Evaluation of Low Input Pecan Orchard Floor Management Systems

N.R. Rice, M.W. Smith, R.D. Eikenbary, Don C. Arnold,

Oklahoma State University, Stillwater, OK.

W.L. Tedders, B.W. Wood,

USDA/ARS, Byron, GA.

G.G. Taylor, B.S. Landgraf, G.E. Barlow,

Noble Foundation, Ardmore, OK.

Abstract

Legume ground covers were evaluated in pecan (*Carya illinoinensis*) orchards to reduce nitrogen inputs and increase beneficial arthropods. Treatments were established at two sites in Oklahoma, each with 5 ha of a 'Dixie' crimson clover (*Trifolium incarnatum*)/hairy vetch (*Vicia villosa*) mixture and 5 ha of grass sod. Nitrogen was applied at 0-200 kg·ha^{-1} N in 50 kg intervals to the trees in the grass plots but legume plots were not fertilized. Aphids and selected arthropods were monitored on ground covers and in the pecan canopies. A mixture of crimson clover/hairy vetch supplied up to 186 kg·ha^{-1} N to the pecan trees. Beneficial arthropods monitored were lady beetles and green lacewings. Lady beetles were the most important aphid predator in the spring, and green lacewing (*Chrysopa* and *Chrysoperla* spp.) was the most important fall predator. *Coleomegilla maculata lengi*, *Hippodamia convergens* and *Coccinella septempunctata* were the most abundant lady beetle species in the legume ground covers, and *Olla v-nigrum*, *Cycloneda munda*, and *Hippodamia*

convergens were the most abundant species in the pecan canopies. There were fewer aphids infesting pecan trees using a crimson clover/hairy vetch ground cover than a grass sod.

Introduction

Legumes were once commonly used in pecan orchards as cover or green manure crops before the widespread access to inexpensive synthetic N fertilizers in the 40's and 50's (Tedders, 1983). Since nitrogen rates are high and soil water tables usually shallow in pecan producing areas, the potential for groundwater and surface water contamination by nitrate is high. Pecan growers use intense pest control programs with 8 to 10 insecticide applications in the southeastern U.S. and 5 to 7 insecticide applications in the southcentral U.S. (Tedders, 1983; Bugg et al., 1991). The frequent use of certain insecticides has led to pesticide resistance, especially in aphids (Dutcher and Htay, 1985), necessitating even more insecticide applications. Insecticide use also leads to the outbreak of secondary pests and reduces native beneficial arthropod populations that act as a natural control of pecan pests in the orchard (Mizell, 1991). Also few pesticides are available and even fewer new ones are being registered for pecan use (Mizell, 1990). Lower pesticide and N fertilizer usage would reduce the possibility of water contamination and negative environmental effects (Lee, 1992). This might be accomplished by integrated management using legume ground covers in pecan orchards (Blackmon, 1948; Bugg et al., 1991). The N fixed by legumes can range upto several hundred kg/ha of N (Erdman, 1967). Legumes which harbor large aphid populations attract beneficial arthropods which can control pecan aphids (Tedders, 1986) and other pests (Tedders, 1983).

In a preliminary study, a legume mixture of 'Dixie' crimson clover and hairy vetch was chosen for evaluation as a pecan orchard groundcover. Crimson clover and hairy vetch are well-adapted to Oklahoma growing conditions and both have high N fixation rates. Both legumes harbor large populations of blue alfalfa aphid (*Acrthosiphon kondoi*), pea aphid (*Acyrthosiphon pisum*) and cowpea aphid (*Aphis craccivora*), which are not pests of pecans. These high aphid populations attract beneficial arthropods into the orchard where they rapidly multiply on the abundant food source. When their food source (aphids on the legumes) is depleted, the beneficial arthropods migrate to the pecan canopies, thus controlling pecan aphids (*Monelliopsis pecanis*, *Monellia caryella* and *Melanocallis caryaefoliae*).

Materials and Methods

This study was conducted at two sites in Oklahoma, Knight Creek Farm located in central Oklahoma and Noble Foundation Research Ranch located in southern Oklahoma. Both sites contain native pecan trees. A mixture of hairy vetch and 'Dixie' crimson clover was seeded annually during September at 8 kg/ha and 18 kg/ha, respectively. At both sites 5 ha of bermudagrass (*Cynodon dactylon*) was left intact as the control plot. Legume and control plots were separated by 0.5 to 1.5 kms. Ammonium nitrate was applied at 0, 50, 100, 150 or 200 $kg \cdot ha^{-1}$ N to the grass sodded areas during February. No nitrogen was applied to the legume plots. Arthropods in the legumes were sampled at seven to 10 day intervals, April thru June, using sweep nets. Ten sweeps per replication with 5 replications per legume plot were collected. The arthropods monitored were aphids (Homoptera: Aphididae), lady beetles (*Hippodamia convergens*, *Coccinella septempunctata*, *Coleomegilla*

maculata lengi, *Cycloneda munda*, *Olla v-nigrum*, Coleoptera: Coccinellidae), green lacewings (*Chrysoperla* and *Chrysopa* spp., Neuroptera: Chrysopidae), and stink bugs (Hemiptera: Pentatomidae). Arthropod samples from the tree canopy were collected at seven to 10 day intervals, May thru September, by vaccuum sampling tree limbs. Five 0.1 m^2 areas per tree on five trees, both in the legume and grass plots, were sampled on each date. Arthropods monitored in the tree canopy were the same as those in the legumes. Aphids (*Monelliopsis pecanis*, *Monellia caryella* and *Melanocallis caryaefoliae*, Homoptera: Aphididae) were counted on ten leaves per tree on five trees at 7-10 day intervals.

Pecan leaf samples (middle leaflet pair from the middle leaf on current season's growth) were collected during July from 10 trees in the legume plots and 50 trees in grass plots with known nitrogen application rates (10 trees/N rate), then dried, ground to pass a 20-mesh screen and analyzed for nitrogen using the macro-Kjeldahl method. Stink bug damage was monitored by harvesting two 20-nut samples per tree on 10 trees each from legume and grass plots and analyzing for stink bug damage (black spots on the kernels).

Results and Discussion

The main type of aphids found on the legumes were pea aphids, with smaller populations of cowpea aphid and blue alfalfa aphid (data not shown). These aphids are not pests of pecan trees, but sustain beneficial arthropod populations. Aphid populations were highest during April, then decreased (Fig. 1 and 2). Differences in aphid populations on the legumes between 1992 and 1993 can be attributed to rainfall.

Lady beetle adult and larval populations on the legumes at both sites in 1993 are shown on Fig.3 and Fig.4. The primary peak in larval and adult populations at Knight Creek Orchard occurred in May (Fig. 3) and was associated with an increase in the aphid population (Fig. 1). The second peak in larvae was not associated with legume aphid populations but appeared to be associated with the tarnish plant bug nymph population on the legumes (data not shown). Tarnish plant bugs are not harmful to pecan trees, but can serve as a food source for certain beneficial arthropods. At Knight Creek Orchard *Coleomegilla maculata lengi* was the most abundant lady beetle in the legumes (50%) followed by *Hippodamia convergens* (26%), *Coccinella septempunctata* (14%) and lastly *Cycloneda munda* (9%)(Fig. 3). At Noble Foundation Orchard the peak in larval population was associated with the aphid population on the legumes (Fig. 2 and 4). *Hippodamia convergens* (43%) was the most abundant lady beetle species followed by *Coccinella septempunctata* (23%), *Coleomegilla maculata lengi* (22%), with small populations of *Cycloneda munda* (10%) and *Olla v-nigrum* (2%)(Fig. 4).

Lady beetle species found in the pecan canopies differed from those in the legumes. At Knight Creek Orchard 57% of the lady beetles sampled in the pecan canopy were *Cycloneda munda* (Fig. 5) compared to 9% *Cycloneda munda* found in the legumes (Fig. 3). *Olla v-nigrum* and *Hippodamia convergens* followed as the second and third most abundant species found in the pecan canopies at both sites (Fig. 5). Even though a large percentage of the lady beetles were *Coleomegilla maculata lengi* and *Coccinella septempunctata* in the legumes, they do not appear to play as important a role in aphid control in the pecan canopies. *Cycloneda munda*, *Olla v-nigrum* and *Hippodamia convergens* were the predominant lady beetle species in pecan canopies.

Green lacewing adult and larval populations on the legumes peaked in late May, and as the legumes senesced the first week of June, their populations declined (Fig. 6). At the same time there was a peak in the green lacewing population in the pecan canopies with the crimson clover/hairy vetch as the groundcover and a slight population increase in the control plot (Fig. 6). During mid-summer green lacewing populations decreased which was associated with a low aphid population in the pecan canopy. A green lacewing population increase in the Fall, was associated with an increase in the aphid population in the pecan canopy.

Early season peaks in pecan aphids were higher in the grass control plots than the legume plots (Fig. 7). This coincided with a migration of green lacewings from the crimson clover/hairy vetch groundcover into the pecan canopy (Fig. 6). The mid-summer aphid population declined in both areas. In the Fall a second aphid build-up occurred and was also associated with the Fall peak in green lacewings (Fig. 6 and 7).

The stink bug population in the pecan canopies was extremely low (Fig. 8). Damaged nuts were minimal with $< 1\%$ of the nuts damaged by stink bugs from the crimson clover/hairy vetch plots. There were no significant differences in stink bug damage between the grass and legume treatments (data not shown).

Regression analysis was used to determine the relationship between the leaf N concentration and N application rate. Then apparent N supplied by the legume mixture was calculated from the equation describing the relationship. At Knight Creek Orchard the legume mixture supplied the equivalent of 186 $kg \cdot ha^{-1}$ N (166 lb/A N) in 1992 (Fig. 9).

In summary, a crimson clover/hairy vetch ground cover increased certain beneficial arthropods. These beneficials suppressed pecan aphid populations; however, data are inconclusive. The crimson clover/hairy vetch mixture supplied over 150 kg/ha of N.

Literature Cited

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Fig. 1. Aphid populations on 'Dixie' crimson clover/hairy vetch at Knight Creek Orchard, 1992 & 1993.

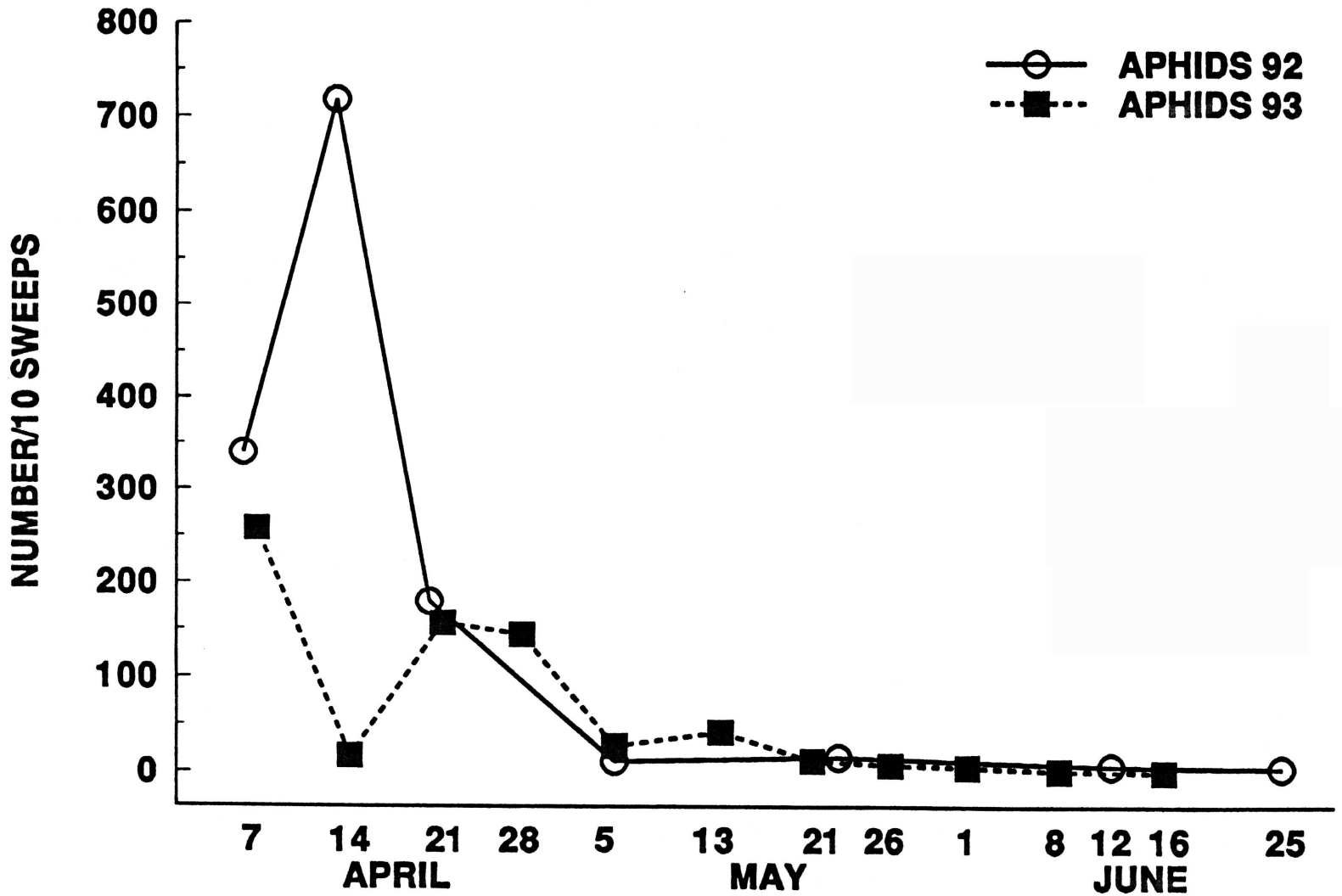

APHIDS 92
APHIDS 93
NUMBER/10 SWEEPS
800
700
600
500
400
300
200
100
0
7
14
21
28
5
13
21
26
1
8
12
16
25
APRIL
MAY
JUNE

Fig. 2. Aphid populations on 'Dixie' crimson clover/hairy vetch at Knight Creek Orchard, 1992 & 1993

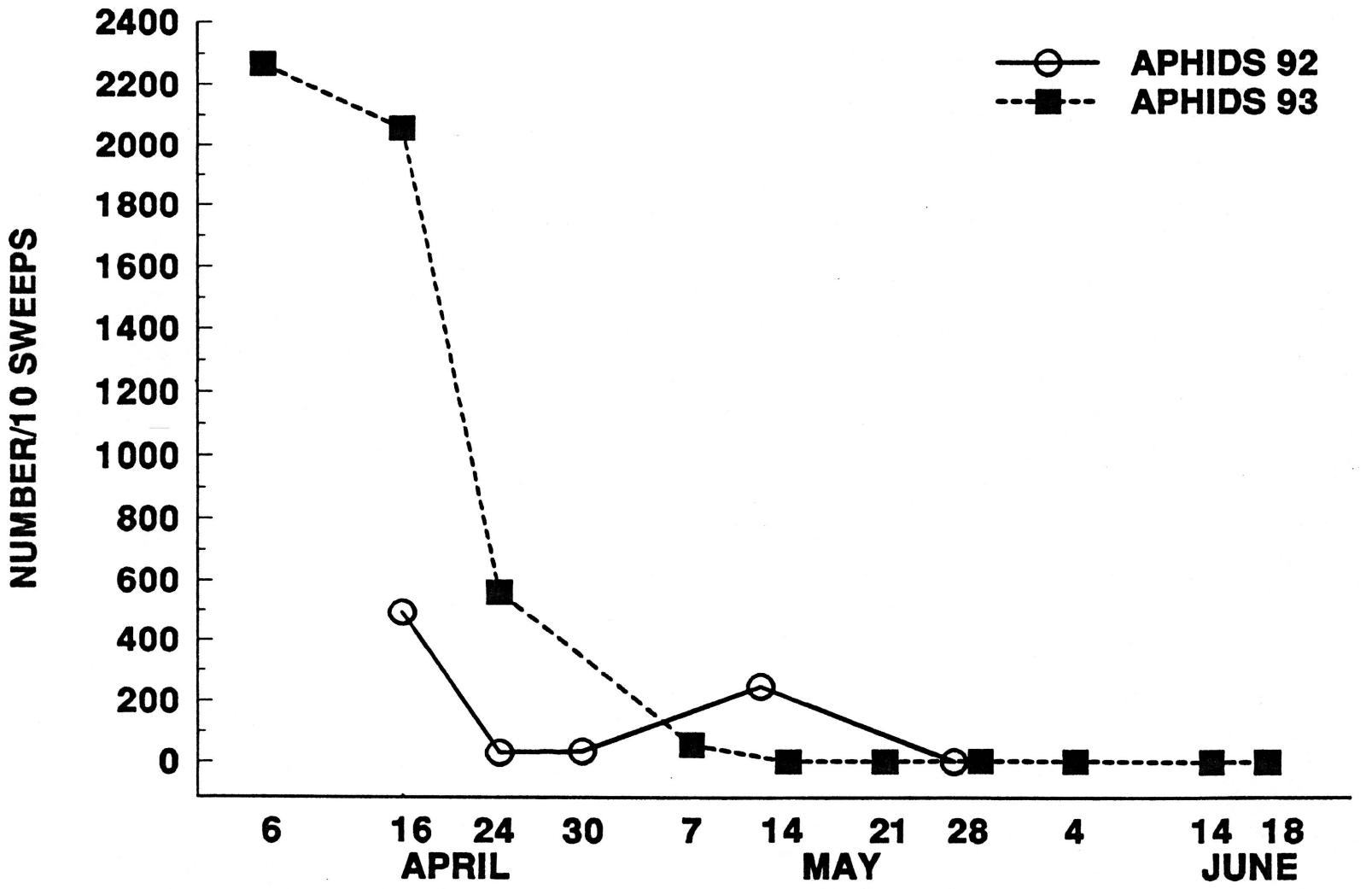

APHIDS 92
APHIDS 93
NUMBER/10 SWEEPS
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
6
16
24
30
7
14
21
28
4
14
18
APRIL
MAY
JUNE

Fig. 3. Lady beetles on 'Dixie' crimson clover/hairy vetch at Knight Creek Orchard, 1993.

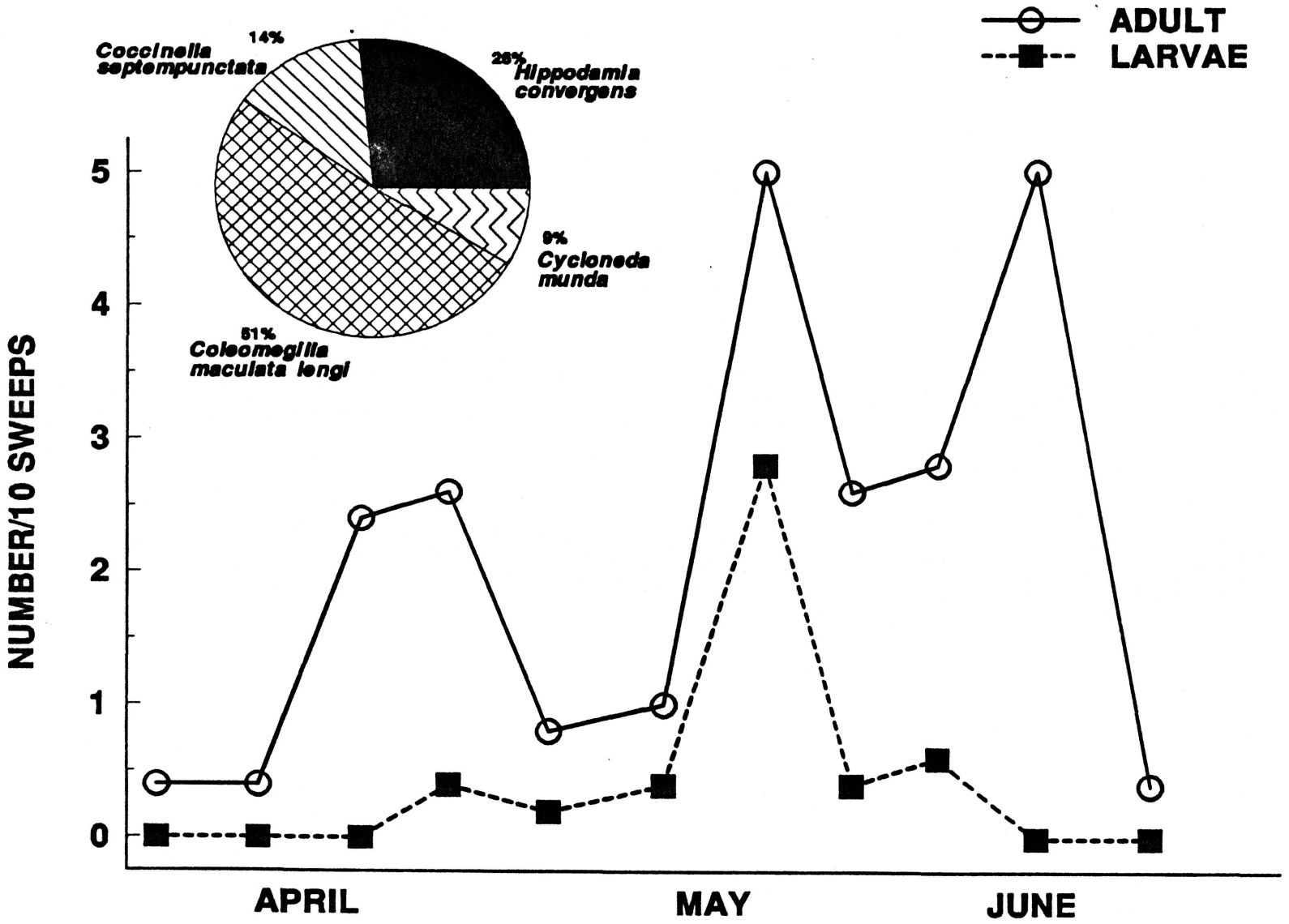

ADULT
LARVAE
NUMBER/10 SWEEPS
0
1
2
3
4
5
APRIL
MAY
JUNE
14%
Coccinella septempunctata
28%
Hippodamia convergens
9%
Cycloneda munda
51%
Coleomegilla maculata lengi

Fig. 4. Lady beetles on 'Dixie' crimson clover/hairy vetch at Noble Foundation Orchard, 1993.

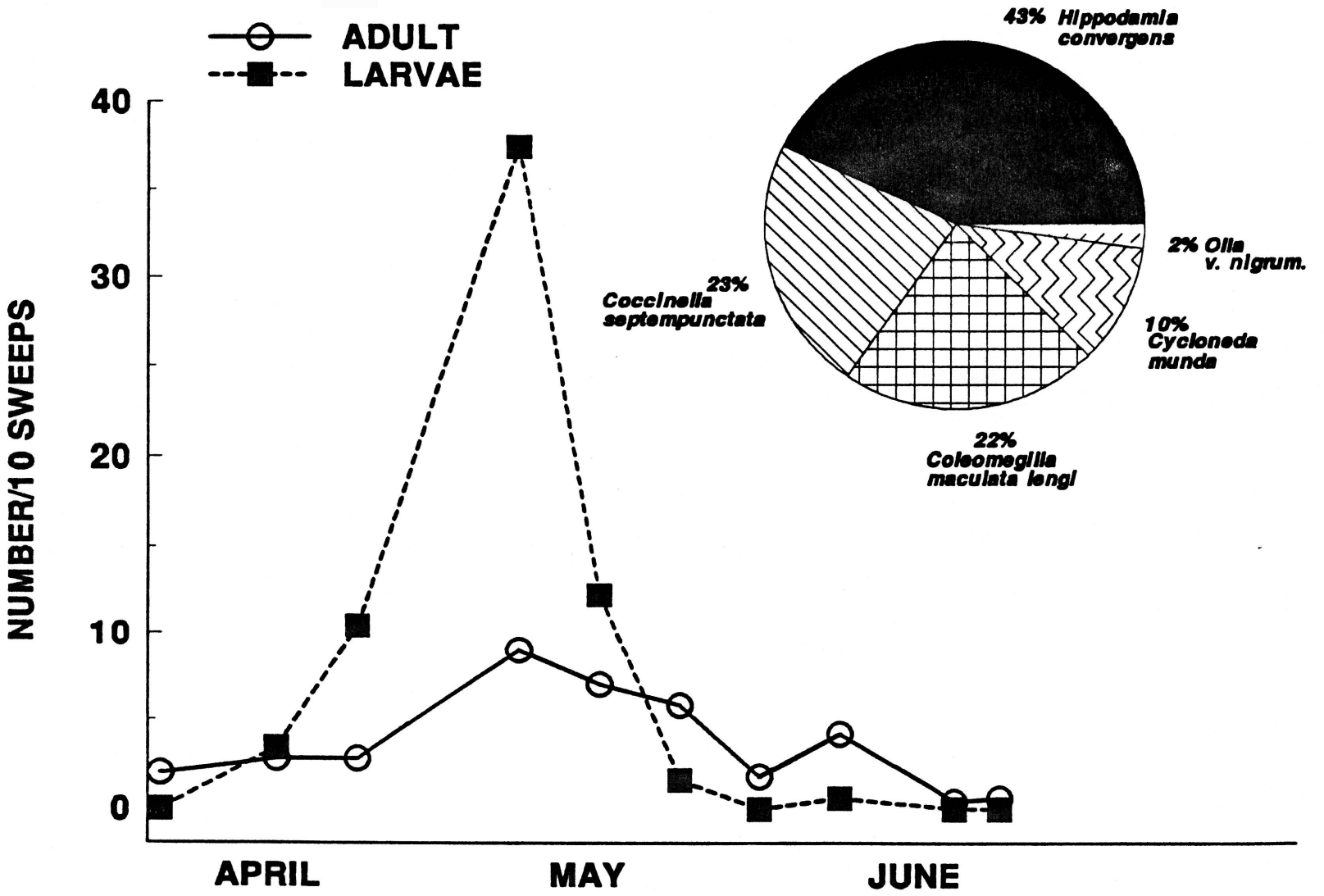
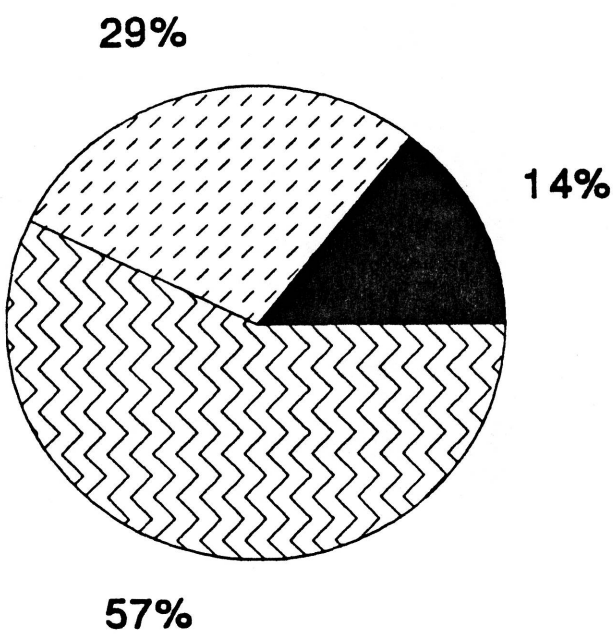

ADULT
LARVAE
NUMBER/10 SWEEPS
40
30
20
10
0
APRIL
MAY
JUNE
43% Hippodamia convergens
2% Olla v. nigrum.
10% Cycloneda munda
22% Coleomegilla maculata lengi
23% Coccinella septempunctata

Fig. 5. Lady beetle species in pecan canopies, 1992 & 1993.

KNIGHT CREEK ORCHARD



NOBLE FOUNDATION ORCHARD

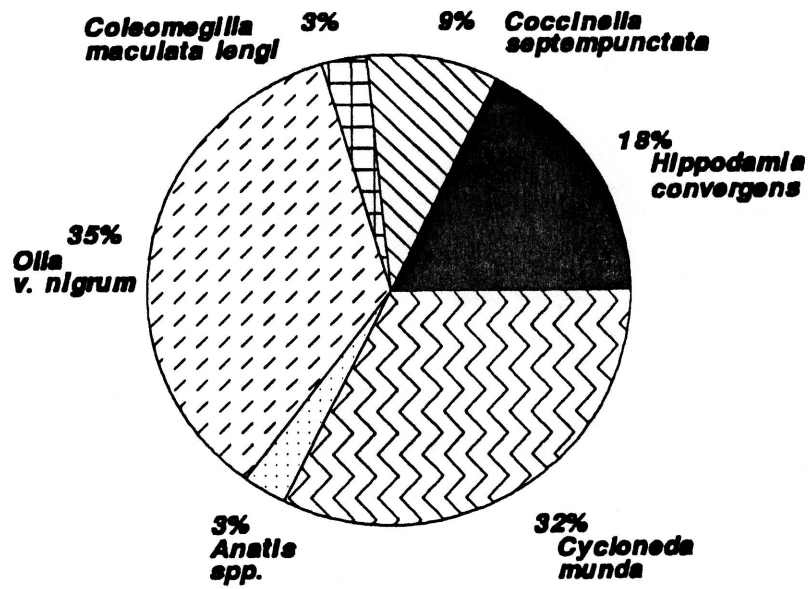


Fig. 6. Green lacewings in pecan canopies and ground covers at Noble Foundation Orchard, 1992.

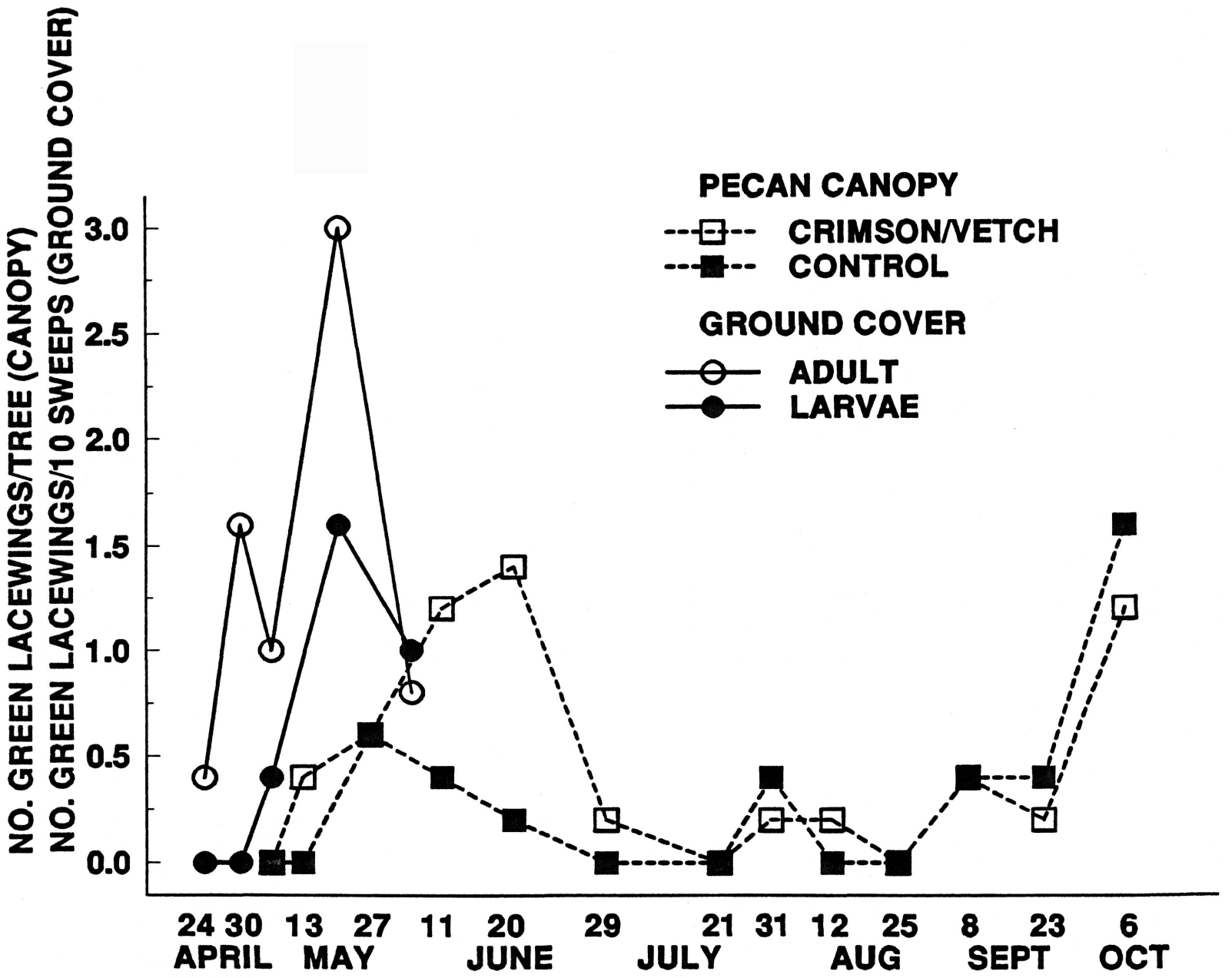

NO. GREEN LACEWINGS/TREE (CANOPY)
NO. GREEN LACEWINGS/10 SWEEPS (GROUND COVER)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
PECAN CANOPY
CRIMSON/VETCH
CONTROL
GROUND COVER
ADULT
LARVAE
24 30 13 27 11 20 29 21 31 12 25 8 23 6
APRIL MAY JUNE JULY AUG SEPT OCT

Fig. 7. Yellow aphid complex (*Monelliopsis pecanis* and *Monellia caryella*) population in pecan canopies at Noble Foundation Orchard, 1992.

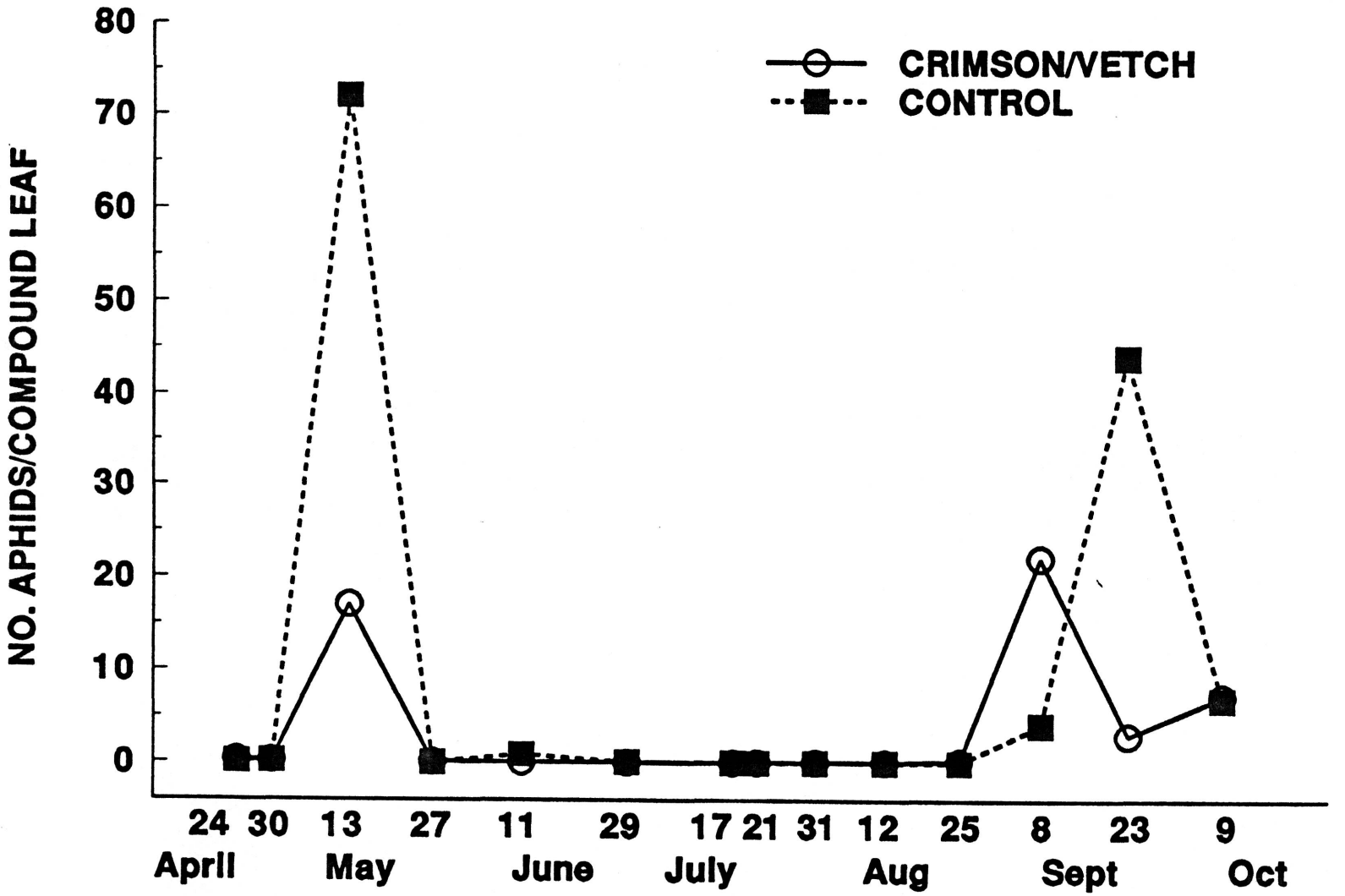

NO. APHIDS/COMPOUND LEAF
80
70
60
50
40
30
20
10
0
CRIMSON/VETCH
CONTROL
24 30 13 27 11 29 17 21 31 12 25 8 23 9
April May June July Aug Sept Oct

Fig. 8. Stink bug populations in pecan canopies at Noble Foundation Orchard, 1992.

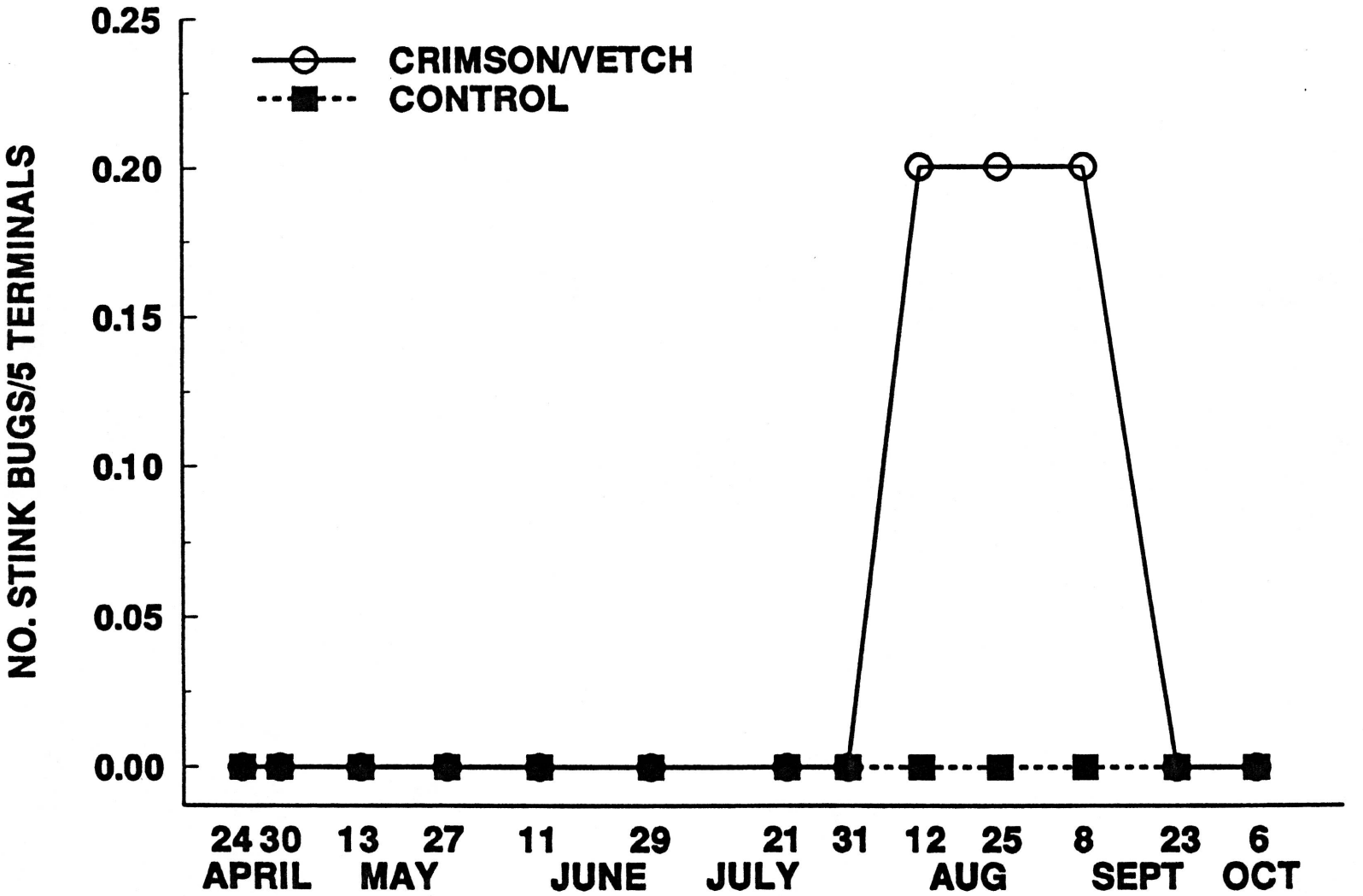
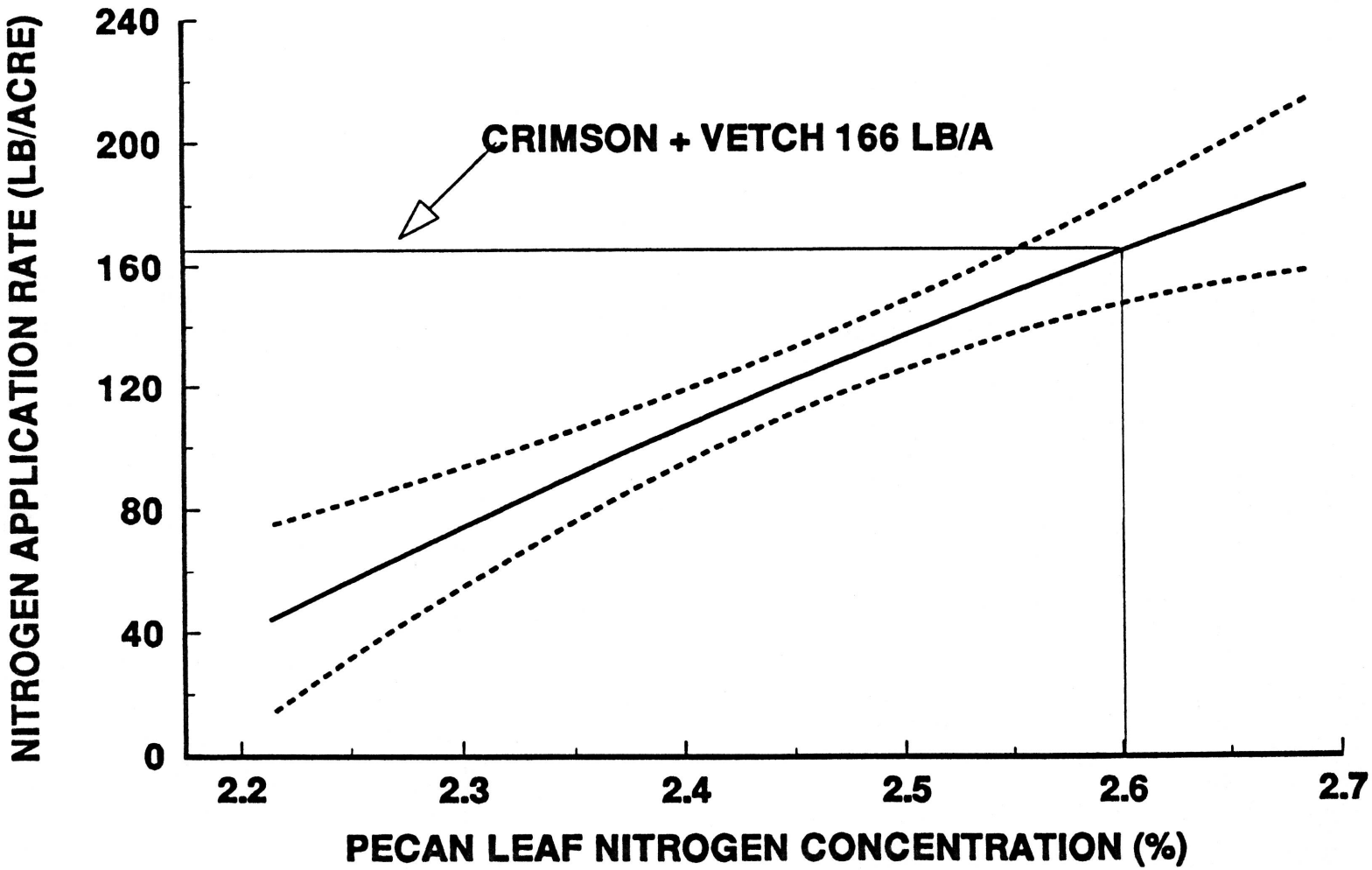

CRIMSON/VETCH
CONTROL
NO. STINK BUGS/5 TERMINALS
0.25
0.20
0.15
0.10
0.05
0.00
24 30 13 27 11 29 21 31 12 25 8 23 6
APRIL MAY JUNE JULY AUG SEPT OCT

Fig. 9. Apparent nitrogen supplied from legumes at Knight Creek Orchard, 1992.


NITROGEN APPLICATION RATE (LB/ACRE)
240
200
160
120
80
40
0
CRIMSON + VETCH 166 LB/A
2.2
2.3
2.4
2.5
2.6
2.7
PECAN LEAF NITROGEN CONCENTRATION (%)