevils switched from dead stems to growing stems, but only after the stems reached a height of 15 to 25 cm. In Oklahoma, weevils oviposited in spring growth as soon as it appeared. Because nondormant cultivars produce crown growth earlier in winter than more dormant ones, they had higher accumulations of eggs.

Eggs deposited in the spring growth usually had a higher viability than those deposited in the fall growth. Eggs laid in new growth developed faster because of increased DD accumulations and were exposed less to extreme cold temperatures than those in fall growth. Similarly, Armburst et al. (1966) reported that the percentage of successfully overwintering eggs in New York varied according to snow cover and severity of winter. Fall growth became desiccated and contributed to increased numbers of inviable eggs while the spring growth was succulent during the season. Sweetman (1929) reported that reduced viabilities were related to low humidity while increased egg survival was because of greater succulence of alfalfa.

Percentage viability was usually not different among cultivars in the fall or spring growth and this is in aggreement with the study by Reid et al. (1989). However, dormant cultivars in February 1988 had higher viabilities in the spring growth than the less dormant ones. This estimate may be inaccurate for the dormant cultivars because only a few eggs were available to determine viability.

Estimating the age of alfalfa weevil eggs would be helpful in predicting larval hatch in spring. Because this insect oviposits from October to March in southern regions like Oklahoma, it is difficult to determine whether a sample of eggs are from fall or spring deposition. Many eggs laid in the fall and winter hatch during warm periods in the winter and early spring, exposing larvae to subfreezing temperatures. Thus, egg numbers alone do not adequately predict larval densities because many older eggs will not contribute to larval populations in southern regions.

Based on total numbers, eggs deposited in fall growth contributed more to larval populations than those in spring growth. This is in contrast to Armbrust et al. (1966) who reported that even though fall oviposition of the alfalfa weevil was significant in New York, early larval populations which developed from fall eggs were far less important than populations developed from spring-laid eggs. Burbutis et al. (1967) and Townsend and Yendol (1968) also indicated that overwintering eggs contributed only a small percentage to the spring larval population.

Conclusions

A greater number of alfalfa weevil eggs were deposited in the fall growth than in the spring growth. As crown growth appeared in January and February, alfalfa weevils began ovipositing in this growth as evidenced from the number of newly deposited yellow eggs. Egg populations in the fall and spring growth were usually higher in the nondormant cultivars in comparison with dormant ones. Percentage viabilities of eggs were usually not different between growth types or cultivars and were affected by low temperatures, drying winds, and snow cover. Larval populations corresponded well with egg population trends among the cultivars in that nondormant cultivars usually had larger larval densities.

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CHAPTER V

PREFERRED OVIPOSITIONAL LOCATIONS OF THE ALFALFA WEEVIL, HYPERA POSTICA (COLEOPTERA: CURCULIONIDAE), WITHIN STEMS OF ALFALFA

Introduction

The alfalfa weevil, (*Hypera postica* (Gyllenhal)), is a very destructive pest of alfalfa, (*Medicago sativa* L.), throughout the United States. In Oklahoma, ovipositional activity of the alfalfa weevil begins in late October and continues into early spring (Berberet et al. 1980). Factors that have been identified as influencing oviposition of the alfalfa weevil include stem height and diameter.

Whether alfalfa weevils prefer to oviposit at crown level, in the terminal region, or indiscriminantly along the stem length is as yet unclear. Sweetman (1929) reported in Wyoming that 90% of alfalfa weevil eggs in Wyoming were laid within 15 cm of the crown, while 75% of these were within 8 cm of the crown. However, when he caged alfalfa weevils at both the ground and terminal levels of alfalfa plants, he found the greatest numbers of eggs in the terminal regions (Sweetman 1932). Hamlin et al. (1949) in Utah reported that 50% of egg clusters were found within 8 cm of the crown. In a greenhouse study to determine alfalfa weevil resistant cultivars, Busbice et al. (1968) reported that more eggs were found close to terminals, with 45% of eggs deposited in the apical one-third of stems, while 35% and 20% were deposited in the middle and basal regions, respectively.

Some reports have indicated that the location of alfalfa weevil eggs in stems effects the survival of the eggs through the winter. Sweetman (1929) incubated alfalfa weevil eggs at 5 cm and 1.1 m levels and found the percentage of eggs hatching at the lower level was 96% while it was 86% at the upper level. In a later study, he found that only 43% of eggs hatched at the top while 73% hatched at the 5 cm level (Sweetman 1932). The high percentage of eggs hatching at the lower level was apparently associated with the high humidity at this position; poor hatching at the upper position was a result of lower humidity causing dessication.

Dively (1970) conducted a study to determine the population density and viability of overwintering alfalfa weevil eggs in three stages of alfalfa growth in New Jersey. The growth stages in late fall were stubble (young crown shoots, 5-8 cm), new growth (15-18 cm), and bud stage alfalfa (30-36 cm). The new growth had greater numbers of eggs per stem than other growth stages during fall and early winter. Dively assumed that temperature and succulent condition of the new growth provided a favorable microhabitat for incubation of alfalfa weevil eggs. Less oviposition in the taller (bud stage) alfalfa was due to a lower moisture content. Viability increased with proximity of eggs to the crowns.

Sweetman (1929) classified alfalfa stems into three groups according to diameter and reported that medium-sized stems were chosen twice as often as large stems and three times as often as small stems. Busbice et al. (1968) reported that oviposition and stem diameter were positively correlated. Stem diameters ranged from 1.65 to 1.90 mm, with smaller stem diameters having significantly lower egg numbers than larger ones. Similarly, VanDenburgh (1966), Norwood et al. (1967), and Dhaliwal and Grewal (1983) reported that alfalfa stems of small diameters received fewer eggs. In contrast, Summers and Lehman (1976) found no significant relationship in California between the numbers of eggs per stem and stem diameters for the Egyptian alfalfa weevil, H. brunneipennis (Boheman). Eggs were found in stems with diameters ranging from < 2.0 to > 4.0 mm, with the greatest concentration in stems ca. 2.5-3.5 mm. However, 75% of stems sampled were distributed within this size range.

The objectives of this study were to determine preferred ovipositional locations of the alfalfa weevil in alfalfa stems and possible effects of location of eggs in stems on egg viability throughout winter.

Methods and Materials

Alfalfa was planted in two sites at the Agronomy Research Station at Stillwater, Oklahoma on 18 September 1984 (Port soil) and 17 September 1985 (Pulaski fine sandy soil). Six alfalfa cultivars were selected that represented a wide range of dormancies. The cultivars were planted in 3.4 X 5 m plots and arranged in a randomized complete block design with six replications. Dormancies were estimated based on the amount of growth after the last harvest in fall. The most dormant cultivars had the least fall growth ('Advantage' and 'WL 318'), moderately dormant cultivars had intermediate growth ('Baron'and 'WL 515'), while the nondormant cultivars had the greatest growth ('Granada' and 'CUF 101'). Data was collected from Fall 1985 to Spring 1988.

The last harvest of each year occurred by mid-September or early October and freezing weather usually caused a cessation of growth by mid-November. This browned fall growth was dead and remained until it decayed in March or April. Ten alfalfa stems per plot were measured in late fall to estimate the habitat for returning adult females. Locations in alfalfa stems where adult alfalfa weevils concentrated egg depostion were determined from monthly egg samples taken in December, January, and February. Thirty stems per plot were cut at ground level and separated into three sections: basal (5 cm), midportion, and distal (10 cm). Eggs were extracted from the stem sections using the blender extraction method of Pass and VanMeter (1966). Percent viability was estimated for eggs from each section to determine if differences occurred depending on location in the stem. Eggs were incubated at 23 ± $2^{o}C$ for 10 d.

Since middle stem sections were different between cultivars, comparisons of mean egg totals were biased between cultivars. To compensate, egg numbers from the middle sections were modified to represent egg densities at every 5 cm interval along the middle section. First, lengths of middle sections were determined by subtracting 15 cm from the average height of fall growth for each cultivar (5 cm from bottom + 10 cm from top sections). This number, representing the middle length, was then divided by 5 to determine how many 5 cm intervals were present for the middle section in each cultivar. Mean egg totals for each cultivar in the middle sections were divided by the number of 5 cm intervals to estimate the density of eggs. Mean egg totals in top sections (10 cm) were divided by 2 to exemplify densities comparable in length to 5 cm intervals.

Differences in stem diameters among the cultivars were measured using 10 stems per plot collected in November or December of each year. A micrometer was used to measure stem diameter at the crown, 5 cm above the crown, and 10 cm below the terminal.

All data were subjected to analysis of variance (SAS Institute 1985) and significant differences ($\underline{P} < 0.05$) between means were determined with Duncan's Multiple Range test (Duncan 1955) and the Least Significant Difference (LSD) test.

Results

The height of fall growth was variable from year to year because of harvest date and warmth of fall temperatures. In December 1985, 4 cm of snow and unusually low temperatures (-17^{o}C) occurred while temperatures were above average from January through March 1986. By late January , the fall growth was observed to be more dessicated in the nondormant cultivars than in the dormant ones. In 1987, the dormant cultivars remained in a succulent condition longer than the nondormant cultivars and top growth was not completely killed by frost until late February. The winter of 1987-1988 was unusually cold for northcentral Oklahoma with low temperatures of -16, -24, and -17 ^{o}C occurring in December, January, and February, respectively. Large amounts of snow (24 cm) and ice were present during the periods of low temperatures and acted as an insulating cover for alfalfa weevil eggs in shorter stems. Only the nondormant cultivars had completely dead growth by early January and became more desiccated than the dormant cultivars.

Differences in stem diameter and plant height were observed among the cultivars because of varying amounts of fall growth associated with each dormancy type. Fall growth of dormant vs. nondormant cultivars in 1986 and 1987 ranged from 31.5 to 60.0 and 33.4 to 44.2 cm, respectively, (Fig. 7). In 1988, height differences were greater among dormancy types and the fall growth was much shorter than in the previous 2 years, ranging from 15.2 to 36.1 cm.

Bottom Stem Section

Stem diameters of the dormant cultivars were always significantly smaller than the nondormant ones in the bottom alfalfa sections (Table XVII). In 1986, 1987, and 1988, diameters from dormant, moderately dormant, and nondormant cultivars ranged from 2.6 to 3.0, 2.4 to 2.9, and 2.2 to 2.8, respectively.

Egg numbers were consistently low, ranging from 2 to 16 eggs/30 stems in the bottom alfalfa stem sections and were not significantly different among cultivars in December or early January of 1986, 1987 or 1988 (Table XVIII). In late January of 1986 ($F = 2.29$; df = 5, 25; $P < 0.05$) and 1988 ($F = 2.00$; df = 5, 25; $P < 0.05$), bottom sections of 'Advantage' had significantly more eggs than 'Granada'. This is probably because the basal stem sections of the dormant cultivars stayed succulent for a longer period than the nondormant ones. By February of each year, no consistent trends in the egg densities from the bottom sections among the cultivars were evident probably because of increased hatching.

Viabilities of the alfalfa weevil eggs in the bottom sections were not usually different among cultivars, with

Figure 7. Fall growth of several alfalfa cultivars in Oklahoma. A, 1985; B, 1986; C, 1987.

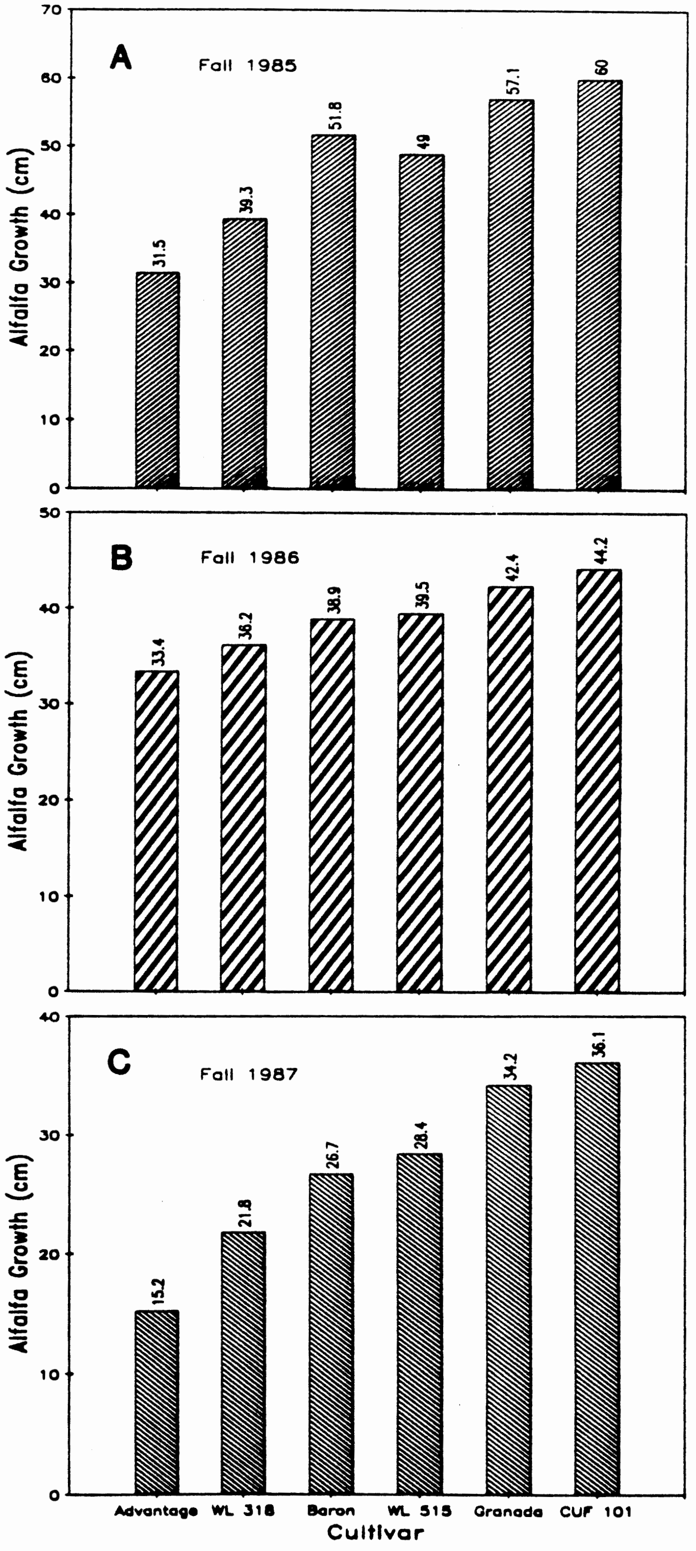
A
Fall 1985
Alfalfa Growth (cm)
0
10
20
30
40
50
60
70
31.5
39.3
51.8
49
57.1
60
B
Fall 1986
Alfalfa Growth (cm)
0
10
20
30
40
50
33.4
36.2
38.9
39.5
42.4
44.2
C
Fall 1987
Alfalfa Growth (cm)
0
10
20
30
40
15.2
21.8
26.7
28.4
34.2
36.1
Advantage
WL 318
Baron
WL 515
Granada
CUF 101
Cultivar

TABLE XVII

STEM DIAMETERS (MM) OF SEVERAL ALFALFA CULTIVARS IN OKLAHOMA.

	Cultivar					
Location	Advantage	WL 318	Baron	WL 515	Granada	CUF 101
			1985-1986			
Bottom[a]	2.6a	2.6a	2.8bc	2.7ab	3.0 c	2.8bc
Middle	2.6a	2.6a	2.8cd	2.7bc	2.9 d	2.8cd
Top	2.3bcd	2.2bc	2.4 d	2.2ab	2.3cd	2.1a
			1986-1987			
Bottom	2.4a	2.5a	2.6b	2.4a	2.8c	2.9 c
Middle	2.4a	2.5ab	2.5b	2.4a	2.7c	2.8 d
Top	2.2ab	2.2ab	2.2ab	2.1a	2.3c	2.3 c
			1987-1988			
Bottom	2.2a	2.3a	2.6bc	2.5b	2.7cd	2.8 d
Middle	2.2a	2.3 b	2.6 c	2.4b	2.7 d	2.8 d
Top	2.1a	2.2 b	2.4 c	2.2b	2.4c	2.4 c

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[a] Means within rows followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

TABLE XVIII

NUMBERS OF ALFALFA WEEVIL EGGS IN BOTTOM SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.[a]

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[b]	8a	8a	8a	13a	11a	16a	± 4
31 Jan.	16b	9ab	7a	7a	5a	9ab	± 3
20 Feb.	5a	4a	5a	5a	7a	6a	± 2
			1986-1987				
13 Dec.	7a	5a	6a	3a	7a	2a	± 2
13 Jan.	9a	9a	10a	7a	7a	15a	± 2
13 Feb.	6a	11ab	7a	11ab	18b	14b	± 3
			1987-1988				
4 Jan.	7a	12a	5a	13a	9a	5a	± 4
29 Jan.	18 b	17ab	7ab	11ab	6a	8ab	± 4
22 Feb.	31 b	18ab	6a	6a	9a	15ab	± 5

---

[a] Egg numbers per 30 stems.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

exceptions in 1986 when viability ranged from 40 to 84% on 12 January (Table XIX). By 31 January, 'Baron' had a significantly (F = 2.20; df = 5, 19; $P < 0.05$) lower percent viability than 'Advantage', 'WL 515', 'Granada', and 'CUF 101'. Viability was much lower in most cultivars by February and overall averaged 29%. In 1987, egg survival on 13 January ranged from 67 to 85%. Unexpectedly, 'Advantage' and 'WL 318' were the only cultivars with significant (F = 2.10; df = 5, 30; $P < 0.05$) differences in viability. Viability remained high in the basal sections by February, with an overall mean of 78%. Percent survival in the bottom sections in 1988 was not different on any date, with an overall average of 72, 81, and 79 % on 4 and 29 January, and 22 February, respectively.

Middle Stem Section

Middle stem diameters for 'Advantage' and 'WL 318' were always significantly smaller than those for 'Granada' and 'CUF 101'. In 1985, 1986, and 1987, diameters from dormant to nondormant cultivars ranged from 2.6 to 2.9, 2.4 to 2.8, and 2.2 to 2.8 mm, respectively (Table XVII).

Overall, lengths of middle sections varied from year to year because of differing amounts of fall growth. Mean lengths of middle stem sections ranged from 16.5 to 42.0 cm (1986), 18.4 to 29.2 cm (1987), and 0.2 to 21.1 cm (1988), in the dormant vs. nondormant cultivars. Because the dormant cultivars in 1988 had relatively little fall growth,

TABLE XIX

PERCENTAGE VIABILITY OF ALFALFA WEEVIL EGGS IN BOTTOM SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[a]	61abc	84 c	40a	50ab	77bc	64abc	± 9
31 Jan.	74 b	62ab	35a	64b	75b	75b	± 8
20 Feb	34a	27a	35a	14a	37a	24a	± 14
			1986-1987				
13 Jan.	67a	85b	84ab	69ab	83ab	83ab	± 6
13 Feb.	80a	80a	80a	72a	78a	78a	± 6
			1987-1988				
4 Jan.	66a	68a	84a	82a	61a	75a	± 11
29 Jan.	85a	65a	89a	75a	79a	91a	± 9
22 Feb.	78a	86a	70a	85a	76a	70a	± 7

[a] Means within rows followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

the stems collected often were not taller than 15 cm and middle sections were not always available. An average of 12 middle stem sections were collected from 'Advantage' and 24 from 'WL 318' on each date and the mean length of these were 3.7 and 6.1 cm, respectively.

Mean totals. 'Advantage' and 'CUF 101' did not have significantly different egg population densities in 1986 (Table XX) despite a 25.5 cm height differential that occurred between the two cultivars. In 1986-1987, there was only a 10.8 cm height differential between 'Advantage' and 'CUF 101'. Lack of distinct differences in growth between the dormancy types could have contributed to similarities in egg numbers among the cultivars on 13 December and between the dormant and nondormant cultivars on 13 January. The highly significant differences between egg numbers in middle sections of the dormant and nondormant cultivars in 1988 can be attributed to several things including distinct differences in fall growth in the dormant vs. nondormant cultivars (0.2 to 21.1 cm) and fewer middle sections processed for 'Advantage' (12 stems) and 'WL 318' (24 stems) vs. 30 stems for the other cultivars.

Adjusted Egg Population Densities. Egg numbers from middle stems sections were not different among the cultivars on any date when adjusted relative to plant height, with exceptions on 13 January and 13 February 1987 (Table XXI). This is in contrast to the unadjusted mean egg totals which do indicate several significant differences among cultivars.

TABLE XX

NUMBERS OF ALFALFA WEEVIL EGGS IN MIDDLE SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.[a]

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[b]	43a	48a	115b	64a	79ab	88ab	± 16
31 Jan.	33a	45a	52a	62a	69a	65a	± 12
20 Feb.	20a	17a	45ab	39ab	51b	38ab	± 9
			1986-1987				
13 Dec.	24a	23a	24a	32a	27a	30a	± 5
13 Jan.	40b	28ab	19a	28ab	30ab	38b	± 5
13 Feb.	46b	25a	37ab	47b	39ab	25a	± 6
			1987-1988				
4 Jan.	12a	11a	20a	37a	82b	81b	± 8
29 Jan.	18a	23ab	34abc	48bcd	60cd	66d	± 9
22 Feb.	7a	15ab	28b	19ab	26b	29b	± 5

[a] Egg numbers per 30 stems.

[b] Means within rows followed by the same letter are not significantly (*P* > 0.05) different.

TABLE XXI

ADJUSTED NUMBERS OF ALFALFA WEEVIL EGGS IN MIDDLE SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.[a]

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[b]	13a	11a	16a	9a	9a	9a	± 5
31 Jan.	10a	9a	7a	9a	8a	8a	± 4
20 Feb.	6a	4a	6a	6a	6a	4a	± 2
			1986-1987				
13 Dec.	6a	6a	5a	7a	5a	6a	± 2
13 Jan.	11b	6a	4a	6a	6a	7a	± 2
13 Feb.	13b	6a	8a	10a	7a	4a	± 2
			1987-1988				
4 Jan.	-	9a	9a	14a	22a	21a	± 5
29 Jan.	-	22a	16a	18a	16a	18a	± 5
22 Feb.	-	12a	11a	7a	7a	8a	± 4

[a] Egg numbers per 30 stems per 5 cm of stem.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

Egg densities were similar in 1985-1986, ranging from 4 to 16 eggs/5 cm/30 stems. On 13 February 1987, 'Advantage' had a significantly ($F = 1.00$; df = 5, 55; $P < 0.05$) greater density of eggs/5 cm than 'CUF 101'. Densities were higher at 5 cm intervals in 1987-1988, and ranged from 9 to 22 egg/5 cm/30 stems.

Egg viabilities were not different among cultivars in the middle sections on any date in 1986, with a high of 74% viable eggs in 'Advantage' on 12 Janaury to a low of 25% in 'WL 515' in February (Table XXII). In February 1987, 'Advantage' had a significantly ($F = 2.87$; df = 5, 40; $P < 0.05$) higher egg survival than 'Baron', 'WL 515', 'Granada', and 'CUF 101'. Unexpectedly, viabilities on 4 January 1988 were significantly ($F = 2.87$; df = 5. 19; $P < 0.05$) different between the two dormant cultivars. However, by 29 January, 'Advantage' had the highest viability (92%).

Top Stem Section

Stem sections from the tops of alfalfa plants appeared to become brittle earlier than other regions as the winter progressed. In 1986, 'CUF 101' had a significantly ($F = 6.13$; df = 5, 324; $P < 0.05$) smaller top stem diameter than the dormant cultivars, although bottom and middle sections of 'CUF 101' had greater diameters than dormant cultivars (Table XVII). In 1987, diameters ranged from 2.1 mm in 'WL 515' to 2.3 mm in 'Granada'. 'Baron' and the nondormant cultivars in 1988 had significantly ($F = 13.69$; df = 5, 342;

TABLE XXII

PERCENTAGE VIABILITY OF ALFALFA WEEVIL EGGS IN MIDDLE SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[a]	74a	74a	56a	60a	63a	67a	± 7
31 Jan.	54a	53a	62a	58a	59a	51a	± 11
20 Feb.	35a	39a	32a	25a	29a	35a	± 9
			1986-1987				
13 Jan.	91a	89a	91a	89a	90a	87a	± 3
13 Feb.	87b	77ab	65a	67a	67a	61a	± 6
			1987-1988				
4 Jan.	66a	96 c	84bc	82abc	85bc	77ab	± 5
29 Jan.	92 b	89ab	84ab	85ab	87ab	78a	± 4
22 Feb.	77a	82a	79a	81a	80a	83a	± 6

[a] Means within rows followed by the same letter rows are not significantly (*P* > 0.05) different.

$\underline{P} < 0.05$) larger top diameters than the other cultivars. Top sections of 'Advantage' and 'WL 318' in 1988 had average lengths of 8.5 and 9.8 cm per date, respectively.

Mean Egg Totals. In 1986, egg numbers in the top stem sections were not different among cultivars on any date (Table XXIII). On 13 January, egg numbers ranged from 62 to 87 eggs/30 stems in 'Advantage' to 'Granada', respectively. Egg populations in 1986-1987 were not different among the cultivars in December, January, or February. They were much lower compared to 1986, with overall mean egg densities averaging 20, 29, and 33 eggs/30 stems/cultivar, respectively. In 1988, egg populations were lower in 'Advantage' and 'WL 318' than in 'CUF 101'. On 29 January and 22 February, densities ranged from 35 to 101 eggs/30 stems and 33 to 81 eggs/30 stems, respectively.

Adjusted Egg Population Densities. Egg numbers in Table XXIV represents densities of alfalfa weevil eggs per 5 cm of stem in top sections. As in Table XXIII for mean egg totals, adjusted egg densities were not different among cultivars in 1985-1986 or December and January 1987. In 1987-1988, adjusted egg densities were lower in the dormant cultivars than in 'CUF 101'.

Viabilities in early January 1986 ranged from 65 to 83% in the top sections (Table XXV). Because of the dry condition of the stems, viabilities were much lower by February, with an overall average of 26%. Alfalfa weevil eggs in early January 1987 had viabilities that ranged from

TABLE XXIII

NUMBERS OF ALFALFA WEEVIL EGGS IN TOP SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.[a]

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
13 Jan.[b]	62a	65a	83a	80a	87a	77a	± 13
31 Jan.	60a	64a	58a	44a	62a	46a	± 11
20 Feb.	34a	35a	36a	46a	37a	41a	± 6
			1986-1987				
13 Dec.	24a	19a	23a	20a	18a	19a	± 4
13 Jan.	31a	31a	28a	23a	34a	28a	± 5
13 Feb.	27a	31a	36a	26a	42a	36a	± 6
			1987-1988				
4 Jan.	34a	39a	61ab	61ab	55ab	81b	± 12
29 Jan.	35a	54a	54a	67ab	73ab	101b	± 14
22 Feb.	42ab	33a	64bc	70c	81c	76c	± 9

[a] Egg numbers per 30 stems.

[b] Means within rows followed by the same letter are not significantly ($P > 0.05$) different.

TABLE XXIV

ADJUSTED NUMBERS OF ALFALFA WEEVIL EGGS IN TOP SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.[a]

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[b]	31a	32a	41a	40a	44a	39a	± 5
31 Jan.	30a	32a	29a	22a	31a	23a	± 4
20 Feb.	17a	18a	18a	23a	19a	20a	± 2
			1986-1987				
13 Dec.	12a	9a	12a	10a	9a	10a	± 2
13 Jan.	16a	15a	14a	12a	17a	14a	± 2
13 Feb.	14ab	15ab	18ab	13a	21b	18ab	± 2
			1987-1988				
4 Jan.	17a	20a	31ab	31ab	27ab	40b	± 5
29 Jan.	18a	27a	27a	34a	36ab	51b	± 5
22 Feb.	21a	17a	32b	35b	41b	38b	± 4

[a] Egg numbers per 30 stems per 5 cm of stem.

[b] Means within rows followed by the same letter are not significantly (*P* > 0.05) different.

TABLE XXV

PERCENTAGE VIABILITY OF ALFALFA WEEVIL EGGS IN TOP SECTIONS OF ALFALFA STEMS IN OKLAHOMA, 1985-1988.

	Cultivar						
Date	Advantage	WL 318	Baron	WL 515	Granada	CUF 101	S.E.
			1985-1986				
12 Jan.[a]	71a	68a	65a	83a	78a	68a	± 8
31 Jan.	47a	65a	38a	61a	48a	52a	± 9
20 Feb.	35a	24a	27a	22a	21a	28a	± 7
			1986-1987				
13 Jan.	93b	85ab	89ab	82a	91b	92b	± 2
13 Feb.	78a	81a	73a	65a	73a	69a	± 6
			1987-1988				
4 Jan.	75a	78a	80a	75a	85a	80a	± 4
29 Jan.	80a	84a	80a	74a	75a	74a	± 6
22 Feb.	82ab	86b	75ab	70a	82ab	74ab	± 4

[a] Means within rows followed by the same letter are not significantly (*P* > 0.05) different.

93% in 'Advantage' to a low of 82% in 'WL 515'. On 4 and 29 January, viabilities were not different among the cultivars and averaged 79 and 77%, respectively. By February, 'WL 318' had a significantly (F = 1.64; df = 5, 20; $P < 0.05$) higher viability than 'WL 515'.

Ovipositional Preference of the Alfalfa Weevil

Alfalfa weevil adults appeared to prefer to deposit more eggs in the top sections of alfalfa than in other regions. In 1985-1986, top stem sections from each cultivar had significantly higher egg populations than bottom and middle segments on every date, except for 'WL 515' on 31 January (Table XXVI). In 1986-1987, bottom and/or middle sections tended to have lower egg densities than top sections (Table XXVII). Substantial differences in egg densities occurred between the stem locations in 1987-1988 (Table XXVIII). Bottom and middle stem sections from all cultivars except 'Advantage' always had significantly lower egg densities per 5 cm than top segments, except for 'Baron' on 29 January.

Location Across Cultivars

Cultivar X stem location interactions were significant on 13 and 22 February 1987 and 1988. Block X stem location was used as the error term when averaging across cultivars and block X stem locations interactions were not significant except on 20 February 1986.

TABLE XXVI

DENSITIES OF ALFALFA WEEVIL EGGS IN ALFALFA CULTIVARS RELATIVE TO STEM POSITION, 1985-1986.[a]

	Cultivar					
Location	Advantage[b]	WL 318	Baron	WL 515	Granada	CUF 101
	12 January 1986					
Bottom[c]	8a	7a	8a	13a	11a	16a
Middle	13a	11a	16a	9a	9a	10a
Top	31b	32b	41b	40b	44b	39b
	31 January 1986					
Bottom	16a	9a	7a	11ab	6a	9a
Middle	10a	9a	7a	9a	8a	8a
Top	30b	32b	29b	22b	31b	23b
	20 February 1986					
Bottom	5a	4a	5a	5a	7a	6a
Middle	6a	4a	6a	6a	6a	4a
Top	17b	18b	18b	23b	19b	20b

[a] Egg numbers in each location represent densities per 5 cm of stem.

[b] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

[c] The LSD used to determine differences in locations for each date is 14, 11, and 6, respectively.

TABLE XVII

DENSITIES OF ALFALFA WEEVIL EGGS IN ALFALFA CULTIVARS RELATIVE TO STEM POSITION, 1986-1987.[a]

	Cultivar					
Location	Advantage[b]	WL 318	Baron	WL 515	Granada	CUF 101
	13 December 1986					
Bottom[c]	7ab	5a	6a	3a	7a	2a
Middle	6a	6a	5a	7ab	5a	6ab
Top	12b	9a	12b	10b	9a	10b
	13 January 1987					
Bottom	9a	9a	10ab	7ab	7a	15b
Middle	11a	6a	4a	6a	6a	7a
Top	16b	15b	14b	12b	17b	14b
	12 February 1987					
Bottom	6a	11ab	7a	11a	15b	15b
Middle	13ab	6a	8a	10a	7a	4a
Top	14b	15b	18b	13a	21b	18b

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[a] Egg numbers in each location represent densities per 5 cm of stem.

[b] Means within columns followed by the same letter are not significantly (P > 0.05) different.

[c] The LSD used to determine differences in locations for each date is 5, 5, and 7, respectively.

TABLE XVIII

DENSITIES OF ALFALFA WEEVIL EGGS IN ALFALFA CULTIVARS RELATIVE TO STEM POSITION, 1987-1988.[a]

	Cultivar					
Location	Advantage[b]	WL 318	Baron	WL 515	Granada	CUF 101
	4 January 1988					
Bottom[c]	7a	12a	5a	13a	9a	5a
Middle	-	9a	9a	14a	22a	21b
Top	17a	21a	31b	31b	27ab	40c
	29 January 1988					
Bottom	18a	17a	7a	11a	6a	8a
Middle	-	22a	16ab	18a	16a	18a
Top	18a	27a	27b	34b	36b	51b
	22 February 1988					
Bottom	31a	18a	6a	6a	9a	15a
Middle	-	12a	11a	7a	7a	8a
Top	21a	17a	32b	35b	41b	38b

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[a] Egg numbers in each location represent densities per 5 cm of stem.

[b] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

[c] The LSD used to determine differences in locations for each date is 14, 15, and 11, respectively.

Alfalfa weevils oviposited more in top regions of alfalfa than in other areas during 1986, 1987, and 1988 (Table XXIX). From 1986-1988, egg densities at 5 cm intervals ranged from 5 to 11 eggs/30 stems from bottom sections, 4 to 12 eggs/30 stems from middle sections, and 10 to 38 eggs/30 stems from top segments.

The location where eggs were deposited did not consistently affect the viabilities of alfalfa weevil eggs in stems. Cultivar X stem location interactions were not significant, except on 13 January 1987 and 4 January 1988. Block X stem location was used as the error term when averaging across cultivars. Block X stem location interactions were not significant on any date, with the exception of 12 January 1986.

There were no consistent trends when comparing egg viabilities among stem locations (Table XXX). In 1986, egg survival was not different among locations in early January or February, with overall means of 67 and 29%. This is because the low temperatures that occurred in December affected the eggs similarly in all locations. Eggs survived better in the bottom sections in late January 1986. Egg viabilities were high in all locations in 1987 because extreme low temperatures did not occur. Morrison and Pass (1974) reported that eggs may become inviable after being exposed to temperatures of $-20.5^{o}C$ for 24 h. Despite air temperatures that may have been detrimental to egg survival, viabilities were high in all locations in 1988 because snow

TABLE XXIX

AVERAGE NUMBER OF ALFALFA WEEVIL EGGS IN THE BOTTOM, MIDDLE, AND TOP STEM SECTIONS OF ALFALFA IN OKLAHOMA IN 1986, 1987, AND 1988.[a]

Date	Bottom	Middle	Top	S.E.
		1985-1986		
12 Jan.[b]	11a	9a	38b	± 2
31 Jan.	9a	6a	28b	± 1
20 Feb.	5a	4a	19b	± 1
		1986-1987		
13 Dec.	5a	5a	10b	± 1
13 Jan.	10ab	6a	15b	± 1
13 Feb.	11ab	6a	17b	± 1
		1987-1988		
4 Jan.	9a	12a	30b	± 2
29 Jan.	10a	12a	35b	± 2
22 Feb.	11a	6a	32b	± 2

[a] Egg numbers per 30 stems per 5 cm of stem.

[b] Means within rows followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

TABLE XXX

AVERAGE PERCENTAGE VIABILITY OF ALFALFA WEEVIL EGGS IN THE BOTTOM, MIDDLE, AND TOP STEM SECTIONS OF ALFALFA IN OKLAHOMA IN 1986, 1987, AND 1988[a].

Date	Bottom	Middle	Top	S.E.
		1985-1986		
12 Jan.	63a	66a	72a	± 3.7
31 Jan.	67 b	55a	53a	± 3.0
20 Feb.	28a	33a	26a	± 3.4
		1986-1987		
13 Jan.	79a	89b	89b	± 1.6
13 Feb.	78b	71a	73ab	± 3.5
		1987-1988		
4 Jan.	72a	81b	79ab	± 2.0
29 Jan.	79a	85b	77a	± 3.5
22 Feb.	78a	81a	78a	± 3.4

[a] Means within rows followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

insulated weevil eggs in the stems. Dormant cultivars remained succulent for a longer period and contributed to a higher egg survival.

Overall from 1986-1988, alfalfa weevils preferred to oviposit more eggs in top alfalfa stem sections (Table XXXI). In 1986, alfalfa weevils deposited an average of 29 eggs/30 stems in top sections. Egg densities were lower in all locations in 1987, with top sections having half the number of eggs than in 1986. In 1988, top segments had three times more eggs than bottom and middle regions, averaging 30 eggs/30 stems/5 cm.

Alfalfa weevil eggs had an overall viability that averaged 58% in 1986 (Table XXXII). Egg viabilities in the different stem locations were up to 23% higher in 1987 compared with 1986. In 1988, bottom and top stem sections had significantly ($\underline{F}$ = 9.47; df = 2, 10; $\underline{P} < 0.05$) lower percent viabilities than the middle section and ranged from 76 to 82%.

Discussion

The different stem diameters occurring among the cultivars in this study do not appear to influence the ovipositional activity of alfalfa weevils. Busbice et al. (1968) reported that alfalfa stems with smaller diameters had significantly fewer eggs. They used stems with diameters ranging from 1.65 to 1.90 mm. However, it was not indicated where the measurements were taken along the stem.

TABLE XXXI

ADJUSTED ALFALFA WEEVIL EGG NUMBERS IN BOTTOM, MIDDLE, AND TOP ALFALFA STEM SECTIONS, OKLAHOMA.[a]

Stem location	1986	1987	1988
Bottom[b]	11a	8ab	10a
Middle	9a	6a	11a
Top	29b	14b	30b
S.E.	1.0	0.5	1.0

[a] Egg numbers per 30 stems per 5 cm of stem.

[b] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

TABLE XXXII

YEARLY PERCENT VIABILITY OF ALFALFA WEEVIL EGGS IN BOTTOM, MIDDLE, AND TOP ALFALFA STEM SECTIONS, OKLAHOMA.

Stem location	1986	1987	1988
Bottom[a]	61a	78a	76a
Middle	56a	80ab	82b
Top	57a	81b	78a
S.E.	2.9	1.7	1.3

[a] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

The diameters of alfalfa stems are not consistent from the base to the top of plants. Average differences in diameters from the bottom to the terminal regions ranged from 0.1 to 0.7 mm. Diameters included from all cultivars and locations were between 2.1 to 3.0 mm. My results are more similar to those of Summers and Lehman (1976) who used stems with diameters between 2.0 and 4.0 mm and reported no relationship between diameters and egg numbers.

The basal stem area at crown level had relatively limited utilization as an ovipositonal site by the alfalfa weevil compared with other regions of the alfalfa stem. Approximately 10% of the mean total number of alfalfa weevil eggs were deposited in the bottom regions of alfalfa stems over the course of this study, while ca. 41 and 49 % were concentrated in the middle and top sections, respectively. These results are similar to Busbice et al. (1968) who reported 20% of alfalfa weevil eggs were deposited in the lower one-third of alfalfa plants while 45% were in the upper one-third.

Top sections were preferred more for oviposition because this region had significantly higher egg populations than bottom or middle sections when adjusted relative to plant height. Bottom stem sections probably had lower egg numbers because these regions appeared to become tougher as the plants aged. Similarly, Busbice et al. (1966) reported that as alfalfa stems matured, weevils were more likely to oviposit in apical regions. Mean total egg numbers were higher in middle regions, but after adjustment relative to plant height, egg densities were substantially lower in middle sections than in top sections. Alfalfa weevils probably preferred to oviposit more in terminal regions because these areas were more succulent early in the season. In addition, the leaves located at the top could have possibly provided a better place for protection during feeding and oviposition than at more exposed areas along the alfalfa stem.

There were virtually no significant differences in percent viabilities among the cultivars in the bottom, middle, or top sections. Thus, in a particular region of the stem, dormant and nondormant cultivars usually yielded similar numbers of viable eggs. There were some significant differences in egg survival depending on the location where eggs were deposited in the stems. This is because of variations in exposure to different weather situations and succulence of the alfalfa. Similarly, Sweetman (1932) reported that low viabilities in top regions of alfalfa were produced by a dry environment. Over the course of this study, viability of eggs in bottom sections averaged 68%, while middle and top sections averaged 70 and 68%, respectively. Egg viabilities were different between years in the bottom, middle, and top stem locations as was expected due to the variable environmental conditions.

Conclusions

Alfalfa weevils did not prefer to oviposit in the basal regions at crown level, but instead deposited more eggs in the terminal sections of alfalfa stems. Top stem sections also had significantly greater egg numbers at 5 cm intervals than middle segments. Differences in stem diameters occurred between locations among the cultivars; however, these differences were quite small and probably did not influence oviposition because no consistent trends were evident. There was little difference in egg populations within stem locations among the cultivars. Percent viabilities were usually similar among cultivars in a particular stem location. Some differences in viability were evident between the bottom, middle, and top locations. These may be attributable to variations in alfalfa moisture content and exposure to different weather conditions.

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CHAPTER VI

PRODUCTIVITY OF ALFALFA CULTIVARS WITH DIFFERENT DORMANCIES AND POPULATIONS OF ALFALFA WEEVIL LARVAE (COLEOPTERA: CURCULIONIDAE)

Introduction

Alfalfa (Medicago sativa L.) grown in the United States has been developed to exhibit different growth characteristics or dormancies which allow better adaptation to a particular area. These distinct types of fall dormancy are dependent on daylength and temperature (McKenzie 1988) and involve the temporary suspension of visible growth (Lang 1987). In addition, fall dormancy can be used as an indication of a plant's ability to survive the winter environment (Viands and Teuber 1985) because fall dormancy and cold hardiness in alfalfa are known to be positively correlated (Kohel and Davis 1960; Smith 1961).

Alfalfa cultivars can be classified according to dormancy type which is estimated based on the amount of fall growth after a last harvest. They include dormant, moderately dormant, and nondormant cultivars. Dormant cultivars stop growing early in fall, are able to survive cold winters, and initiate regrowth later in spring. Nondormant cultivars continue to grow later in the fall, are easily killed by low temperatures, and begin regrowth earlier in spring than dormant cultivars. Moderately dormant alfalfas possess growth characteristics that are intermediate between dormant and nondormant cultivars.

Alfalfa cultivars that are more dormant are not always desirable for maximum production. Elliot et al. (1972) and Sarraf (1985) have reported that increased yields of alfalfa have been found to be associated with reduced winter dormancy. However, in areas where winters are not too severe, it is uncertain how dormant and nondormant cultivars compare in productivity.

The alfalfa weevil (_Hypera_ _postica_ Gyllenhal) has caused serious damage to alfalfa and great economic loss in Oklahoma since 1972 (Berberet et al. 1980). Predictable reductions in alfalfa yield by weevil larvae have been shown by several researchers (Liu and Fick 1975, Hintz et al. 1976). A reduction of 188 kg/ha of alfalfa is expected for the first alfalfa crop in Oklahoma for each larva per stem (Berberet et al. 1981). Alfalfa weevil larvae are known to significantly reduce stem length, dry weight, forage yields, and quality of first harvest alfalfa (Wilson and Quisenberry 1986). Similarly, larval densities exceeding the economic threshold have been shown to decrease stem density by 33% and reduce stem height and moisture content of alfalfa (Godfrey and Yeargen 1987).

In southern regions of the United States where the alfalfa weevil oviposits from October through April, nondormant alfalfa cultivars tend to have greater egg and larval densities than more dormant ones (Reid et al. 1989). It is not certain how the productivity of alfalfa cultivars with different dormancies compare under varying larval populations. Thus, the objectives were to compare the yield, stand retention, and quality of alfalfa cultivars with different dormancies under weevil-infested and uninfested treatments.

Materials and Methods

Alfalfa was planted at the Agronomy Research Station at Stillwater, Oklahoma on 17 September 1985 on a Pulaski fine sandy loam soil. Six cultivars were planted with a five row planter at a rate of 18.0 kg/ha. Irrigation was used after planting and at later dates as needed. The amount of fall growth after the last harvest in September was used to estimate the dormancy of the cultivars. 'Advantage' and 'WL 318', the most dormant cultivars, had the least growth in fall. Cultivars classified with intermediate growth and estimated as moderately dormant were 'Baron' and 'WL 515'. The cultivars, 'Granada' and 'CUF 101', had the greatest amount of fall growth and were grouped as nondormant.

The cultivars were grown under weevil-infested and uninfested treatments. In each treatment area, the plots were arranged in a randomized complete block design. In the weevil-infested area, the plots were 3.4 X 5 m , where 2.4 X 5 m of this was used for sampling. The remaining 1 X 5 m portion was used only for yield estimates. Adjacent plots in the uninfested area were 1 X 5 m.

Natural weevil infestations were allowed to build up after the seedling year in the weevil-infested plots only. Alfalfa weevil populations were controlled with carbofuran at 1.12 kg (AI)/ha after peak larval infestations threatened complete destruction of alfalfa foliage in the 2nd and 3rd years. In the uninfested area, weevil populations were controlled at the first sign of damage.

Population densities of weevil larvae were estimated at the first sign of damage in March 1987 and 1988. Subsequent samples were taken every 100 DD above the developmental threshold of 10°C (50°F) accumulated from 1 January. A 30 stem sample was randomly pulled from each plot on each date in March and April. Plant height was estimated at the time of sampling from 10 stems/plot. Larvae were extracted with Standard berlese funnels and stored in 50% ethyl alcohol for counting and separation into instars by head capsule size.

Effects of larval feeding and evidence of any tolerance among the cultivars were determined by visually rating a random group of 30 stems per plot for damage. All plots were rated for damage using a scale based on the amount of foliage consumed (Armbrust et al. 1966). A rating from 1 to 9 was given each plot, with 1=undamaged and 9=100% defoliation.

To assess the effects of weevil-infested vs. uninfested plots, estimations of stand density were made by counting alfalfa stems in five 0.3 m row samples per plot. Counts were made in November, and before first and second harvest of each year. The rate of decline in stem densities was compared among the cultivars to determine whether a particular alfalfa dormancy level is better adapted for production in Oklahoma.

Yield estimates were made from the weevil-infested and uninfested areas at five harvests per season with each taken at approximately the 10% bloom stage using a Carter-flail type harvester. Green forage from a 1 X 5 m section was weighed from each plot. A 300 to 500 g subsample of alfalfa was oven-dried from each plot to estimate the percent dry matter. A portion of the dried subsample was used to measure crude protein for each cultivar.

All data were subjected to analysis of variance (SAS Institute Inc. 1985) and differences between means were tested for significance ($\underline{P} < 0.05$) with the Duncan's Multiple Range (1955) test.

Results

In 1987 and 1988, alfalfa weevil larvae reached densities in the infested area that were above the economic threshold of 1.5 larvae per stem in Oklahoma. Nondormant cultivars had higher numbers of larvae than dormant ones. Populations at peak infestations ranged from 8 per stem in 'Advantage' to a high of 13 larvae per stem in 'CUF 101'. In 1988, 'WL 318' reached peak populations estimated at 5 per stem while 'Granada' had 10 larvae per stem.

The alfalfa cultivars showed variations in the amount of damage caused by larval feeding, primarily because of differences in larval populations. Peak infestations occurred by 13 April and damage ratings ranged from 4.7 in 'WL 318' to 5.8 in 'CUF 101' (Table XXXIII). In 1988, the nondormant cultivars were more heavily damaged by larval feeding than the dormant cultivars. By 11 April, 'Advantage' and 'WL 318' had significantly ($F = 22.5$; df = 5, 25; $P > 0.05$) less damage than the moderately dormant and nondormant cultivars and ratings ranged from 4.5 to 7.8 (Table XXXIV). After peak infestations occurred, the plots were sprayed with carbofuran and allowed to grow before a first harvest.

Plant height measurements before first harvest indicated that 'Advantage' and 'WL 318' had significantly ($F = 54.15$; df = 5,25; $P > 0.5$) greater alfalfa growth after larval feeding than the other cultivars (Table XXXV) and heights ranged from 45 cm in 'WL 515' to 60 cm in 'Advantage'. Cultivars were up to 33 cm taller in the uninfested area. The effect of larval damage on plant height at first harvest was less for the dormant cultivars. The average difference in height between the two treatments was only 10 cm for 'Advantage' while averaging 32 cm for the moderately dormant and nondormant cultivars. The difference in growth was greater for the less dormant cultivars, in part, because the nondormant cultivars in the weevil-

TABLE XXXIII

DAMAGE RATINGS[a] OF SEVERAL ALFALFA CULTIVARS FROM LARVAL INFESTATIONS OF THE ALFALFA WEEVIL IN 1987, OKLAHOMA.

	Date		
Cultivar	21 March	3 April	13 April
Advantage[b]	2.0a	3.9ab	4.8ab
WL 318	2.0a	3.7a	4.7a
Baron	2.1a	4.5bc	5.5ab
WL 515	2.0a	4.2abc	5.3ab
Granada	2.0a	4.3abc	5.4ab
CUF 101	2.1a	4.8b	5.8b
S.E.	0.05	0.2	0.3

[a] Damage rating from 1 to 9, where 1=no damage and 9=100% defoliation.

[b] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

TABLE XXXIV

DAMAGE RATINGS[a] OF SEVERAL ALFALFA CULTIVARS FROM LARVAL INFESTATIONS OF THE ALFALFA WEEVIL IN 1988, OKLAHOMA.

	Date		
Cultivar	24 March	4 April	11 April
Advantage[b]	2.3ab	4.3a	5.1a
WL 318	2.2a	4.3a	4.5a
Baron	2.8bc	5.7b	6.5b
WL 515	3.0 c	5.9bc	6.3b
Granada	3.3 c	5.9bc	7.5c
CUF 101	3.2 c	6.3 c	7.8c
S.E.	0.2	0.2	0.3

[a] Damage rating from 1 to 9, where 1=no damage and 9=100% defoliation.

[b] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

TABLE XXXV

HEIGHT OF SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1987, OKLAHOMA

	13 May 1987			19 June 1987		
Cultivar	WI[a]	UN	Diff.	WI	UN	Diff.
Advantage	60b	80ab	10a	66b	71b	5a
WL 318	59b	82b	23b	64b	68ab	4a
Baron	50a	82b	32c	58a	68ab	10b
WL 515	45a	77a	32c	55a	65a	10b
Granada	48a	79ab	31c	54a	70ab	16c
CUF 101	49a	82b	33c	54a	72b	18c
S.E.	2.1	1.2		1.5	1.6	

[a] Means within columns followed by the same letter are not significantly ($\underline{P} > 0.05$) different.

infested area could not survive the freezing temperatures that occurred in late March as well as the dormant cultivars and those in the uninfested area.

Cultivars from the weevil-infested area were 5 to 10 cm taller by second harvest. The dormant cultivars again had more growth than the other cultivars. In the uninfested area, plant heights ranged from 65 cm in 'WL 515' to 72 cm in 'CUF 101'. The residual effects of larval feeding was less by second harvest. The average difference in plant heights between the weevil-infested and uninfested area ranged from 4 to 18 cm.

In 1988, the dormant cultivars in the weevil-infested area had taller growth than the nondormant cultivars before first and second harvests (Table XXXVI). Again freezing temperatures occurred in the spring which killed the growth of the nondormant cultivars in the weevil-infested area. This suggests that the growth of dormant cultivars damaged by alfalfa weevil larvae in spring can survive freezing temperatures better than nondormant cultivars. The average difference in amount of growth between the treatments ranged from 6 to 18 cm at first harvest and 1 to 12 cm at second harvest.

Stem densities for each cultivar between the two treatments were essentially the same in October 1986. Stem densities ranged from 22 stems/0.3 row m in 'Advantage' to 15 stems/0.3 row m in 'CUF 101' (Table XXXVII). By May 1987, stem densities were lower in the weevil-infested area

TABLE XXXVI

HEIGHT OF SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1988, OKLAHOMA.

	18 May 1988			22 June 1988		
Cultivar	WI[a]	UN	Diff.	WI	UN	Diff.
Advantage	71d	81c	10b	81b	85ab	4b
WL 318	69cd	75b	6a	81b	82ab	1a
Baron	64b	75b	11b	77a	83ab	6bc
WL 515	66bc	72ab	6a	81b	85ab	4b
Granada	55a	69a	14c	74a	81a	7c
CUF 101	56a	74b	18c	74a	86b	12d
S.E.	1.2	1.3		1.1	1.6	

[a] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

TABLE XXXVII

STEM DENSITIES[a] FOR SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1987, OKLAHOMA.

	Date								
	30 October[b]			13 May			15 June		
Cultivar	WI	UN	Diff.	WI	UN	Diff.	WI	UN	Diff.
Advantage	22a	21a	1a	23c	21b	2a	22d	26c	4ab
WL 318	18b	19ab	1a	20c	24b	4a	20cd	22ab	2a
Baron	18b	17ab	1a	15b	22b	7b	17c	23abc	6bc
WL 515	18b	18ab	0a	13ab	22b	9b	17c	23abc	6bc
Granada	17b	17ab	0a	10a	17a	7b	13b	20a	7c
CUF 101	15b	15b	0a	9a	16a	7b	9a	24bc	15d
S.E.	1.2	1.2		1.3	1.3		1.0	1.0	

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[a] Stem density=number of stems/0.3 row m.

[b] Means within columns followed by the same letter are not significantly (P > 0.05) different.

for all the cultivars except 'Advantage' and 'WL 318'. In the uninfested area, the cultivars had the same or higher numbers of stems than were present in October. The average difference between the treatments in May indicate that the stem densities of the dormant cultivars were not affected as much from larval feeding as the moderately dormant and nondormant cultivars. However, because freezing temperatures in late March killed the growth of the less dormant cultivars, the degree to which only the larvae had on reducing the stand can not be determined. The cultivars recovered slightly from weevil damage in the infested area because all the cultivars except 'CUF 101' had increased stem densities by 15 June.

The cultivars had lower stem densities in both treatments by 13 November 1987 (Table XXXVIII). In May 1988, densities ranged from 7 to 16 stems/0.3 row m in the weevil-infested area and from 12 to 16 stems/0.3 row m in the uninfested treatment. The dormant cultivars in both treatments had greater stem densities compared to the other cultivars. The stands changed little by June and 'CUF 101' had the greatest difference in stem densities between treatments.

Alfalfa weevils had an effect on the productivity of the cultivars. At first harvest in 1987, dormant cultivars yielded significantly ($\underline{F} = 31.00$; df = 5, 25; $\underline{P} > 0.05$) more alfalfa than the moderately dormant and nondormant cultivars in the weevil-infested area, ranging from 4.6 Tm/ha in

TABLE XXXVIII

STEM DENSITIES[a] FOR SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1988, OKLAHOMA.

	Date								
	13 November[b]			17 May			15 June		
Cultivar	WI	UN	Diff.	WI	UN	Diff.	WI	UN	Diff.
Advantage	12ab	12a	0a	16c	16c	0a	15d	16c	1ab
WL 318	13b	16a	3a	16c	15bc	1ab	14cd	14bc	0a
Baron	12ab	12a	0a	12b	14abc	2b	13cd	12ab	1ab
WL 515	14b	17a	3a	12b	16c	4c	12c	14bc	2ab
Granada	11ab	13a	2a	8a	13ab	5c	9b	12ab	3bc
CUF 101	9a	15a	6b	7a	12a	5c	5a	10a	5c
S.E.	0.9	1.7		0.9	0.9		0.8	1.1	

[a] Stem density=number of stems/0.3 row m.

[b] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

'Advantage' to 1.9 Tm/ha in 'CUF 101' (Table XXXIX). In the uninfested area, the cultivars produced 6.0 to 4.1 Tm/ha of alfalfa and were significantly (*F* = 114.07; df = 1, 8; *P* > 0./05) higher than the cultivars in the weevil-infested area. The dormant cultivars had the lowest difference between treatment. By second harvest, most cultivars in the weevil-infested area had recovered slightly from larval damage. However, 'CUF 101' yielded much lower amounts of alfalfa than the other cultivars. This is also true in the uninfested area. Feeding by the alfalfa weevil appeared to affect the overall productivity of the dormant cultivars less than the other cultivars.

The productivity of the cultivars was affected by larval feeding at first harvest in 1988 (Table XL). The average difference between the treatments ranged from 1.3 to 2.7 Tm/ha. The cultivars in the weevil-infested area continued to yield significantly (*F* = 42.52; df = 1,8; df = *P* > 0.05) lower amounts of alfalfa at second harvest than those in the uninfested area. The total yields of cultivars in the infested area ranged from 16.3 to 9.6 Tm/ha, while those in the uninfested area produced 20.6 to 15.4 Tm/ha.

The crude protein contents of some cultivars from the weevil-infested area in May 1987 were significantly (*F* = 12.44; df = 1, 8; *P* > 0.05) higher than those in the uninfested area (Table XLI). The crude protein content averaged 21% in the weevil-infested area while averaging only 19% in the uninfested area. By second harvest, crude

TABLE XXXIX

PRODUCTIVITY (Tm/ha) OF SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1987, OKLAHOMA.

	1ST Harvest[a]			2ND Harvest			Total (5 Cuts)		
Cultivar	WI	UN	Diff.	WI	UN	Diff.	WI	UN	Diff.
Advantage	4.6c	6.0b	1.4a	4.7e	4.6c	0.1a	15.9d	17.5b	1.6a
WL 318	4.3c	5.9b	1.6a	4.2d	4.3c	0.1a	15.5cd	17.1b	1.6a
Baron	3.1b	5.7b	2.6b	3.4c	3.9b	0.5b	12.5bcd	16.7b	4.2b
WL 515	2.2a	5.7b	3.5c	3.1c	3.9b	0.8bc	12.1abc	17.6b	5.5c
Granada	2.3a	4.5a	2.2b	2.6b	3.6b	1.0c	10.3ab	14.8a	4.5bc
CUF 101	1.9a	4.1a	2.2b	2.0a	3.2a	1.2c	8.7a	13.9a	5.2bc
S.E.	0.2	0.3		0.1	0.1		0.6	0.5	

[a] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

TABLE XL

PRODUCTIVITY (Tm/ha) OF SEVERAL ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1988, OKLAHOMA.

	1ST Harvest[a]			2ND Harvest			Total (5 Cuts)		
Cultivar	WI	UN	Diff.	WI	UN	Diff.	WI	UN	Diff.
Advantage	5.1d	7.1b	2.0b	4.9e	6.1bc	1.2ab	16.0 c	20.6ab	4.6b
WL 318	5.2d	6.5b	1.3a	4.7de	5.8bc	1.1a	16.3 c	19.8ab	3.5a
Baron	4.0c	6.5b	2.5cd	4.0cd	5.6b	1.6bc	14.2bc	20.5ab	6.3cd
WL 515	4.0c	6.7b	2.7d	4.4c	6.5c	2.1c	15.0bc	22.0b	7.0d
Granada	3.0b	5.1a	2.1bc	3.4b	4.5a	1.1a	12.4ab	16.2ab	3.8ab
CUF 101	2.2a	4.4a	2.2bc	2.3a	4.3a	2.0c	9.6a	15.4a	5.8c

[a] Means within columns followed by the same letter are not significantly (*P* > 0.05) different.

TABLE XLI

CRUDE PROTEIN CONTENT (%) OF ALFALFA CULTIVARS UNDER ALFALFA WEEVIL-INFESTED (WI) AND UNINFESTED (UN) CONDITIONS IN 1987, OKLAHOMA.

	Date					
	13 May 1987			19 June 1987		
Cultivar	WI[a]	UN	Diff.	WI	UN	Diff.
Advantage	21a	20a	1a	18a	18a	0a
WL 318	21a	19a	2ab	18a	19a	1ab
Baron	22a	19a	3b	16a	19a	3c
WL 515	22a	19a	3b	17a	19a	2bc
Granada	21a	20a	1a	17a	18a	1ab
CUF 101	21a	19a	2ab	17a	19a	2bc
S.E.	0.5	0.4		0.5	0.5	

[a] Means within columns followed by the same letter are not significantly ($P > 0.05$) different.

protein contents were lower in both treatments, averaging 17% in the weevil-infested area and 19% in the uninfested treatment.

Discussion

Larval population densities were higher in the nondormant cultivars and because of these larger densities, damage was greater in the nondormant cultivars. Damage to the nondormant cultivars was estimated an average of only one point higher than 'Advantage' and 'WL 318' in 1987 on the nine point rating scale. Because the larvae feed in the terminals, damage in this area is not yet exposed when ratings occur. Increased damage would be evident after the last rating. The dormant cultivars were able to recover more quickly after larval infestations were controlled and these cultivars produced more growth than the moderately and nondormant cultivars.

Freezing weather occurred unusally late in the spring of 1987 and 1988, producing pronounced differences between treatments. In the weevil-infested area, the leaves of the dormant cultivars became frosted at the tips and the growth of the nondormants was killed each year. The uninfested plots appeared to recover fully from the freezing temperatures. Because both treatments were exposed to the low temperatures, feeding by alfalfa weevil larvae definitely effected the growth of the cultivars before first harvest and had a residual effect on the growth at second harvest. Alfalfa under severe alfalfa weevil larval infestations have been reported to decrease growth by 8.5 cm in the first crop (Godfrey and Yeargan 1987). Berberet et al. (1981) reported that decreased growth does occur in the second crop although virtually all weevil feeding happens before first harvest.

The dormant cultivars reacted favorably under larval infestations by producing axillary branching or new crown buds. Godfrey and Yeargan (1987) reported that moderate larval feeding below the economic threshold increased stem density by 25.5 stems/0.25 m^2 because destruction of the terminal buds promoted development of lateral buds into additional stems.

Freezing temperatures in late March and April of each year in addition to the higher larval populations contributed to lower stems densities in the nondormant cultivars. The nondormant cultivars had the greatest difference in stem densities compared to the other cultivars. Reductions in stand densities have been observed in second crops of alfalfa although damage does occur prior to first harvest (Berberet et al. 1981).

Dramatic differences in production were evident between the treatments because of feeding by alfalfa weevil larvae and the late spring freezes, particularly for the nondormant cultivars. The cultivars in the uninfested area produced up to 2.0 times more at first harvest than in the weevil-infested area. The nondormant cultivars appeared to perform poorly when exposed to late freezes in combination with larval feeding. According to Berberet et al. (1981), alfalfa yields can decrease ca. 188 kg/ha for each addition of one larvae per stem. Wilson and Quisenberry (1986) reported that feeding by alfalfa weevil larvae significantly reduced forage yields of the first harvest.

The crude protein contents of the cultivars were high in the weevil-infested area although larvae had damaged the alfalfa. This is because of differences in the maturities of the cultivars in the two areas. Alfalfa herbage at comparable maturity stages are known to have similar quality (Sanderson and Wedin 1988) and leaf tissue is higher in crude protein than stems (Fick and Holthausen 1975). Crude protein at second harvest was significantly lower from cultivars in the weevil-infested area. This is in contrast to Wilson and Quisenberry (1986) who reported that plots with alfalfa weevil larval damage had significantly higher crude protein contents at second harvest than noninfested plots. Berberet and McNew (1986) reported that no consistent trends in crude protein were detectable over a wide range of damage levels.

Conclusions

Nondormant cultivars had higher larval populations and greater damage than dormant cultivars. Less-dormant cultivars performed poorly when exposed to late freezes in combination with larval feeding. The dormant cultivars in the weevil-infested area were affected less by alfalfa weevil larvae because plant heights, stem densities, and total yields were significantly higher than the nondormant cultivars in 1987 and 1988.

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