SEASONAL POPULATION DYNAMICS, LIFE STAGE COMPOSITION OF *THRIPS TABACI* (THYSANOPTERA: THRIPIDAE), AND PREDACEOUS NATURAL ENEMIES ON ONIONS IN SOUTH TEXAS

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ABSTRACT

Onion thrips, *Thrips tabaci* Lindeman, is the most important insect pest of onions in the Lower Rio Grande Valley (LRGV) of south Texas. The population dynamics and life stage composition of *T. tabaci* populations and the predaceous natural enemy populations on onions were determined in three consecutive seasons from 2000 to 2002. *T. tabaci* were first present on onion plants in early February, increased in numbers gradually, and peaked in abundance in late March and early April. Visual counts of field populations revealed ≈75% of total thrips and at least 77% of total predators by absolute counts. Developmental stages of *T. tabaci* on onion plants consisted of 76-85% larvae, <0.1% pupae, and 10-28% adults. Although insecticide applications reduced thrips density, an average of 92 thrips was found on each onion plant over the season, which far exceeded the economic threshold. Several species of predators were found on onion plants. *Orius insidiosus* (Say) was the most abundant predator species, with 37.4-74.5% on onion plants, depending on the season and insecticide application. There were significant correlations between predators and thrips densities on untreated onion plants (r = 0.7327-0.8234), but there were no such correlations on insecticide-treated onion plants (r = 0.0536-0.4537). It appears that predators were not a major factor regulating thrips populations. Of the weather conditions, temperature affected only the early infestation in January and February; and a daily rainfall of 1.8 cm or more caused temporary reduction of thrips densities on onion plants.

INTRODUCTION

Onion (*Allium cepa* L.) is a major vegetable crop in south Texas with >6,000 ha harvested with a value of >$80 million in 2001 and an economic impact of >$150 million (Anonymous 2001). Onion thrips, *Thrips tabaci* Lindeman, is one of the most important pests of onions in south Texas (Royer et al. 1986, Edelson and Magaro 1988, Edelson et al. 1989, Sparks et al. 1998, Liu and Chu 2004).

Although conventional chemical control of *T. tabaci* on onions is fairly ineffective because of insecticide resistance resulting from years of exposure to many active ingredients, it is still the only means of managing this thrips on onions in south Texas (Sparks et al. 1998, Liu, unpublished data). Knowledge of the population dynamics and life stage composition for a certain thrips population in a given field and time may be useful for providing management recommendations because different life stages of thrips (i.e., adult-larva ratio) respond differently to insecticides (Liu et al., unpublished data). For example, a population with more larvae may be more susceptible to insecticides compared with one with more adults. In contrast, thrips larvae may be hard to manage with insecticides because they are not migratory and hide inside the leaf whorls.

Natural enemies of thrips, especially predators, may play a significant role in suppressing thrips populations (Hoffmann et al. 1996, Sabelis and van Rijn 1997). Information on predators, hymenopterous parasitoids, parasitic nematodes and fungal pathogens of thrips has been reviewed by Sabelis and van Rijn (1997), Loomans et al. (1997), and Butt and Brownbridge (1997). However, the importance of natural enemies of thrips, especially the predators, in south Texas has not been investigated.

The objectives of this study were to determine: (1) the population dynamics and life stage composition of *T. tabaci* populations, and (2) species composition of predaceous natural enemies on onion plants in south Texas.

MATERIALS AND METHODS

The study was conducted at the Research Farm of the Texas A&M University Agricultural Research and Extension Center at Weslaco, Texas. Onions (var. "1015") were planted on a 1-m bed and spaced at 25 cm. The plants were maintained under standard cultural practices for south Texas. Each plot had 10 rows, and each was 30-m long. The two insecticides used were, λ-cyhalothrin (Warrior with Zeon Technology, 1 EC; Syngenta, Greensboro, NC) at 0.033 kg AI/ha (0.03 lb AI/acre), and methomyl (Lannate L, 24% AI; Du Pont, Wilmington, DE) at 0.5 kg AI/ha (0.45 lb AI/acre). The two treatments, an insecticide treatment and an untreated control, each with three replications, were arranged in a randomized complete block design. Sorghum was planted along the margins of the plots as a windbreak to reduce possible between-plot thrips migration. Herbicides (bensulide [Prefar 4E], Gowan, Yuma, AZ; 1,112 g AI/ha) and fungicide (chlorothalonil [Equu 720], Griffin, Valdosta, GA; 1,260 g AI/ha) were applied as needed.

Whole plant sampling methods were used in 2000. Thrips sampling began on 7 February 2000 and carried out weekly until harvest. When sampling, 10 onion plants randomly selected from each plot were cut at ground level before the bulb was formed, or were cut from the neck or the upper part of the bulb after the bulb was formed. The plants were individually placed in 1-gallon zip-lock plastic bags (S.C. Johnson & Son, Inc., Racine, WI). In the laboratory, the leaves of the plant were separated inside the plastic bag and rinsed with water. All thrips, natural enemies, and larvae inside the bases of onion leaves or near the neck were washed off with a bottle sprayer. All insects washed off each plant were filtered in a funnel, and were transferred to a clear plastic Petri dish (9-cm diameter × 1.5-cm deep). Thrips adults, larvae, pupae, and predators were identified and counted. Visual counts methods were used in 2001 and 2002. From early February, 10 onion plants were randomly selected, and numbers of adult thrips and larvae were visually counted in the fields. All voucher specimens were deposited in the Insect Collection of the Texas A&M University Agricultural Experiment Station at Weslaco.

The weather data were obtained from a weather station monitoring temperature, rainfall, and wind direction and speed located approximately 100 m from the experimental onion field.

Data on thrips collected from onion plants, blue and white plastic cup traps and CC traps were analyzed using analysis of variance (ANOVA, SAS Institute 2002). Means were separated using the honestly significant difference test or Tukey test after a significant F-test at $P = 0.05$ (Zar 1999). Because only a few pupae were collected from onion plants, representing <1% of the total thrips, they were combined with larvae in the analyses. Correlations of the numbers of thrips with the numbers predators were analyzed using PROC CORR (SAS Institute 2002).

RESULTS AND DISCUSSION

Because there were only a few *F. occidentalis* (<1%) found in the onion field (Liu and Sparks, unpublished data), they were not separated in data analysis in the three seasons. Thrips population abundance on onion plants fluctuated through the season in all three seasons (Fig. 1). Generally, thrips were present on onion plants in early February, and increased in abundance gradually to the end of the season in mid or late April.

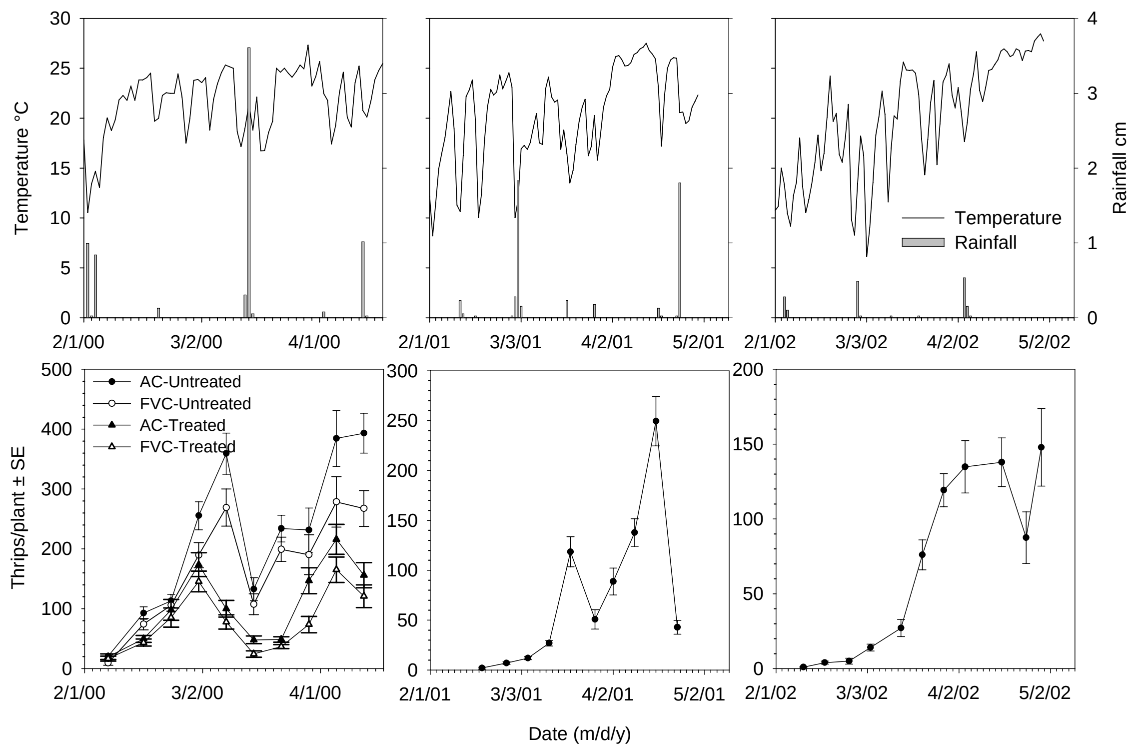

FIG. 1. Population dynamics of *Thrips tabaci* on onions and temperature and rainfall in the springs of 2000 to 2002 (Weslaco, Texas).

Thrips populations on onion plants as determined from both the absolute counts and field visual counts were more abundant throughout the 2000 season relative to those in 2001 and 2002 seasons. In the 2000 season, thrips abundance averaged 222 and 116 thrips per plant in untreated and insecticide-treated plots by absolute counts, respectively, and 167 and 91 thrips per plant in untreated and insecticide-treated plots by field visual counts, respectively (Table 1). Thrips densities also varied greatly among the plants as indicated by the extremely wide ranges, from 2 to 979 thrips per plant. Although thrips populations on untreated plants in 2001 and 2002 were lower than those in 2000, average numbers of thrips over the two seasons were still as great as 102 and 92 per plant in each of the two seasons, respectively.

TABLE 1. Mean Abundance of *Thrips tabaci* per Onion Plant and Adults-Larvae Composition on Onion Plants (Weslaco, Texas)

Season and treatment[a]	Mean/plant ± SE			
	All thrips	Adults	% adults	Larvae/adult
2000: AC, treated	116.4 ± 7.2	27.1 ± 1.7	27.6 ± 1.1	5.0 ± 0.4
2000: AC, untreated	221.6 ± 11.1	34.8 ± 1.9	19.0 ± 0.7	6.7 ± 0.3
2000: FVC, treated	91.3 ± 8.9	16.2 ± 3.1	17.7 ± 2.8	5.6 ± 0.9
2000: FVC, untreated	166.8 ± 21.8	26.4 ±3 .1	15.8 ± 1.2	5.3 ± 0.8
2001: FVC, untreated	102.1 ± 7.5	7.3 ± 0.6	10.4 ± 0.8	21.1 ± 1.9
2002: FVC, untreated	91.9 ± 4.9	9.9 ± 0.5	18.0 ± 1.0	16.4 ± 1.6

[a] AC: absolute counts; FVC: field visual counts.

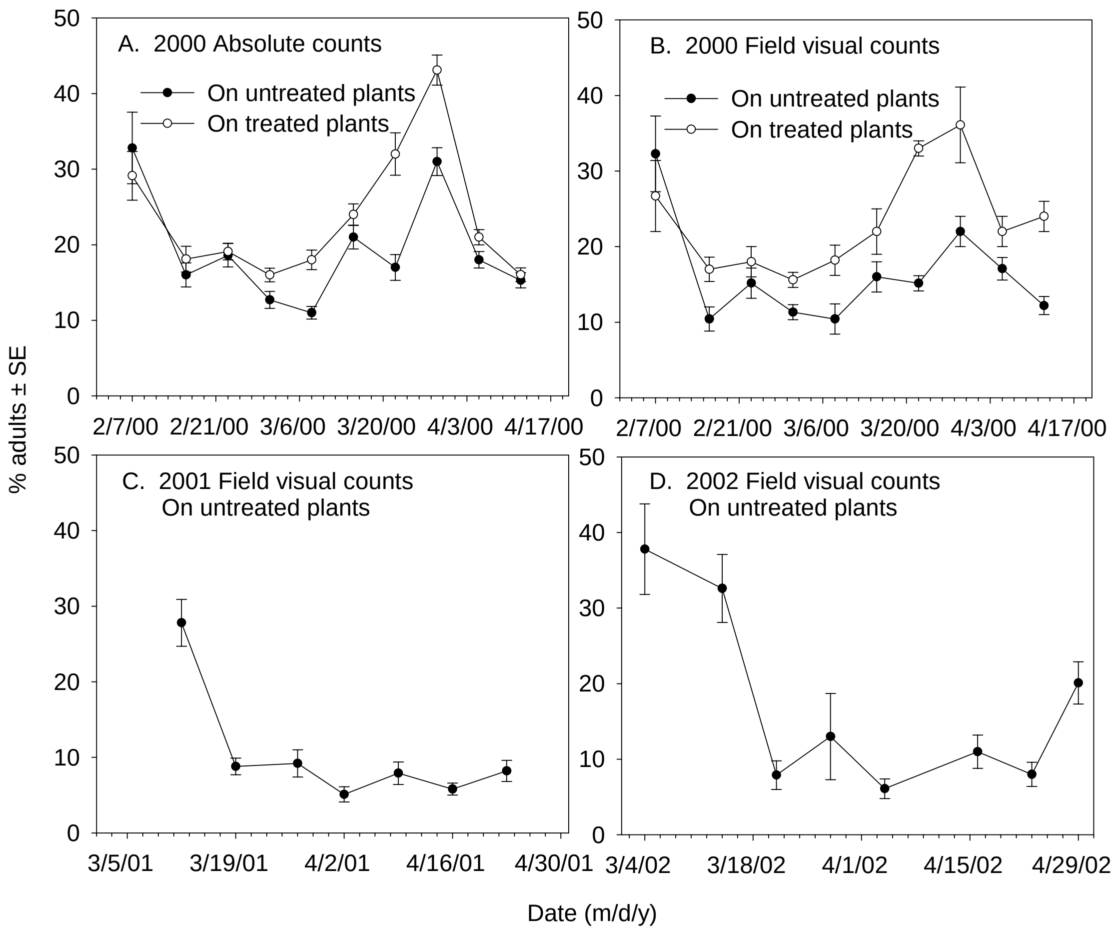

FIG. 2. Percentages of adult *Thrips tabaci* on onion plants sampled using absolute counts and field visual counts in the springs of 2000 to 2002 (Weslaco, Texas).

Applications of insecticides (λ-cyhalothrin and methomyl) in 2000 significantly reduced thrips populations on onions compared with untreated plants based on absolute counts (F = 102.96; df = 1, 580; P < 0.0001) and field visual counts (F = 151.27; df = 1, 580; P < 0.0001). However, three applications of λ-cyhalothrin and five applications of methomyl did not effectively suppress thrips populations on onions during the season, and numbers of thrips on insecticide-treated plants were still greater than the economic threshold of 1 thrips per plant (Edelson et al. 1986).

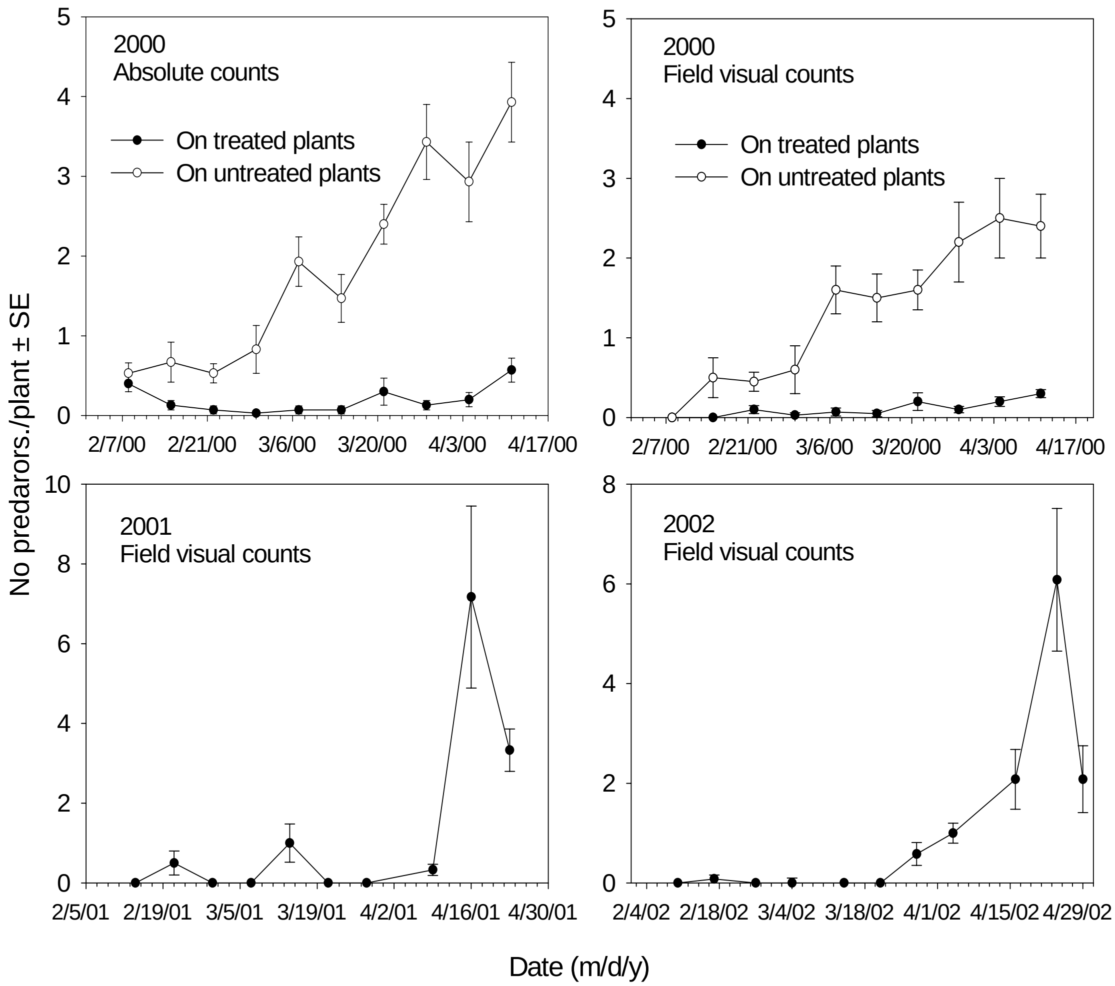

FIG. 3. Predators of *Thrips tabaci* on onion plants in the springs of 2000 to 2002 (Weslaco, Texas).

Weather conditions could significantly affect the population dynamics of *T. tabaci* on onions (Fig. 1). Of the environmental conditions, heavy rainfall was the most important factor regulating thrips densities in this experiment (Figs. 1, 3). For example, a rainfall of 3.7 cm with a 51.5 km/h (32 mph) wind on 14 March 2000 was followed by a reduction in *T. tabaci* densities, especially larval thrips, on onion plants. The rainfall was followed by thrips population rapidly increasing for almost three weeks. In 2001, a rainfall of 1.83 cm on 3 March was not followed by a reduction in thrips populations because thrips populations were already low, but a rainfall of 1.80 cm on 24 April was followed by a reduction in thrips populations following rain events ≈/<1 cm in all three seasons. It appears that temperature was only related to the thrips population increase in early spring, not in the middle and late season in south Texas (Figs. 1, 3).

Percentages of adult thrips abundance to total thrips abundance on onion plants varied on different sampling dates during each season and between the three seasons (Fig. 2). Overall percentages of adults to total thrips ranged from 27.6% on insecticide-treated plants and 19.0% on untreated plants in 2000, to as low as 10.4% in 2001 (Table 1). Generally, adult thrips composed of <20% of all thrips on onion plants as estimated by both the absolute counts and the field visual counts. The higher percentages of adult thrips to total thrips were found in the early season when thrips infestation was at an early phase (Fig. 2). With the increase of adult thrips population, more immatures were produced, lowering the adult percentage. The lower percentages of adults in the late season could be caused by fewer larvae molting to adults, or more adults leaving the plants as the plants became mature. In addition, adult thrips may migrate from plants, especially when plants were senescing. In the fields where insecticides were applied, the insecticides might irritate the adult thrips and cause migration to adjacent untreated plants or wild hosts.

Several species of predators were found on onion plants, including *Orius insidiosus* (Say), bigeyed bug, *Geocoris punctipes* (Say), assassin bug, *Sinea spinipes* (Herrich-Schaeffer), *Chrysoperla rufilabris* (Burmeister), several species of lady beetles, spiders, predacious mites, and rove beetles. Most predators found in this study are generalist predators. Generally, the numbers of predators were extremely low on either insecticide-treated plants or untreated plants in the early and mid-season, and peaked in the late season in April when thrips populations peaked (Fig. 4). Numbers of thrips and numbers of predators on untreated onion plants were correlated, with correlation coefficients ranging from 0.73 to 0.82 (Table 2). However, numbers of thrips and numbers of predators on insecticide-treated onion plants were not correlated (r = 0.05 to 0.45).

TABLE 2. Correlation of Numbers of *Thrips tabaci* and Numbers of Predators on Onion Plants (Weslaco, Texas)

Season and treatment	Correlation coefficient, *r*	
	Treated plants	Untreated plants
2000: absolute counts	0.0536	0.7597[a]
2000: field visual counts	0.4537	0.8234[b]
2001: field visual counts	-	0.7327[a]
2002: field visual counts	-	0.7649[a]

[a], [b] Significant at $P = 0.05$ and 0.01, respectively (Tukey test, SAS Institute 2002).

TABLE 3. Numbers of Predaceous Arthropods of *Thrips tabaci* per Plant and Proportion of *Orius Insidiosus* on Insecticide-Treated or Untreated Onion Plants (Weslaco, TX)

Seasons [a]	Treated		Untreated		*F*
	Predators ± SE	% *Orius*	Predators ± SE	% *Orius*	
2000 AC	0.20 ± 0.03	40.2	1.87 ± 0.13	74.5	221.89[b]
2000 FVC	0.24 ± 0.03	43.1	1.44 ± 0.11	72.3	136.38[b]
2001 FVC	-	-	1.69 ± 0.19	37.4	-
2002 FVC	-	-	1.26 ± 0.32	42.7	-

[a] AC: absolute counts; FVC: field visual counts.
[b] Significant at $P = 0.01$ (Tukey test, SAS Institute 2002).

Of the predators from the absolute counts in 2000 or field visual counts in the three seasons, a majority were *Orius insidiosus* (Say) (Table 3), ranging from 65.2-74.5% of total predators. However, on insecticide-treated plants in 2000, only 40.2 and 45.2%

were *O. insidiosus*, which were significantly different from percentages on untreated onion plants. Numbers of thrips per *Orius* ranged from 23 in early February to 177 in early 5 April on untreated plants and 13 in early February to 458 in early April on insecticide-treated plants in 2000, from 25 to 171 thrips per *Orius* in 2001, and 15 to 273 in 2002. It appears that predators were susceptible to insecticides as shown from the data in 2000, and that numbers of predators were significantly greater on untreated plants than on insecticide-treated plants in both absolute counts ($F = 221.89$; df = 1, 580; $P < 0.0001$) and field visual counts ($F = 221.89$; df = 1, 580; $P < 0.0001$) (Table 3).

DISCUSSION

Onions are normally directly seeded in October, but can be planted early in September to late in November or December in south Texas. After germinating 5-7 d after seeding, onion seedlings grow slowly during the winter, and are normally in the 5-7 leaf stage by January. Although the first presence of onion thrips on onion plants depends on the temperature in the early spring, the cool weather during December, January and February, which approximates the lower development threshold (11.5ºC) for *T. tabaci*, is the cause of low populations during these months (Edelson and Magaro 1988). Thrips infestations in fields start to increase as early as January, but normally in early February. Populations increase gradually with the growth of onion plants, and reach peaks in abundance in late March or early April; however, there is no significant correlation between temperature and thrips density. Despite the substantial differences in the thrips populations during the three seasons in 2000-2002, onion thrips population dynamics pattern among the three consecutive seasons coincided with the normal pattern of thrips occurrence on onion plants under field conditions in south Texas.

The hot, dry conditions in south Texas in the spring not only favor the onion crop growth but also thrips population increases. As shown in Fig. 1, rain is rare in the spring in south Texas. In the three seasons, only a few days received a rainfall over 1 cm. Therefore, we do not normally expect heavy rainfall to occur and wash thrips from plants. Although temperature and thrips density is not correlated over the season, the low temperatures in January and February in 2001 and 2002 might prevent thrips population from rapid increasing until mid-March (Fig. 1). In contrast, temperatures reached 20ºC or higher in early February in 2000, and the thrips populations increased rapidly from mid-February and peaked in early March. These results indicate that temperature in the early spring can play a significant role for early season thrips infestation and population increase.

Results from the 2000 season show that applications of insecticides reduced predacious natural enemy abundance. For instance, only 40.2 and 43.1% of predators were *O. insidiosus*, which is significantly different from untreated onion plants. These low percentages of *Orius* to total predators in the insecticide-treated plots indicate that *Orius* might be more susceptible to insecticides than other predators. These results confirmed that predacious insects are typically more susceptible to insecticides than the phytophagous pest species due to the evolution of a mechanism for detoxification of plant secondary compounds (Croft 1990).

Natural enemies, including predators, hymenopteran parasitoids, parasitic nematodes and fungal pathogens of thrips can play prominent roles in regulating thrips populations on plants under natural conditions (Hoffmann et al. 1996, Sabelis and van Rijn 1997, Loomans et al. 1997, Butt and Brownbridge 1997). There is no doubt that natural enemies can be successfully used to manage thrips in greenhouses (Jacobson 1997). However, there are controversies regarding the importance of natural enemies in suppression of thrips populations in the field. Parrella and Lewis (1997) indicated that natural enemies play an insignificant role in regulating thrips populations under field conditions. Although the results in this study indicate that predation by natural enemies was not a major factor or was at least not adequate in suppressing thrips populations on onions, it is difficult to make firm conclusions about the impact of natural enemies in a field where the thrips population exceeded an economic threshold by such a large margin. In addition, these predators may be hampered by the fact that thrips feed under close-fitting leaves and down in the leaf sheaths where they are difficult to access. Also, when thrips populations were as high as those in 2000 and 2001, it may mask the role of natural enemies.

In conclusion, *T. tabaci* is the most important pest insect affecting onion quality and yield in south Texas. Field visual counts estimated ≈75% of total thrips and 77% of total predators by absolute counts. Of the developmental stages of *T. tabaci* on onion plants, 76-85% were larvae, <0.1% were pupae, and 10-28% were adults. Application of insecticides significantly reduced thrips densities, but there were still >90 thrips per onion plant throughout the season. Several species of predators were found on onion plants, and a majority of these predators were *O. insidiosus*. Temperatures in January and February affect early thrips infestations, but have no significant effects thereafter. Heavy rainfalls can temporarily wash off thrips densities, but it is rare in south Texas. Although the level of infestation by *T. tabaci* can be extremely heavy during March and April before harvest, at present there are no effective management measures (Sparks et al. 1998, Liu and Sparks unpublished data). Because there are no thrips-resistant varieties (Edelson et al. 1991, Hamilton et al. 1999), an integrated thrips management program, including monitoring thrips infestation levels, reevaluating current economic threshold, screening efficacious insecticides, and determining the potential of biological control, is needed.

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