RELAY INTERCROPPING:
EFFECT ON PREDATORS IN COTTON

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Abstract

Relay intercropping of winter and spring strip crops with cotton was used to illustrate conservation and amplification of predators in a three-year study in the Texas Rolling Plains. Numbers of aphids and aphid predators in cotton isolated from other crops were compared to those where wheat, canola, sorghum (intercrops), and cotton were planted adjacent to each other and overlapped temporally. The intercrops "relayed" aphid predators from canola and wheat in the winter, to sorghum in the spring, and to cotton in the summer. Predators appeared in high numbers earlier in the summer in relay than in isolated cotton. The three-year average of predator numbers exceeded 20 per meter by 4 August in relay cotton, but not until 2 September in isolated cotton. Predator numbers in relay cotton were higher than in isolated cotton until late August when aphid populations in relay cotton declined. Predator numbers in isolated cotton (where aphid densities were still accelerating) became higher after late August. Aphid abundance was lower in relay than in isolated cotton. The three-year average of aphid abundance in relay cotton never exceeded 1,932 aphids/10 leaves on any one sample date, but it reached 4,898 aphids/10 leaves in isolated cotton. The most commonly encountered group of predators in cotton were lady beetles (67.2% of the total number of predators).

Introduction

The use of Integrated Pest Management (IPM) in cotton agroecosystems relies in part on the enhancement of biological control for cotton pests. Providing refugia for insect predators has been one method of successfully enhancing biological control (Alderweireldt 1994). Strip intercropping (growing two or more crops simultaneously in different strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically) can be used for various purposes (Vandermeer 1989), including the purpose of diversifying refugia in agroecosystems to attract insect predators (Burleigh et al. 1973). More specifically, relay intercropping (growing two or more crops simultaneously during part of the life cycle of each) can have some advantages over simple strip intercropping: there is less competition for water and nutrients between the crops in the relay system (Fukai and Trenbath 1993); relay systems provide a predator reservoir for extended periods or continuously; and depending on the crops chosen and the placement of crops, relay intercropping may relay insect predators, but not pests, from one crop to another as the crops themselves mature and decline.

In our study, a relay cropping system was used for the conservation and enhancement of insect predators in cotton by providing predator refugia throughout the noncotton season until cotton could support natural enemy populations. The strip crops were chosen on the basis of crop maturation and pest complexes. Wheat and canola were chosen as winter strip crops, and sorghum was chosen as a spring strip crop bridging the gap between the winter crops and cotton. Each crop had aphid pests associated with it, but none that infest cotton. The crops were planted in strips adjacent to each other to facilitate movement of predators from one crop to the next available crop. As wheat and canola declined in the spring, the adjacent sorghum provided fresh refugia for predators. As sorghum declined in mid-summer, cotton aphids colonizing the adjacent cotton crop provided a fresh food source for predators.

Cotton aphid density typically begins to build in late July and peaks by mid-August in the Texas Rolling Plains. The density dependent functional response to host numbers assumes that predator numbers are too low in a monoculture cotton crop to limit initial aphid population increases (Slosser et al. 1989). The objectives of this study were to: 1) conserve and amplify predators of cotton aphids before the cotton season by providing refugia in the form of relay strip crops planted in the winter and spring, 2) compare predator numbers in cotton isolated from other crops with predator numbers in cotton adjacent to relay strip crops, and 3) compare cotton aphid abundance in cotton isolated from other crops with cotton aphid abundance in cotton adjacent to relay strip crops.

Materials and Methods

The study took place at the Texas Agricultural Experiment Station in Munday, Texas in 1991-2, 1992-3 and 1993-4. Cotton aphids and aphid predators were monitored in two treatments each year in 1992, 1993, and 1994. The two treatments were relay and isolated cotton, planted in late June. The relay treatment consisted of a fall planting of 4 rows of canola, adjacent to a fall planting of 4 rows of wheat, adjacent to a spring planting of 4 rows of sorghum, adjacent to a summer planting of 16 rows of cotton. Plots were approximately 100 meters long. The isolated treatment was a summer planting of cotton isolated from other crops, and located not more than eight km from the relay treatment. Treatment plots were in different areas of the Experiment Station each year to eliminate differences in plant development due to location. The three years were treated as replications for analyses. Crops were not sprayed with pesticides in the study.

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Predator and aphid counts in cotton were made from late June to late September in all three years. Predators were identified and counted weekly in relay and isolated cotton by visually inspecting plants in one meter of row in four locations in the two treatments. Aphids were counted weekly on five top and five bottom cotton leaves in four locations in the two treatments.

Predator and aphid numbers were averaged over the four subsamples in each treatment (relay and isolated cotton) each week. For predators, the individual weekly means from 28 July to 17 August (N=4) from the two treatments were compared using a paired t-test. For aphids, the individual weekly means from 11 August to 2 September were compared using a paired t-test. These individual weekly samples were used to make comparisons between the two treatments within individual years. For all three years combined, average predator and aphid numbers from the same dates were used. The data were analyzed as a randomized complete block experiment with two treatments (relay and isolated cotton), and the three years were used as the source for replication. Curvilinear regression analysis was used to define the relationship between predator numbers in early August and aphid density in late August. The ratios of yearly averages for predator numbers (28 July to 17 August), divided by the yearly averages for aphid density (11 August to 2 September), were treated as the independent variable (X), while the yearly averages for aphid density (11 August to 2 September), were treated as the dependent variable (Y). Predator and aphid numbers were transformed to $\log_{10}$ for regression analysis.

Results and Discussion

Predator numbers averaged over years began increasing earlier in the season in relay cotton than in isolated cotton (Fig.1). Peak predator density occurred in mid-August in relay cotton, and in early September in isolated cotton. Predator numbers in relay cotton were higher than in isolated cotton until late August. Predator numbers in isolated cotton became higher than predator numbers in relay cotton after late August. The average number of predators from late July until mid-August were higher in relay cotton than in isolated cotton (Table 1).

The most common group of predators in cotton were lady beetles, mostly *Hippodamia convergens*, (67.2% of the total number of predators). Other important predators included spiders (11.5%), big-eyed bugs (9.4%), lacewings (3.8%), minute pirate bugs (3.5%), *Collops* beetles (2.5%), and nabids, or damselbugs (2.1%).

Aphid abundance began to decline in early August in relay cotton, while it dramatically increased in isolated cotton (Fig. 2). The three-year average of aphid abundance in relay cotton never exceeded 1,932 aphids/10 leaves on any one sample date, but it reached 4,898 aphids/10 leaves in isolated cotton. Average aphid abundance from early August until early September was lower in relay cotton than in isolated cotton in each year (Table 2).

There was a significant curvilinear correlation (R= 0.967) between the aphid density/predator density ratio in early August and aphid density in late August (Fig. 3). The decline in aphid abundance in relay cotton in early August was followed by a decline in predator abundance in relay cotton in mid-August. When aphid numbers were still accelerating in isolated cotton in mid-August, an increase in predator numbers followed.

Relay intercropping can be used as a strategy for enhancement of biological control of cotton aphids and possibly other cotton pests in agroecosystems that do not employ chemical means of insect control. The establishment of relay intercrops during the noncotton season can serve the additional purpose of complimenting requirements of the 1990 Farm Bill to protect highly erodible land with cover crops in the Texas Rolling Plains.

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Table 1. Predators (number per meter row) in isolated and relay cotton (late July to mid-August), Munday, Texas

	Cotton System		
Year	Isolated	Relay	Pr > t
1992	7.38	40.38	0.17
1993	7.63	10.25	0.26
1994	0.38	1.38	0.14
$\bar{x}$	5.13	17.33	0.19

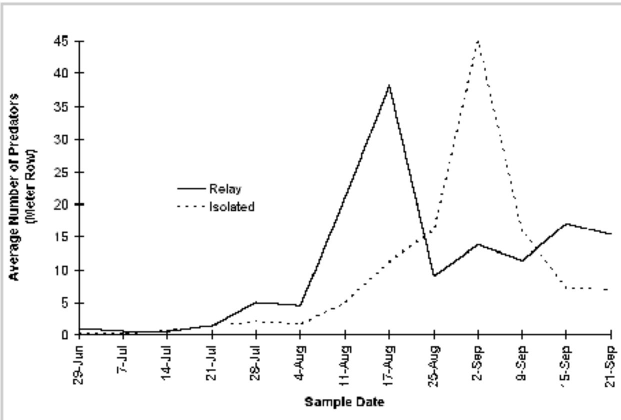

Figure 2. Aphid abundance in isolated and relay cotton, Munday, TX 1992-94.

Table 2. Aphids in cotton (number per 10 leaves) in isolated and relay cotton (early August to early September), Munday, Texas

	Cotton System		
Year	Isolated	Relay	Pr > t
1992	4,092.44	1,173.94	0.33
1993	1,867.81	11.19	0.09
1994	5,273.45	2,349.19	0.08
$\bar{x}$	3,744.56	1,178.11	0.02

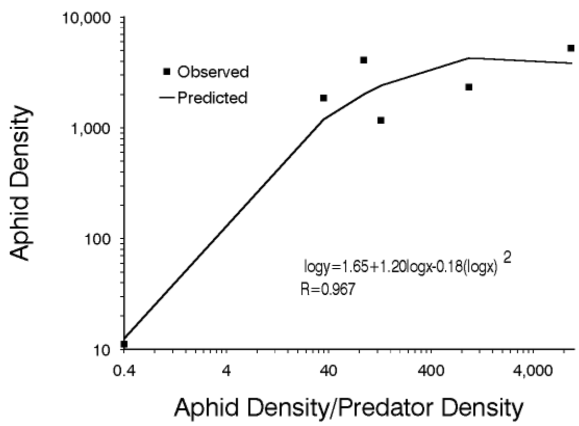

Figure 3. Aphid//predator ratio vs aphid density, Munday, TX.