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Screening cool-season legume cover crops for pecan orchards

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Abstract. *We evaluated selected cool-season annual and perennial legumes as potential ground covers to supply nitrogen and to increase beneficial arthropod populations in a pecan orchard. Densities of aphids (Homoptera: Aphididae), lady beetles (Coleoptera: Coccinellidae), damsel bug (Hemiptera: Nabidae), green lacewings (Neuroptera: Chrysopidae), brown lacewings (Neuroptera: Hemerobiidae), hover flies (Diptera: Syrphidae), spined soldier bug and other stink bugs (Hemiptera: Pentatomidae), and spiders (Araneida) were monitored at 7-14 day intervals during the growing season for three years. Aboveground biomass production and nitrogen content of the legumes was measured for two years. Aphids peaked during early spring each year, with the highest density usually on 'Dixie' crimson clover and 'Kenland' red clover. Density of lady beetles was positively correlated with those of aphids, but spider densities were not. Other arthropods usually were not abundant. Nitrogen in the tops of the annual legumes ranged from 20 kg/ha to 89 kg/ha when assessed after a single harvest at anthesis; for the perennial legumes it was from 108 kg/ha to 179 kg/ha following two harvests in June and September. We chose two annual legumes ('Dixie' crimson clover and hairy vetch) and two perennial legumes ('Louisiana S-1' white clover and 'Kenland' red clover) for further evaluation.*

Key words: aphid, Aphididae, Araneida, biological control, pecan, cover crops, Chrysopidae, Coccinellidae, Hemerobiidae, Insecta, Fabaceae, Nabidae, Pentatomidae, Syrphidae

Fertility and Pest Management of Pecan Orchards

Pecan (*Carya illinoinensis* [Wangenh.] C. Koch) is produced in two types of commercial orchards in the U.S. One type is based on wild trees (called natives) that have been cleared of competing vegetation and thinned periodically to the correct spacing for optimum production (Harris, 1983). Management of native orchards ranges from complete fertility and pest management programs to little management, with the trees harvested irregularly. From 1970 through 1990, native pecans accounted for 38% of production in the U.S., and 92% in Oklahoma (Napper, 1991). About 70% of the native pecan orchards in Oklahoma are combined with cattle grazing (Mitchell and Wright, 1991). This requires managers to minimize pesticide use and choose pesticides that are compatible with cattle grazing.

The second type of orchard is planted with a few improved cultivars. There are over a thousand pecan cultivars (Thompson and Young, 1985), but only about 40 are common in the U.S. (Thompson, 1990). The main cultivars are 'Stuart', 'Schley' and 'Desirable' in the Southeast, and 'Western Schley' and 'Wichita' in the West. In the central pecan belt, about 20 cultivars dominate. Cultivar orchards are not usually grazed, and the ground cover is a closely mowed grass sod. The lack of genetic diversity among trees in these plantings compared with native orchards and the more aggressive management has meant that frequent pesticide applications have been required. This has caused aphids (Dutcher and Htay, 1985) and mites (Boethel, 1981) to acquire resistance to pesticides. It also has caused outbreaks of secondary pests (Mizell, 1991) because natural enemies were eliminated, which in turn required additional pesticide applications.

Compared with perennial grass sod, legume and mixed legume-grass ground covers can be beneficial in both types of orchards, both for supplying N and for controlling pests. Legumes once were commonly grown as cover or green manure crops in orchards, until inexpensive synthetic N fertilizers became available during the 1940s and 1950s (Tedders, 1983). Interest in legumes has increased recently because of higher N costs, acquired pesticide resistance by certain insects (Boethel, 1981; Dutcher and Htay, 1985), and the need to avoid pesticide loading in the environment. Erdman (1967) reported estimates of N fixed by several legumes ranging from 57 to 207 kg/ha. Wood et al. (1983) reported that 'Amclo' arrowleaf clover (*Trifolium vesiculosum* Savi) added about 112 kg/ha N to the pecan orchard.

Another advantage of legume ground covers is that they can increase beneficial arthropods, which can aid in the control of aphids and other pests. Three aphid species attack pecan: yellow pecan aphid (*Monelliopsis pecanis* Bissell), blackmar-

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gined aphid (*Monellia caryella* [Fitch]), and black pecan aphid (*Melanocallis caryaefoliae* [Davis]) (Tedders et al., 1982). Yellow pecan aphid and blackmargined aphid cause damage to the foliage at the feeding site by clogging phloem, inducing chlorosis, irreversibly suppressing photosynthesis, and reducing nut size (Wood and Tedders, 1982; Wood et al., 1988). Feeding by black pecan aphids causes necrosis in the surrounding mesophyll cells and can cause premature leaf abscission (Lakin, 1972; Tedders et al., 1982). The pecan aphid complex is attacked by generalist predators and parasitoids (Edelson and Estes, 1987). Certain legumes harbor large populations of other prey aphids that tend to attract aphid predators and parasitoids. The alternative prey aphids common on legumes in the southern U.S. are blue alfalfa aphid (*Acyrthosiphon kondoi* Shimji), pea aphid (*Acyrthosiphon pisum* [Harris]), cowpea aphid (*Aphis craccivora* Koch), and yellow clover aphid (*Therioaphis trifolii* [Monell]) (Bugg et al., 1990). Aphids on legumes will not attack pecan; however, the predators and parasitoids that feed on them may also attack alternative prey aphids and other pests in the pecan trees.

Bugg et al. (1991b) proposed a cover crop management system to enhance beneficial arthropods in pecan orchards. Several cool-season and warm-season cover crops were evaluated in Georgia and Massachusetts to increase aphidophagous insects and other entomophaga to enhance biological control in vegetables and pecan (Wood et al., 1983; Bugg and Dutcher, 1989; Bugg and Ellis, 1990; Bugg et al., 1990, 1991a; Bugg and Dutcher, 1993). Among several potential cool-season crops screened, certain legumes were promising candidates to increase beneficials.

This study was undertaken to evaluate several cool-season annual and perennial legumes as potential ground covers in pecan orchards. The primary characteristics we evaluated were their ability to attract beneficial insects into the orchard and supply N.

Materials and Methods

Orchard site and management

We conducted the study in a commercial native pecan orchard near Sapulpa, in central Oklahoma. The soil was a Port loam (fine-silty, mixed, thermic; Cumulic Haplustoll; Mollisols), a deep, well drained, nearly level soil with high available water capacity. These soils occur on bottomland, and are typical soils for pecan production in this region.

In 1991 and 1992, *Bacillus thuringiensis* var. *kurstaki* was applied during early June against first generation pecan nut casebearer (*Acrobasis nuxvorella* Neunzig, Lepidoptera: Pyralidae). In 1993, chlorpyrifos was applied on April 21 and May 3 against phylloxera (*Phylloxera notabilis* Pergande, *P. russelae* Stoetzel, and *P. devastatrix* Pergande, Homoptera: Phylloxeridae), and on June 17 against pecan nut casebearer. Carbaryl was applied to control pecan weevil (*Curculio caryae* [Horn], Coleoptera: Curculionidae) on August 18, September 7 and 27, 1991, on September 15 and October 1, 1992, and on August 28 and September 15, 1993. No other insecticides were used.

Experimental design and analysis

Existing vegetation was killed during August 1990 with glyphospate. The soil was cultivated with a rotary tiller in late September. Legume seeds were inoculated with the appropriate commercial *Rhizobium* culture and distributed with a broadcast planter. The area then was packed with a roller. Perennial legumes were established once during 1990; the annual legumes were reseeded in September of each year. Seeding rates for each legume are listed in Table 1. In 1992, 'Yuchi' arrowleaf clover, rose clover, hairy vetch and 'Mt. Barker' subterranean clover were not included in the trial, and in 1993, rose clover, hairy vetch and 'Mt. Barker' subterranean clover were not included. A plot consisted of a single tree with the legume extending about 50% beyond the drip-line on all sides of the tree (plot sizes were about 1000 m^2). Each legume plot was replicated three times in a completely randomized design. Data were analyzed using analysis of variance with mean separation by Fisher's protected LSD or Duncan's multiple range test.

We sampled arthropod densities in 1991 through 1993 at 7 to 14 day intervals using

Table 1. Legume names and seeding rates.

Legume	Scientific name	Seeding rate (kg/ha)
Annuals		
'Yuchi' Arrowleaf clover	*Trifolium vesiculosum* Savi	9.1
'Dixie' Crimson Clover	*T. incarnatum* L.	18.3
Rose clover	*T. hirtum* All.	9.1
'Mt. Barker' subterranean clover	*T. subterraneum* L.	9.1
Hairy vetch	*Vicia villosa* Roth.	18.3
Perennials		
'Kenland' red clover	T. pratense L	9.1
'Osceola' white clover	*T. repens* L.	3.7
'Regal' white clover	*T. repens* L.	3.7
'Louisiana S-1' white clover	*T. repens* L.	3.7

a 38-cm diameter sweep net. Each sweep net sample consisted of ten sweeps per plot. The collected samples were transferred to plastic bags with pesticide impregnated strips (S.C. Johnson, Inc., Racine, Wisconsin), transported to the laboratory, and frozen until the arthropods of interest could be identified and counted. We monitored the following arthropods: aphids (Homoptera: Aphididae); lady beetles (*Hippodamia convergens* Guerin-Meneville, *Coccinella septempunctata* L., *Coleomegilla maculata lengi* Timberlake, *Cycloneda munda* [Say], Coleoptera: Coccinellidae); damsel bug (*Nabis* spp., Hemiptera: Nabidae); green lacewings (*Chrysopa* and *Chrysoperla* spp., Neuroptera: Chrysopidae); brown lacewings (Neuroptera: Hemerobiidae); hover flies (Diptera: Syrphidae); spined soldier bug (*Podisus maculiventris* [Say], Hemiptera: Pentatomidae); stink bugs (Hemiptera: Pentatomidae); and spiders (Araneida). For aphids, we separated alatae (winged) from apterae (wingless) plus nymphs to determine trends during the growing season. We counted lady beetle adults by species, but we pooled larvae across species. For green lacewings, brown lacewings, and hover flies, we counted both larvae and adults, but we did not distinguish between adults and nymphs of spined soldier bug or stink bugs. On April 19, 1991 and April 23, 1993, we identified aphids by species, and calculated the population percentage of each species.

In 1991, we harvested two 1-m^2 legume biomass samples (tops only) from each plot at the edge of the tree canopy. The legumes were harvested once at the beginning of anthesis. In 1992, we harvested the annual legumes once at anthesis and the perennial legumes twice (during June and September, which coincided with mowing the rest of the plot). The samples were sorted into legumes and non-legumes (primarily grasses), oven-dried at 70°C, and weighed. The legumes were analyzed for N using the macro-Kjeldahl procedure (Horowitz, 1980), with total N in the tops calculated from the dry weight of the legumes in each sample and the N concentration in the legume tops.

Results

Arthropod populations

Aphids. Aphid density during 1991 peaked during late April and early May, then declined with the onset of frequent rainfall (Fig. 1A). 'Dixie' crimson clover had completed flowering, and the plants

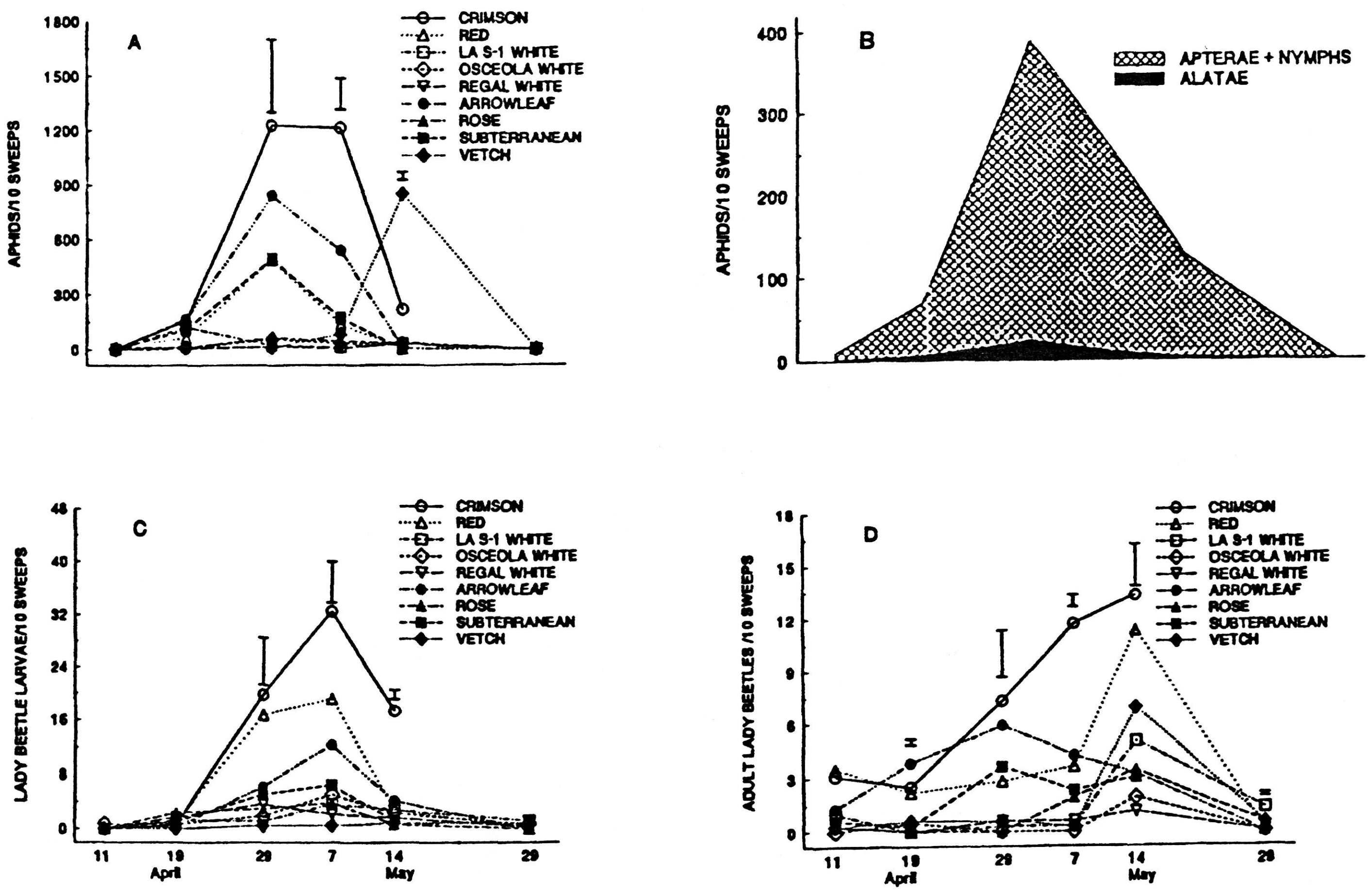

Fig. 1. Densities in 1991 of aphids on legume ground covers (A), alatae and apterae plus nymphs averaged over legume ground covers (B), lady beetle larvae on legume ground covers (C), and lady beetle adults on legume ground covers (D). Vertical bars represent Fisher's protected LSD value (p<.05).

were senescing by May 14. Peak aphid density was greatest on 'Dixie' crimson clover and 'Yuchi' arrowleaf clover, followed by 'Kenland' red clover and 'Mt. Barker' subterranean clover, and least on rose clover and the three white clover cultivars. Aphids on hairy vetch were low until an increase on May 14, which coincided with the onset of flowering. However, on the next sampling date (May 29) no aphids were collected from hairy vetch or the other legumes. In 1991, alatae never exceeded 9% of the total aphids (Fig. 1B).

In 1992, variations in aphid densities were associated with rainfall patterns. Rainfall was infrequent during early spring, and the first two samples (April 14 and 21) yielded the highest aphid densities (Fig. 2A). There were more aphids on 'Dixie' crimson clover and 'Kenland' red clover than on the other legumes. Frequent rainfall began about May 1 and continued until late June. Aphids were low on legumes from May through mid-September, then increased on the perennial legumes on September 28. Alatae rose to 18% of the total aphids during April, were near zero

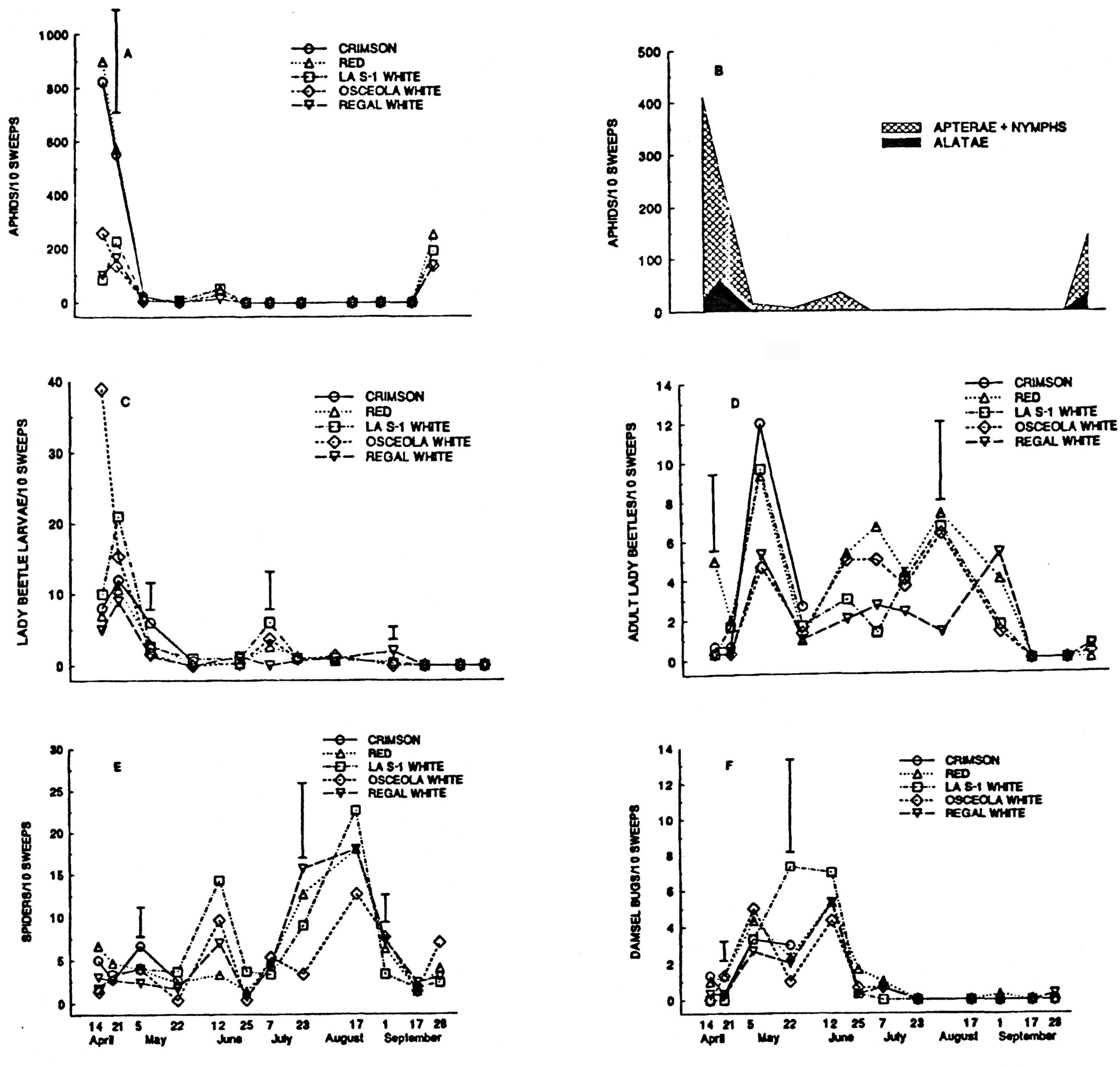

Fig. 2. Densities in 1992 of aphids on legume ground covers (A), alatae and apterae plus nymphs averaged over legume ground covers (B), lady beetle larvae on legume covers (C), lady beetle adults on legume ground covers (D), spiders on legume ground covers (E), and damsel bug on legume ground covers (F). Vertical bars represent Fisher's protected LSD value ($p<.05$).

through the rest of summer, then reached 18% of the total aphids again during late September (Fig. 2B).

In 1993, the aphid densities were erratic (Fig. 3A). For instance, on crimson clover the initial sample on April 8 showed a medium aphid density followed by a sharp decline, then an increase. Chlorpyrifos was applied to the pecan trees for phylloxera control on April 21 and May 3, 1993, which accounts for the sudden decrease in aphid density. During the previous two years, no insecticide applications were necessary during the early season. Aphid densities were highest during the spring, but were low or zero throughout the summer, in agreement with observations the previous two years. Alatae were a maximum of 17% of the total aphids present (May 22) (Fig. 3B).

Aphid species identified on the legumes were blue alfalfa aphid, pea aphid and cowpea aphid. In 1991 blue alfalfa aphid was the dominant species on 'Yuchi' arrowleaf clover, 'Mt. Barker' subterranean clover, and 'Kenland' red clover (Table 2). 'Dixie' crimson clover and 'Osceola'

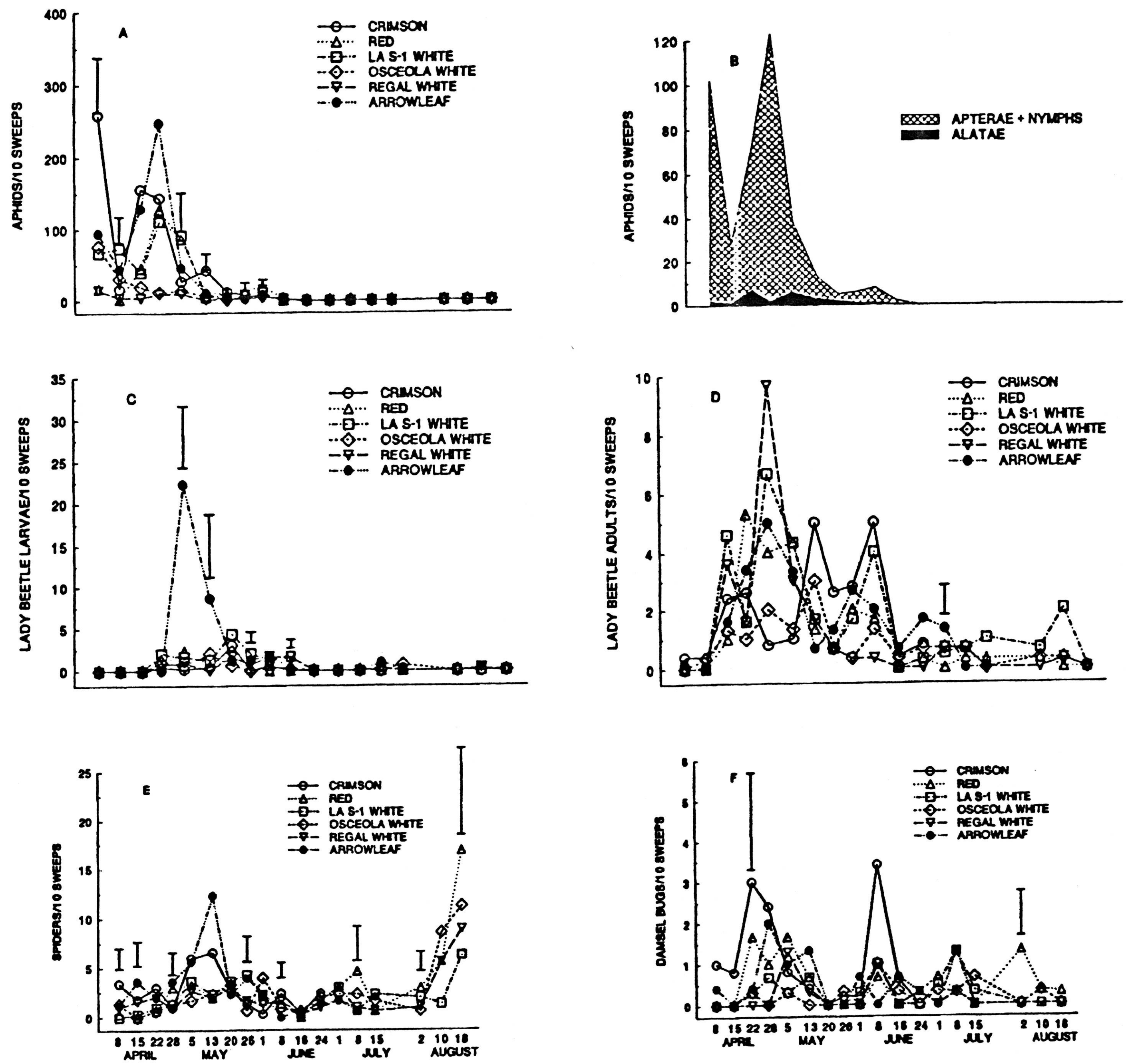

Fig. 3. Densities in 1993 of aphids on legume ground covers (A), alatae and apterae plus nymphs averaged over legume ground covers (B), lady beetle larvae on legume covers (C), lady beetle adults on legume ground covers (D), spiders on legume ground covers (E), and damsel bug on legume ground covers (F). Vertical bars represent Fisher's protected LSD value (p<.05).

Table 2. Influence of legume on aphid species in 1991 and 1993.

Legume	Aphid Species (%)		
	Blue alfalfa aphid	Pea aphid	Cowpea aphid
	April 19, 1991		
'Yuchi' arrowleaf clover	94.8	9.4	0.8
'Dixie' crimson clover	51.5	48.3	0.2
Rose clover	4.9	73.0	22.0
'Mt. Barker' subterranean clover	62.3	36.0	1.7
Hairy vetch	8.8	73.5	17.7
'Kenland' red clover	92.6	6.9	0.5
'Osceola' white clover	53.0	40.4	6.5
'Regal' white clover	19.0	63.5	17.5
'Louisiana S-1' white clover	6.7	91.3	2.0
	April 21, 1993		
'Dixie' crimson clover	0.5	99.0	0.5
'Kenland' red clover	16.3	82.9	0.8
'Osceola' white clover	1.8	96.5	1.7
'Regal' white clover	0.0	100.0	0.0
'Louisiana S-1' white clover	8.4	90.8	0.8

white clover had similar densities of blue alfalfa aphid and pea aphid. Pea aphid was the dominant species on rose clover, hairy vetch, 'Regal' white clover and 'Louisiana S-1' white clover. Although cowpea aphid was not the dominant species on any legume, three legumes (rose clover, hairy vetch, and 'Regal' white clover) had more cowpea aphids than the other legumes. In 1993, pea aphid was the dominant species on the legumes evaluated, although 'Kenland' red clover had many blue alfalfa aphids.

Lady beetles. The density of lady beetle larvae in 1991 peaked during late April and early May, then declined (Fig. 1C). This trend was strongly correlated with aphid trends (Table 3). The greatest lady beetle larval density was on 'Dixie' crimson clover, followed by 'Kenland' red clover (Fig. 1C). There were few differences in the number of lady beetle larvae in the other legumes.

In 1991, the density of adult lady beetles generally rose from early April until mid-May, then declined abruptly (Fig. 1D). Adult lady beetles were strongly correlated with aphid density (Table 3). As the number of lady beetles increased during late April and May, their density on 'Dixie' crimson clover was consistently among the highest (Fig. 1D). Other legumes that occasionally had abundant adult lady beetles were 'Kenland' red clover, 'Yuchi' arrowleaf clover, and hairy vetch. Other legumes had either intermediate or low densities. *Hippodamia convergens* (72%) was the dominant species in 1991, followed by *Cycloneda munda* (15%), *Coccinella septempunctata* (10%), and *Coleomegilla maculata lengi* (3%). We did not detect any differences among legumes in the species composition of lady beetles (data not shown).

In 1992, the lady beetle larval density was high during April, then declined sharply in May and remained low through September (Fig. 2C). This trend was weakly correlated with aphid densities (Table 3). There were few differences in densities of lady beetle larvae among the legumes in 1992. There was a clear peak in adult lady beetles on May 4, then a second peak during mid-June through late July (Fig. 2D). However, there were few aphids present or other arthropods that might serve as a food source, and we observed little egg laying. The species distribution was very different between 1991 and 1992. *Coleomegilla maculata lengi* accounted for 58% of the lady beetles collected, followed by *Coccinella septempunctata* (24%), *Hippodamia convergens* (12%), and *Cycloneda munda* (6%). In 1990, in contrast, *Hippodamia convergens* was the dominant species (72%), with *Coleomegilla maculata lengi* making up only 3% of the lady beetles.

In 1993, we observed few lady beetle larvae on the legumes, except on 'Yuchi' arrowleaf clover sampled on May 5 (Fig. 3C). The lower aphid density than the previous two years and the early-season chlorpyrifos application probably account for the reduced density of lady beetle larvae.

Table 3. Correlations of aphid densities with lady beetle adults and larvae, spiders, and damsel bug.[1]

Lady Beetles			
Adults	Larvae	Spiders	Damsel bug
		1991	
0.58***	0.60***	0.36***	—
		1992	
-0.13NS	0.26*	0.10NS	-0.30*

[1] Correlations in 1991 contained 159 observations: 8 legumes by 3 replications by 6 dates, plus 1 legume by 3 replications by 5 dates. Correlations in 1992 contained 156 observations: 4 legumes by 3 replications by 12 dates plus 1 legume by 3 replications by 4 dates.

NS = non-significant; * = significant at p.<05; *** = significant at p.<001.

The density of adult lady beetles was similar to that of 1992. The population peaked from early May through early June (Fig. 3D). Few significant differences in the number of lady beetles were observed among legumes. Species distribution was similar to 1992, with 68% being *Coleomegilla maculata lengi*, followed by *Hippodamia convergens* (16%), *Coccinella septempunctata* (10%) and *Cycloneda munda* (6%).

Spiders. In 1992, the density of spiders peaked during August (Fig. 2E). This trend was not associated with aphid densities (Table 3). Similarly, spider density in 1993 was low during spring and early summer, then peaked during August when aphid densities were low (Fig. 3E). Spiders are general predators, and their feeding activity was associated with arthropods other than aphids. Although there were some significant differences in spider density among the legumes, these differences were neither large nor consistent.

Other species. Damsel bugs were infrequent in 1991, and there were no significant differences among the legumes (data not shown). In 1992, damsel bug density peaked (Fig. 2F) immediately after the aphids crashed (Fig. 2A). Damsel bug density was low and erratic in 1993 (Fig. 3F), peaking on most legumes during late April. During 1991-93, there were few significant differences among the legumes in damsel bug density.

We collected green lacewings, brown lacewings, hover flies, and spined soldier bugs each year in the legume plots. However, these species were not abundant, and we did not see consistent trends or differences among the legumes (data not shown).

There were few stink bugs (peak population each year was 1 stink bug/10 sweeps) on all legumes in all three years. There were no consistent trends or differences among the legumes.

N in legume tops

Legume biomass from a single harvest in 1991 was greater for 'Yuchi' arrowleaf clover, 'Dixie' crimson clover, rose clover and 'Kenland' red clover than for the other legumes (Table 4). These legumes also tended to have the least non-legume biomass. In 1992, when the four perennial legumes were harvested twice, 'Kenland' red clover and 'Louisiana S-1' white clover produced more biomass than the other legumes. There were no significant differences in either non-legume or total biomass production in 1992.

In 1991, N concentration in legume tops ranged from 2.22% in rose clover to 3.61% in 'Osceola' white clover. The three white clover cultivars had higher N concentrations than 'Yuchi' arrowleaf clover,

Table 4. Biomass, N concentration and total N in the tops of selected legumes harvested once at anthesis during May or June, 1991 or harvested twice during May or June and September, 1992.

Legume	Dry wt. (kg/ha)		May/June		September		Total N in tops
	Non-legume	Legume	N conc. (%)	N in tops (kg/ha)	N conc. (%)	N in tops (kg/ha)	(kg/ha)
				1991			
'Yuchi' arrowleaf clover	4104a[1]	994bc	2.43c	80a	—	—	—
'Dixie' crimson clover	4135a	442c	2.54c	82a	—	—	—
Rose clover	3799a	1426abc	2.22c	65ab	—	—	—
'Mt. Barker' subterranean clover	732c	787bc	2.45c	20c	—	—	—
Hairy vetch	2285b	879bc	2.92abc	75a	—	—	—
'Kenland' red clover	3475a	1497abc	2.78bc	82a	—	—	—
'Osceola' white clover	1108c	3354b	3.47ab	34c	—	—	—
'Regal' white clover	1498bc	2903a	3.61a	44bc	—	—	—
'Louisiana S-1' white clover	1790bc	1430abc	3.46ab	52ab	—	—	—
				1992			
'Dixie' crimson clover	3445b	1742a	2.59b	89ab	—	—	89b
'Kenland' red clover	5745a[2]	928a	2.86b	104a	3.49a	75a	179a
'Osceola' white clover	2593b	2290a	3.71a	61b	3.48a	52ab	108b
'Regal' white clover	2712b	2209a	3.77a	58b	3.61a	42b	100b
'Louisiana S-1' white clover	4634a	800a	3.61a	90ab	3.29a	70ab	160a

[1] Mean separation within columns by Duncan's multiple range test ($p<.05$).
[2] Total biomass from two harvests.

'Dixie' crimson clover, rose clover, or 'Mt. Barker' subterranean clover. Hairy vetch and 'Kenland' red clover were intermediate. In 1992, the three white clover cultivars ranged from 3.6% to 3.8% N during the first harvest and 3.2% to 3.6% during the second harvest. N concentration was higher in the white clover cultivars than in the other legumes during the first harvest, but there were no significant differences in N concentration among the legumes during the second harvest.

A single harvest of legume tops in 1991 showed from 20 kg/ha N in 'Mt. Barker' subterranean clover to 82 kg/ha N in 'Dixie' crimson clover. In 1992, annual legumes were harvested once at anthesis, and perennial legumes were harvested twice to coincide with mowing. Total N in the legume tops ranged from 89 kg/ha N for 'Dixie' crimson clover to 179 kg/ha N for 'Kenland' red clover. 'Kenland' red clover and 'Louisiana S-1' white clover produced more N in the tops than the other legumes evaluated in 1992.

Conclusions

We chose four legumes for further evaluation in large plots. These are the perennials 'Kenland' red clover and 'Louisiana S-1' white clover and the annuals 'Dixie' crimson clover and hairy vetch.

Each legume chosen has certain strengths and weaknesses. 'Kenland' red clover was among the highest in N production and in attracting certain beneficial arthropods. However, the stands began to decline during the third year. Also, pure stands of red clover may compete excessively with the trees for water. 'Louisiana S-1' white clover was the best adapted of the three white clover cultivars evaluated. It produced a large amount of N but attracted few beneficial arthropods. 'Louisiana S-1' was aggressive, with the stands improving each year. 'Louisiana S-1' becomes relatively quiescent during the summer, thus minimizing competition for water, and provides an excellent harvest surface during the fall. Therefore, we chose these two perennial legumes for planting as a mixture in large plots for further evaluation.

'Dixie' crimson clover consistently had larger aphid densities and at racted more beneficial arthropods than the other legumes evaluated. Similarly, Bugg et al. (1990) reported that crimson clover supported abundant coccinellids. 'Dixie' crimson clover also produced a large amount of N. Its major disadvantage is that plants mature and senesce while the trees are foliating, a time when there usually are few arthropod pests in the tree canopy. Planting crimson clover with another annual legume may extend the time that the ground cover will hold beneficial arthropods in the orchard. Bugg et al. (1990) reported that coccinellids were successively abundant on certain cover crops. The seasonal abundance of coccinellids was closely related to the presence of aphids or thrips on the ground covers. They suggested a polyculture of various ground covers to provide a seasonal sequence of foods to aphidophaga.

We observed that hairy vetch began rapid growth about the time crimson clover declined. Others have reported that hairy vetch was superior in harboring aphids or attracting coccinellids (Bugg and Ellis, 1990; Bugg et al., 1990; Bugg et al., 1991a). Aphid density on hairy vetch peaked after aphids on crimson clover had declined, thus extending the availability of foods for aphidophaga. Hairy vetch usually senesces when the density of pecan aphids is starting to increase, which encourages them to migrate into the canopy in search of prey. Therefore, a mixture of crimson clover and hairy vetch could be used to increase beneficial arthropods in the orchard and to get them to prey on pecan aphids.

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