CONTINUED STUDIES OF INSECT POPULATION DYNAMICS IN CRIMSON CLOVER & REFUGIA / COTTON SYSTEMS. PART I: SWEEP & WHOLE PLANT SAMPLING

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Abstract

Sweep, shake and whole plant sampling methods were used to monitor and compare the seasonal abundance of plant-dwelling beneficials and pests in three cotton fields in Dooly and Tift county, in the Coastal Plain region of south Georgia. The two Dooly county sampling sites were a 20 ha conservation-tilled (Crimson clover) field and a nearby 20 ha conventional-tilled (fallow) field. Samples in Tift county were taken from a 10 ha conventional-tilled field interspersed with six permanent 3-row refugia strips comprised of Crimson clover and annual weeds. Beneficial arthropods monitored included the striped lynx spider, *Oxyopes salticus*, Crab spiders (Thomisidae), two big-eyed bugs, *Geocoris punctipes* and *G. uliginosis*, fire ants, *Solenopsis invicta*, the minute pirate bug, *Orius insidiosus*, an Anthicid (ant-like flower beetle), *Notoxus monodon*, three Coccinellids; *Hippodamia convergens*, *Coccinella septempunctata,* and *Harmonia axyridis*, a Nabid (Damsel bug) and a Chrysopid (Green lacewing). Pests monitored included the cotton aphid, *Aphis gossypii*, budworms, *Heliothis virescens*, bollworms, *Helicoverpa zea*, cabbage and soybean loopers, *Trichoplusia ni* and *Pseudoplusia includens*, thrips and the tarnished plant bug, *Lygus lineolaris*.

In Dooly county, the dominant generalist predators taken in Crimson clover sweep samples were *O. insidiosus*, spiders, Geocoris, and a Nabid. Crimson clover also harbors a diverse aphidophagous complex, including Coccinellids, several parasatoids, Syrphids and Chrysopids. Weather had a profound influence on beneficial and pest populations. 1995 was much drier than 1994, and overall densities of spiders, *S. invicta*, Coccinellids, lacewings, lepidopterous larvae, thrips and plant bugs were all significantly lower in both fields in 1995 than in 1994. Cotton aphid densities were seven times higher; Geocoris and Anthicid densities were not significantly different. Ratios of beneficials to lepidopterous larvae were significantly higher ($p < 0.05$) in the clover field. *S. invicta* was the only beneficial with significantly higher densities in the clover field during both seasons. *S. invicta* significantly reduced densities of Geocoris, Anthicids, Coccinellids and lacewings in the clover, but did significantly effect spiders.

In Tift county, seasonal densities of spiders, *S. invicta*, Geocoris and Coccinellids were significantly higher in cotton strips lying between or adjacent to the refugia strips than in cotton strips lying farthest from the refugia. Density and distribution of beneficials in the entire Tift county field remained high throughout the entire season.

A total of four foliar insecticide treatments were applied to the conservation-tilled field in Dooly county in 1994-95, vs. eight in the conventional-tilled field. No foliar insecticide treatments were applied in the Tift county cotton/refugia field.

Introduction

Part I summarizes the results of whole plant, shake and sweep sampling in the second year of an ongoing study, first reported in the 1995 Beltwide Proceedings (Ruberson et al., 1995). The study is designed to 1) Monitor and compare densities of beneficial and pest arthropods found in various conservation- vs. conventional-tilled cotton systems, 2) Evaluate the benefits of cover crops and refugia strips, and 3) Quantify the biological and economic benefits of reduced pesticide use. Three main approaches to help reduce soil erosion and provide increased production and sustainability include 1) Conservation (reduced) tillage, 2) Management of refugia strips (either within the field or as field margins) and 3) Reduced use of broad-spectrum pesticides. The first national symposium dealing with the history, pest management and economics of conservation tillage systems was held in New Orleans in 1975 (Musick, 1976). At that time, the agronomic and economic potential for newly emerging methods of conservation tillage were not widely recognized by entomologists (Ibid). Our data to present provide additional supporting evidence that beneficial insect densities can be enhanced by using cover crops or refugia strips that provide alternate sites for feeding, reproduction, and protection, both during the growing season and during the winter (Blumberg and Crossley 1982; McPherson et al., 1982). Interest in the use of cover crops and conservation tillage to reduce soil erosion and enhance production and sustainability has grown steadily since 1975. For example, the amount of cotton produced using some form of conservation tillage has nearly tripled in the last five years, from 4.6% in 1991 (205,755 out of 4.47 million ha) to 10.8% in 1995 (608,160 out of 5.67 million ha; see Bradley, 1992; McClelland, et al., 1995). This study will help document Georgia's part in the growing movement toward use of conservation tillage, cover crops and refugia strips, and reduced insecticide use to improve biological control and pest management in cotton.

Materials and Methods

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Plots were located in two 20 ha fields located 10 km southwest of Vienna (Dooly county) and in one 10 ha field 15 km east of Tifton (Tift county), in the Coastal Plain region of south-central Georgia. Soil type in all three fields is Tift sandy loam.

Both Dooly county fields were planted with cotton in 1994. Crimson clover (*Trifolium incarnatum* L.) was planted in the conservation-tilled ('clover') field in October of 1993; it re-seeded heavily in the spring of 1994 before senescing in early May, then began re-emerging again in January of 1995. The adjacent conventional-tilled ('fallow') field was cultivated in the fall of 1994 following harvest and remained fallow until it was prepared for planting the following March. The clover field was strip-tilled (ca. 0.5 m; 16-18 in.) three weeks prior to planting, using the same beds as in 1994. The Crimson clover began drying noticeably on April 20; it was completely senescent by May 3. Cotton (DPL 5690) was planted in both Dooly county fields in mid-April, 1995, with Temik applied in-furrow at 3 kg per ha. Foliar insecticide treatments were applied to the fields when standard thresholds were exceeded. Two treatments were applied to the clover field in 1995: Baythroid (July 6) and Asana (August 7). The fallow field received three treatments: Ammo (June 26), Baythroid (July 3) and Asana (July 10). All treatments were applied aerially .

The Tift county field was planted with peanuts in 1994; the entire field was cultivated following harvest in September, 1994, then broadcast seeded in early November with Crimson clover at the rate of 30 kg per ha. In late March of 1995 we staked out a series of six refugia strips, each running the entire length of the field (ca. 415 m), that were each the equivalent of three rows (ca. 3 m) wide. The refugia strips were divided into two groups of three strips each. The first group was separated from the second group by 70 rows of cotton. Each refugia strip within a group was separated by 16 rows of cotton (four passes of a four-row planter). Seedbeds were formed as normal in the cotton strips; the designated refugia strips were not cultivated or disturbed. The field was 243 rows wide; it was bounded on the south by a fence, a drainage ditch and a county road. It was bounded on the north by a buffer of three uncultivated rows (forming a *de facto* refugia strip) and 20 rows of tobacco. The refugia strips, from the south to the north, occupied rows 17-19, 43-45, and 62-64 (Group 1), and 133-135, 152-154 and 171-173 (Group 2). The field was subsequently divided into twelve parallel strip plots of cotton, all running the full length of the field. Each plot was sampled individually. Since our hypothesis was that the refugia strips would have the greatest influence on the closest cotton strips, we used the names '**Full-influence**,' '**Partial-influence**,' and '**Low-influence**' to identify the plots. The four 'Full-influence' plots were the cotton strips enclosed on both sides by refugia strips; the four 'Partial-influence' plots were the cotton strips lying immediately adjacent to, but not between, the refugia strips, and the four 'Low-influence' plots were the cotton strips lying farthest from the refugia strips. Cotton (DPL 5690) was planted in mid-April of 1995, with an in-furrow application of Temik at 3 kg/ha and Treflan at 1.5 kg/ha. No other insecticide treatments were applied in 1995.

Insect Sampling Methods

Four sampling areas were established in both Dooly county fields in the approximate center of each quarter of the field; a fifth site was established in the central area of each field. Sampling areas were marked by a 2 m stake tied with colored flagging ribbon to help facilitate location from a distance. Sweep sampling involved taking 50 sweeps with a 36 cm (15 inch) net at five randomly selected locations within each sampling area, a total of 250 sweeps per field. Samples were taken only in the clover field (the fallow field was barren at this time). Sweep samples were taken from March 22 until May 3, when the clover was completely senesced. Shake and whole plant samples were taken from June 14 (ca. one month after emergence) through August 31, 1995. Five samples were taken from a randomly selected meter of cotton plants in each of the five designated sampling areas, a total of 25 samples per field. Arthropods were first shaken vigorously onto a white 'beat-sheet', then identified and counted. Next, the same plants were examined for any additional arthropods that were not dislodged.

No sweep samples were taken in Tift county in 1995. Four shake/whole plant samples were taken from the approximate median rows in each of the 12 cotton strips. Two of the sampling areas were at least 100 m from the west end of the field; the other two sampling areas were at least 100 m from the east end of the field, with ca. 200 m separating the two sampling areas. Samples were taken weekly from June 16 through August 18, 1995. All data was analyzed for seasonal significant variance (ANOVA; a = 0.05), using weekly pooled means.

Results and Discussion

Dooly County

Clover Sweep Samples

The four dominant non-aphidophagous beneficial groups collected in the 1994 and 1995 clover sweep samples were *Orius insidiosu*s, spiders, *Geocoris punctipes*, and Nabids (**Figure 1**). Spiders comprised 45% of the total density of non-aphidophagous beneficials collected in the sweep samples. Members of the aphidophagous complex included Coccinellids (primarily *H. convergens*), a complex of hymenopterous parasitoids, Chrysopid larvae, and Syrphid fly larvae. The entire aphidophagous complex is presented in **Figure 2**. Thrips and Tarnished plant bugs were also collected in the sweep samples (**Figure 3**).

Dooly County
Shake and Whole Plant Samples: Beneficials
Seasonal densities of each major arthropod group sampled in the Dooly county conservation (clover) vs. conventional (fallow) field in 1995 are presented together with the 1994 results, as reported in Ruberson et al., (1995).

Spiders are typically polyphagous (generalist) predators and have long been recognized as dominant members of the arthropod community in agro-ecosystems. However, at least until more recently, their presence was often considered undesirable, since they prey almost exclusively on insects, but do not discriminate between pests and beneficial species (Roach, 1980; Hayes & Lockley, 1990). There is now a growing body of evidence showing that spiders exert a crucial stabilizing affect on cotton pest densities (Reichert and Lockley, 1984; Nyffeler et al., 1994). In Dooly county, spiders comprised 75% of the total number of non-aphidophagous beneficials collected in the shake/whole plant samples. The Striped lynx spider, *Oxyopes salticus*, and several Thomisid species (crab spiders) comprised the majority of the total spiders captured. Spider populations in the two fields were not significantly different in 1994 or 1995 (p = 0.10 and 0.56). However, the ratio of spiders to lepidopterous larvae in 1994 was 4.9 times higher in the clover field than in the fallow field (p ² 0.001). In 1995 the spider to lepidopterous larvae ratios were not significantly different (p = 0.93), but overall spider densities were >75% lower than in 1994 (p ² 0.001). This relative decline was probably associated with extended periods of drought experienced during the 1995 growing season. The 1994-95 seasonal spider densities are presented in **Figure 4**.

The Red Imported Fire Ant (RIFA), *Solenopsis invicta* Buren, is an aggressive, omnivorous predator that dominates the cotton ecosystem. RIFA densities in the clover field were significantly higher in 1994 and 1995 than RIFA densities in the fallow field (p ² 0.001). As with the spiders, overall *Solenopsis* densities in 1995 were significantly lower than in 1994 (p ² 0.001), again perhaps because of dry soil conditions and relatively low prey densities caused by extended periods of drought (**Figure 5**).

Seasonal densities of *Geocoris*, an important predator on the eggs and small larvae of a wide variety of lepidopterous pests, were significantly higher in the fallow field in 1994 (p = 0.003), and numerically, but not significantly, higher in 1995 (p = 0.09). Although 1994 numerical densities of Geocoris were higher in the fallow field, the ratio of Geocoris to lepidopterous larvae was 1.8 times higher in the clover field (p ² 0.001), just as with the spiders. In 1995 the ratios were not significantly different (p = 0.33). Overall *Geocoris* densities in 1995 were not significantly different from 1994 densities (p = 0.46; **Figure 6**).

Anthicid populations were significantly higher in the fallow field in both years (p ² 0.001). Although *N. monodon* can be quite common in cotton, little is known about its behavior. Presumably, it feeds on lepidopterous larvae; it is known to prey on the larvae of fruitree leafroller, *Archips argyrospita*, in fruit orchards (Arnett, 1973). Seasonal densities of *N. monodon* are summarized in **Figure 7**. Coccinellid densities (adults and larvae of *Hippodamia convergens*, *Coccinella septempunctata*, and *Harmonia axyridis*) were also significantly higher in the fallow field in both years (p = 0.02 and ² 0.001; **Figure 8**).

Densities of Chrysopa (green lacewings) larvae, a voracious predator of aphids, were significantly higher in the fallow field in 1994 (p = 0.05), but not in 1995 (p = 0.08). Overall densities in both fields were significantly lower in 1995 than in 1994 (p ² 0.001; **Figure 9**).

Finally, consistently higher densities of *Geocoris*, *N. monodon*, Coc-cinellids and lacewings observed during two full seasons in the fallow field is a strong indication that they are highly sensitive to the presence of RIFA. Spiders, however, do not appear to be affected by the presence of RIFA.

Dooly County
Shake and Whole Plant Samples: Pests
Between-field cotton aphid densities were not significantly different in 1994 or 1995, but peak densities in 1995 were seven times higher than densities in 1994 (p ² 0.001). Aphid populations increased rapidly in late June, then declined sharply in both fields in mid-July after being attacked by members of the apihophagous complex and the entomophagous fungus, *Neozygites fresenii* (**Figure 10**).

1994 combined densities of budworm, *Heliothis virescens*, bollworm, *Helicoverpa zea*, and cabbage and soybean loopers, *Trichoplusia ni* and *Pseudoplusia includens*, in the fallow field were significantly higher than densities in the clover field (p ² 0.001), but between-field larval densities were not significantly different in 1995 (p = 0.46). Densities of post-first-instar larvae (i.e., larvae that are relatively easy to detect in shake samples) in both fields were also dramatically lower in 1995 than in 1994 (p ² 0.001; **Figure 11**).

Densities of thrips and Tarnished plant bugs remained low in both fields throughout the season, never reaching economic levels. Thrips densities never surpassed 5.0 per meter row; plant bug densities never surpassed 0.1 per meter row, and no significant differences were observed (**Figure 12** & **13**).

Dooly County
Crimson Clover: Benefits and Problems
Cotton plants produce less residue than other major crops like corn, grain sorghum or soybean. The intensive cultivation practices followed in conventional-tilled cotton fields make it one of the most erosive crops grown in the southeast, with an average annual C-value for the Universal

Soil Loss Equation of 0.58 (1.0 represents bare soil in a conventional-tillage system). However, conservation-tillage in cotton dramatically reduces erosion and leads to increased seedcotton yield when compared to conventional-tilled systems (Vencill et al., 1995). It now appears that the most profitable systems in cotton are no-till with a wheat cover crop and no-till with rye-vetch or rye-legume combinations (Paxton and Hutchinson, 1995; Dabney, 1995).

The major factor limiting adoption of conservation-tillage systems in the U. S. is weed control. In the case of Crimson clover, there are other potential problems that may hinder its widespread adoption in cover crop systems. These potential problems include: 1) interference by excess clover foliage with sub-soiling and planting machinery, 2) suppression of germination by residual decaying foliage in the seed beds, 3) subsequent stand reduction, and 4) relative difficulty of management. One approach to help alleviate these problems is to apply a half rate of 2,4-D three to four weeks before planting is anticipated. This stunts the clover but does not kill it, and provides some additional control of broadleaf weeds at the same time. The clover recovers and produces seed, but there is less residual foliage to interfere with sub-soiling and planting machinery, and the potential for suppressed germination by decaying residual foliage is also reduced.

Dooly County
Benefits of Reduced Insecticide Use

During the last two years four insecticide treatments were applied to the clover field, including two in 1995: Baythroid on July 6 and Asana on August 7, and two in 1994: Baythroid on July 14 and Baythroid/Curacron on August 20. During the same period eight insecticide treatments were applied to the fallow field. Three treatments were applied in 1995: Ammo on June 26, Baythroid on July 3 and Asana on July 10, and five were applied in 1994: Lannate on June 18, Baythroid on July 10, Baythroid on July 14, Baythroid on July 23, and Baythroid/Curacron on August 20. All treatments were applied aerially. Overall pest control costs (materials plus application) were ca. $87 per ha in the clover field vs. $174 per ha in the fallow field, a difference of $87 per ha.

Tift County
Sweep Samples

No sweep samples were taken in the Tift county field in 1995.

Tift County
Shake and Whole Plant Samples: Beneficials

Seasonal spider densities in the Full-influence plots were significantly higher than densities in the Low-influence plots ($p = 0.05$), but not significantly different than densities in the Partial-influence plots ($p = 0.33$). Densities in the Partial- vs. Low-influence plots were not significantly different ($p = 0.43$). 1995 seasonal spider densities are presented in **Figure 14**.

Seasonal *Solenopsis* densities in the Full-influence plots were significantly higher than densities in the Partial- and Low-influence plots (p = 0.05 and 0.01). Densities in the Partial- vs. Low-influence plots were not significantly different ($p = 0.56$; **Figure 15**).

Seasonal densities of both *Geocoris* species in the Full-influence plots were significantly higher than densities in the Low-influence plots ($p = 0.04$), but not significantly different than densities in the Partial-influence plots ($p = 0.77$). *Geocoris* densities in the Partial- vs. Low-influence plots were numerically higher, but not significantly different ($p = 0.06$; **Figure 16**).

Between-plot seasonal densities of *Notoxus monodon* were not significantly different ($p = 0.46$; **Figure 17**). Coccinellid densities in the Full-influence plots were significantly higher than densities in both the Partial- and Low-influence plots (p = 0.01 and 0.01). Densities in the Partial- vs. Low-influence plots were not significantly different ($p = 1.00$; **Figure 18**).

Densities of Chrysopid (green lacewings) larvae were significantly higher in the Low-influence plots than Chrysopid densities in the Full- and Partial-influence plots (p = 0.01 and 0.04). Densities in the Full- vs. Partial-influence plots were not significantly different ($p = 0.50$; **Figure 19**).

Finally, the overall seasonal distribution of spiders, *Geocoris* and Coccinellids, all dominant beneficials, followed a sine-wave pattern thru the field, with significantly higher densities occurring in the Full-influence cotton strips (**Figure 20**).

Tift County
Shake and Whole Plant Samples: Pests

Between-plot cotton aphid densities were not significantly different. As in the Dooly county fields, aphid populations increased rapidly in late June, then declined sharply in mid-July after being attacked by aphidophagous beneficials and the entomophagous fungus, *Neozygites fresenii*. (**Figure 21**).

High levels of predation and parasitization in all the plots kept late-instar worm densities low throughout the season. Between-plot densities of budworms, *Heliothis virescens*, bollworms, *Helicoverpa zea*, and cabbage and soybean loopers, *Trichoplusia ni* and *Pseudoplusia includens*, were not significantly different (**Figure 22**). As in Dooly county, thrips and Tarnished plant bug densities were extremely low in all plots during the entire season, never reaching economic levels.

Tift County
Benefits of Using Refugia in Agriculture

The use of refugia is not a new practice in agriculture; it is really a variation of multiple cropping systems that have been used around the world for thousands of years. There are two main types of refugia. The first type is a strip or region of no-till or minimum-till ground located in a producing field that is maintained on a long term (permanent) basis. This type of refugia may be sown with a single plant variety, such as grain sorghum, or a mixture of selected varieties, such as rye combined with vetch, or they may simply be composed of uncultivated native or wild plant species (weeds). Whenever possible, insecticides are not applied to the refugia when the primary crop is treated. Examples of such refugia include cover crops planted in orchard and vineyard middles, and refugia strips planted alternately with row crops. The second type of refugia is cultivated in the same way as the primary crop, but it is either planted with an alternate variety of the same crop, such as transgenic cotton interplanted with strips of non-transgenic cotton, or it is managed differently, as in strip-cut alfalfa. Some of the benefits of integrating refugia into our farming practices include the following: **1**) Refugia provide 'islands' of unexposed (untreated) pest populations, which helps alleviate or delay the development of pesticide resistance (Meyer et al., 1990). **2**) Refugia provide reservoirs of wild, non-crop alternative hosts for pests. One example is annual fleabane, *Erigeron annuus*, a prolific, highly preferred host of the Tarnished plant bug (Young, 1986); **3**) Refugia provide alternative host sites for beneficial parasatoids and predators, allowing them to build up more quickly and disperse into the primary crop (Greathead, 1986; Joshi and Gadgil, 1991). **4**) Refugia aid in the re-colonization of beneficials into crop systems, either at the beginning of the growing season, or following a traumatic disruption such as an insecticide treatment (Wakimoto et al., 1990). **5**) Some species in dominant epigeal (ground-dwelling) beneficial groups, such as Carabid beetles, require undisturbed areas to complete their development (Nixon et al., 1988). **6**) The use of refugia planted with a different variety of the same crop appears to be a better strategy for preventing or delaying the development of insect resistance to transgenic varieties ('Bt cotton') than using seed mixtures, that is, planting a mixture of transgenic and non-transgenic seeds together in the same field (Mallet and Porter, 1992).

Tift County
Refugia Strip Species Composition

1995 was our first year of researching the dynamics of integrating refugia strips into a cotton agro-ecosystem. When the six three-row refugia strips were originally staked out in late March they were composed primarily of bare areas of ground interspersed with patches of Crimson clover, a few rosettes of Cranesbill, *Geranium dissectum*, and scattered clumps of young Wild mustard, *Brassica kaber*, plants. As the season progressed, a number of other weed species germinated and began growing in the spaces not already occupied by established plants. After the clover dried up in mid-April, additional species continued appearing, but they were gradually dominated by a succession of three species, including Wild mustard, Texas panicum, *Panicum taxanum*, and Common ragweed, *Ambrosia artemisiifolia*. All of the wild annual plants (weeds) occurring in the refugia strips are listed in **Table 1**.

Tift County
Benefits of Reduced Insecticide Use

No insecticide treatments were applied to the Tift county field in 1995. Although seasonal densities of dominant beneficial groups in the 'Full-influence' plots were significantly higher, relative densities of beneficials were high in the other two plots, and none of the pests that are commonly treated ever reached economic threshold levels.

Conclusion

In Dooly county, the conservation-tilled clover field was a more stable environment, and required only half number of insecticide treatments as the conventional-tilled field. Numerical densities of beneficials were sometimes lower in the conservation-tilled field, but so were pest densities, and in most cases the ratios of beneficials to pests in the clover field were significantly higher than ratios in the fallow field. In contrast to the conventional-tilled field, densities of beneficials in the clover built up to high levels early in the season, then moved onto the young cotton plants as the clover dried up.

In Tift county, results from our first year of using refugia strips to enhance the density and distribution of beneficials in cotton were informative and encouraging. Seasonal densities of dominant predator groups, including spiders, Geocoris, Coccinellids and Carabid beetles, were all significantly higher in the Full-influence cotton strips than densities in the Low-influence strips. We also observed that the overall density and distribution of beneficials in the Tift county field, even in the cotton strips most distant from the refugia strips, remained very high throughout the 1995 season, and that no insecticide treatments were necessary. Our premise is that the 'overflow' of beneficials from the refugia strips resulted in a relatively high density of beneficials throughout the entire field. In 1996 we will continue studying the effects of refugia strips on beneficial populations, and will attempt to study the effect of plant mixtures on densities and dispersal of beneficials into the cotton.

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Table 1: Species Composition of the Tift Co. Refugia Strips

Gramineae (Grasses)		
Panicum texanum	Texas Panicum	PANTE
Chenopodiaceae (Goosefoot)		
Rumex crispus	Curly Dock	RUMCR
Euphorbiceae (Spurge)		
Croton glandulosus	Tropic Croton	CVNGS
Fabaceae (Legumes)		
Cassia obtusifolia	Sicklepod	CASOB
Desmodium tortuosum	Florida Beggarweed	DEDTO
Sesbania exaltata	Hemp Sesbania	SEBEX
Caryophyllaceae (Pinks)		
Stellaria media	Common Chickweed	STEME
Geraniaceae		
Geranium carolinianum	Carolina Geranium	GERCA
Geranium dissectum	Cranesbill	GERDI
Oenagraceae		
Oenothera laciniata	Cutleaf Eveningprimrose	OEOLA
Rubiaceae (Madder)		
Richardia scabra	Florida Pusley	RCHSC
Verbena bracteata	Prostrate Vervain	VEBBR
Brassicaceae (Mustards)		
Brassica kaber	Wild Mustard	SINAR
Capsella bursa-pastoris	Shepherdspurse	CAPBP
Asteraceae (Sunflowers)		
Ambrosia artemisiifolia	Common Ragweed	AMBEL
Erigeron annuus	Annual Fleabane	ERIAN

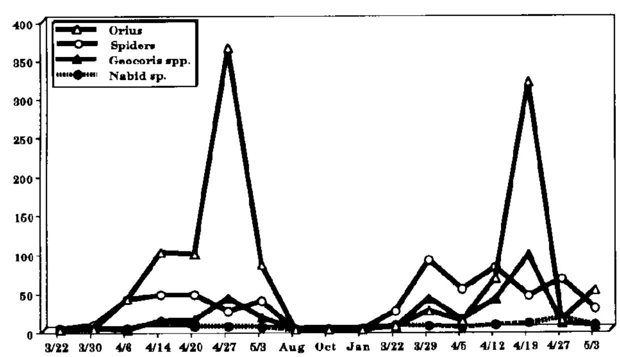

Fig. 1: 1994-95 Dooly County Sweep Sample Densities: BENEFICIALS

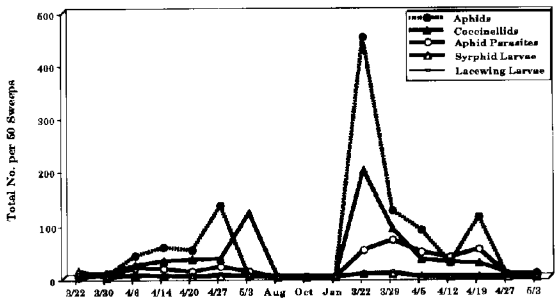

Fig. 2: 1994-95 Dooly County Sweep Sample Densities: APHID COMPLEX

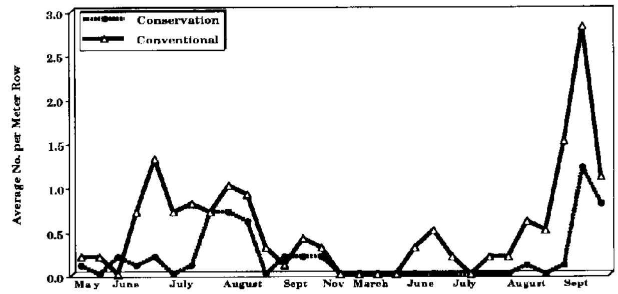

Fig. 6: 1994-95 Dooly Co. Whole Plant GEOCORIS Densities in Conservation vs. Conventional Tilled Cotton

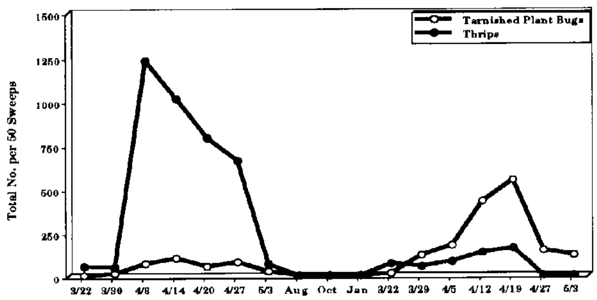

Fig. 3: 1994-95 Dooly County Sweep Sample Densities: OTHER PESTS

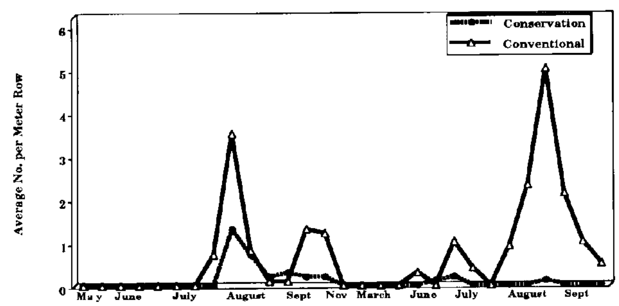

Fig. 7: 1994-95 Dooly Co. Whole Plant ANTHICID Densities in Conservation vs. Conventional Tilled Cotton

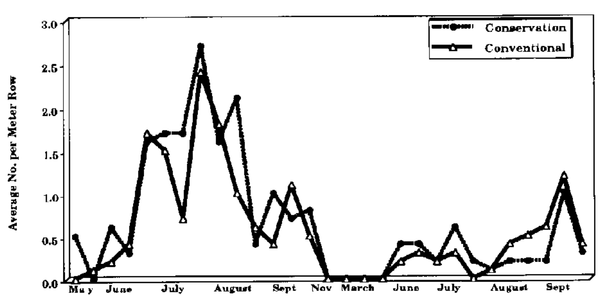

Fig. 4: 1994-95 Dooly Co. Whole Plant SPIDER Densities in Conservation vs. Conventional Tilled Cotton

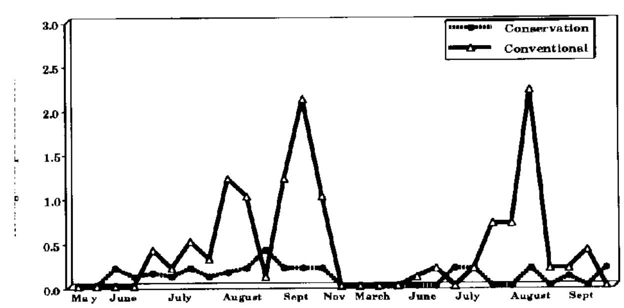

Fig. 8: 1994-95 Dooly Co. Whole Plant COCCINELLID Densities in Conservation vs. Conventional Tilled Cotton

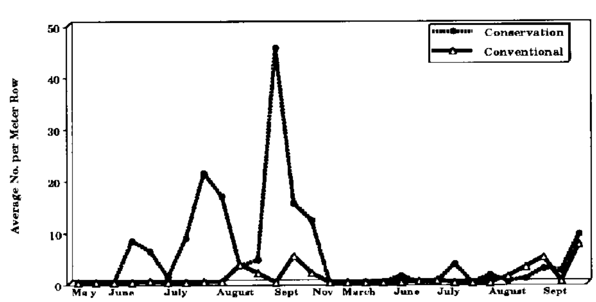

Fig. 5: 1994-95 Dooly Co. Whole Plant SOLENOPSIS Densities in Conservation vs. Conventional Tilled Cotton

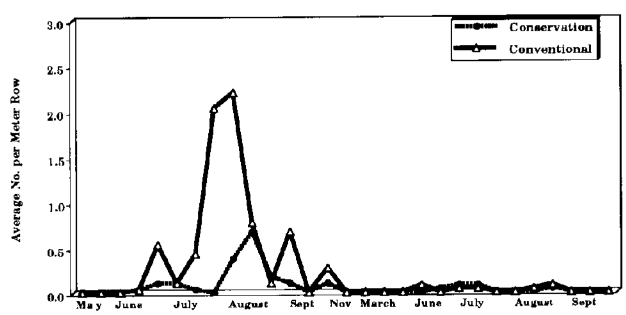

Fig. 9: 1994-95 Dooly Co. Whole Plant LACEWING Densities in Conservation vs. Conventional Tilled Cotton

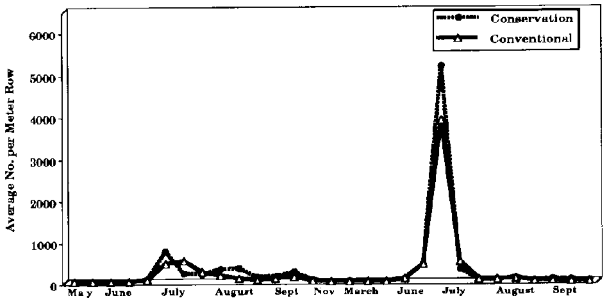

Fig. 10: 1994-95 Dooly Co. Whole Plant APHID Densities in Conservation vs. Conventional Tilled Cotton

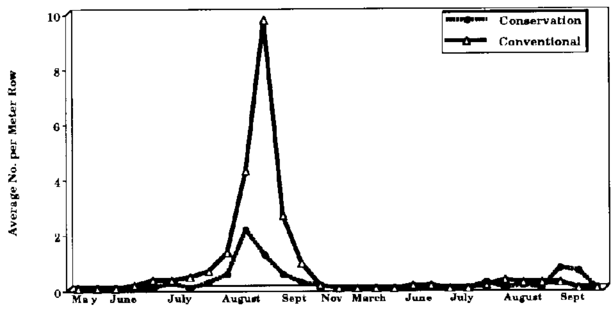

Fig. 11: 1994-95 Dooly Co. Whole Plant LARVAL Densities in Conservation vs. Conventional Tilled Cotton

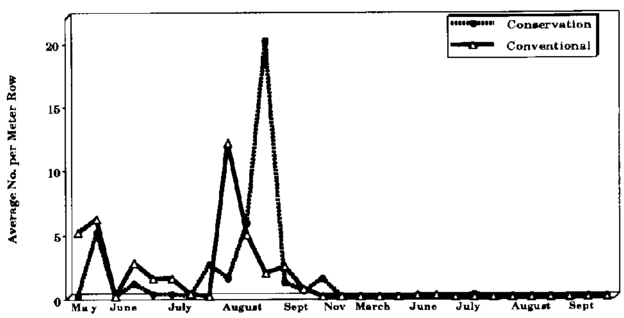

Fig. 12: 1994-95 Dooly Co. Whole Plant THRIPS Densities in Conservation vs. Conventional Tilled Cotton

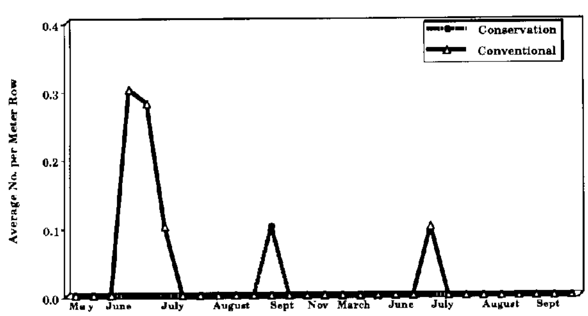

Fig. 13: 1994-95 Dooly Co. Whole Plant LYGUS Densities in Conservation vs. Conventional Tilled Cotton

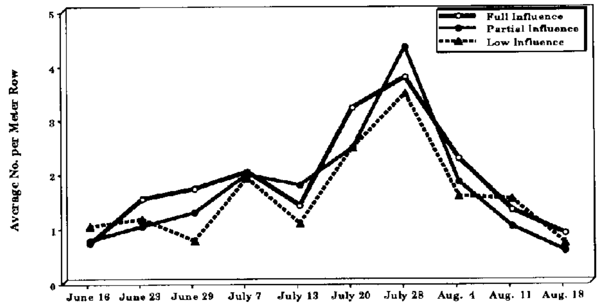

Fig. 14: 1995 Tift County Whole Plant SPIDER Densities in Refugia-Influenced Cotton Strips

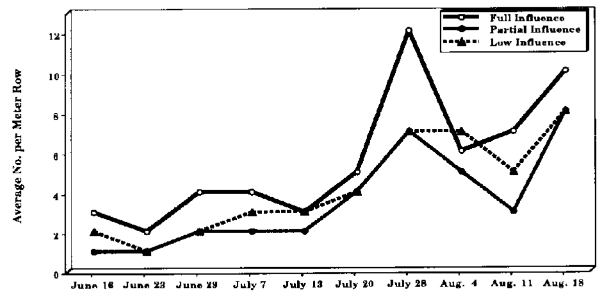

Fig. 15: 1995 Tift County Whole Plant SOLENOPSIS Densities in Refugia-Influenced Cotton Strips

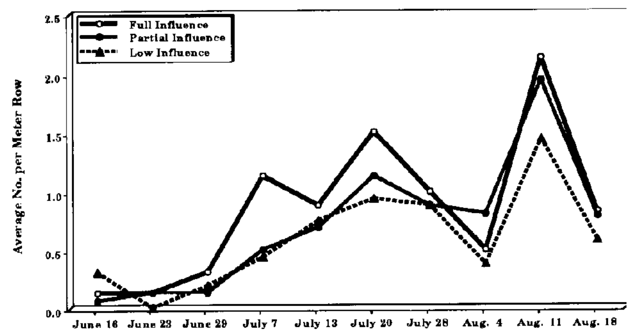

Fig. 16: 1995 Tift County Whole Plant GEOCORIS Densities in Refugia-Influenced Cotton Strips

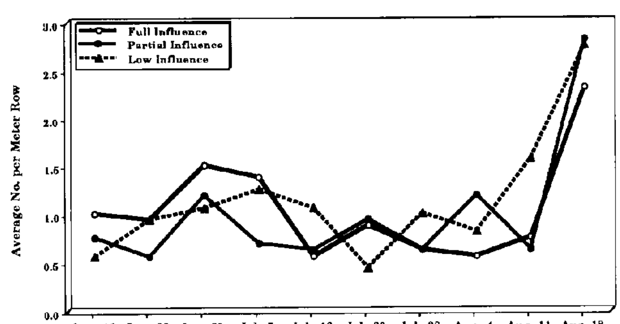

Fig. 17: 1995 Tift County Whole Plant ANTHICID Densities in Refugia-Influenced Cotton Strips

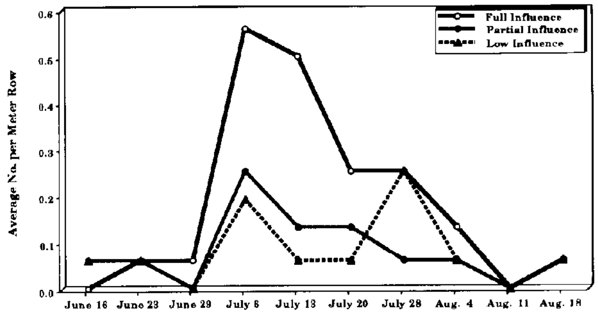

Fig. 18: 1995 Tift County Whole Plant COCCINELLID Densities in Refugia-Influenced Cotton Strips

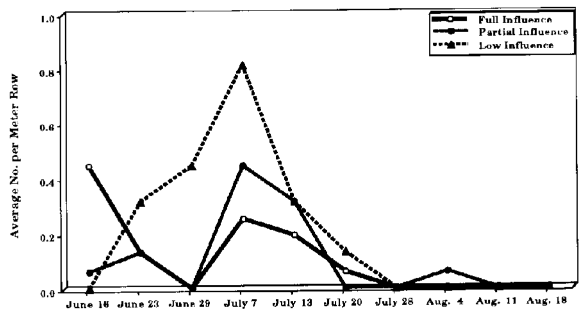

Fig. 19: 1995 Tift County Whole Plant LACEWING Densities in Refugia-Influenced Cotton Strips

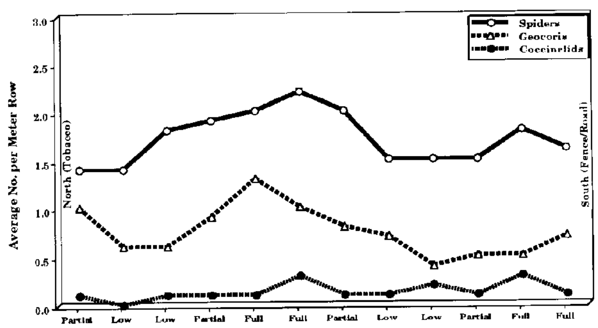

Fig. 20: 1995 Tift County Transect Whole Plant Overall Seasonal Distribution of BENEFICIALS in Full vs. Partial vs. Low Influence Cotton Strips

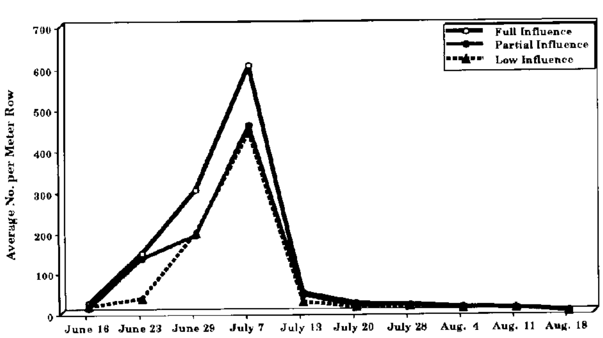

Fig. 21: 1995 Tift County Whole Plant Cotton APHID Densities in Refugia-Influenced Cotton Strips

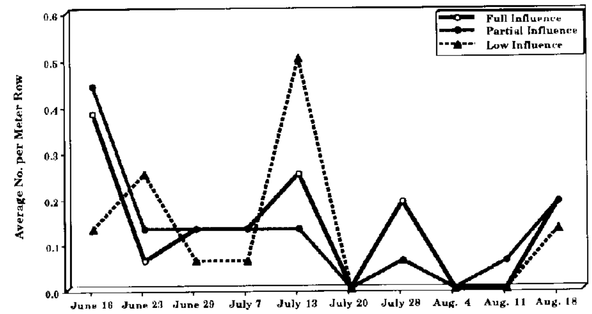

Fig. 22: 1995 Tift County Whole Plant LARVAL Densities in Refugia-Influenced Cotton Strips