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SUSCEPTIBILITY OF PVY-RESISTANT BURLEY TOBACCO BREEDING LINES AND CULTIVARS TO COLONIZATION BY THE GREEN PEACH APHID, MYZUS PERSICAE (SULZER)

A Thesis

Presented for the

Master of Science Degree

The University of Tennessee, Knoxville

Jay Perkins Avery

August 1988

DEDICATION

I dedicate this manuscript to two people who taught me to have confidence along with numerous values and skills. I dedicate this thesis to my wonderful parents, Mr. and Mrs. Hayden C Avery.

ACKNOWLEDGEMENTS

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From the bottom of my heart, the author wishes to extend love and thanks to his family for the encouragement and support they have provided in this and all other endeavors.

The author wishes to express the utmost appreciation and love to his wife, Molly Ann, and children, Jessica Ann and Caleb Perkins, for making me indescribably happy and surrounding me with love and friendship.

ABSTRACT

Selected burley tobacco breeding lines and cultivars were evaluated for colonization by the green peach aphid (GPA), Myzus persicae (Sulzer), in the field and in the laboratory. Tobacco entries utilized in this study included: Five tobacco breeding lines, GR 107, GR 115, GR 131, GR 132 and PDJA 309; three burley tobacco cultivars, 'TN 86' (previously GR 136), 'BU 21' and a standard, 'VA 509'; and a flue-cured tobacco, TI 1112. GR 115, which has non-secreting trichomes, and TN 86, which has secreting trichomes, were further evaluated in the laboratory for lack of colonization by GPA due to predation by convergent lady beetle (CLB), Hippodamia convergens Guerin-Meneville.

In the field, without adequate applied or natural control methods, or in the absence of predators, all plants became colonized by the GPA. When CLBs were present, GPA populations were suppressed on the non-secreting breeding lines but not on the secreting breeding lines and cultivars. In the laboratory, under controlled conditions, aphids colonized all entries at similar rates. CLBs did not choose aphid-infested leaves of TN 86; whereas, implied resistance to GPA exhibited by GR 115 was due to CLB selecting aphid-infested leaves of this non-secreting breeding line.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

Aphids or plantlice constitute a large group of small, soft-bodied insects that are frequently found in large numbers sucking sap from stems and leaves of plants (Borror et al. 1981, Comstock 1950). Both nymphs and adults are common in aphid populations. Wingless (apterous) and winged (alate) forms can usually be recognized by their characteristic elliptic shape, a pair of cornicles at the posterior of the abdomen, and long antennae.

Aphids excrete honeydew, which is emitted from the anus. Honeydew consists mainly of excess sap ingested by the insect, to which are added excess sugars and waste material (Borror et al. 1981). Honeydew, produced in sufficent quantities, may cause the surface of objects beneath aphids to become sticky. Honeydew deposited on the surface of plants is a good substrate for growth of sooty mold (Kulash 1949, Lawson and Chamberlain 1957).

The life cycles of many aphid species are rather unusual and complex. In the northern United States, most species overwinter in the egg stage. These eggs hatch in the spring into females that, when mature, reproduce parthenogenetically (without mating) and ovoviviparously (giving birth to living young) (Richards and Davies 1977). Several generations of ovoviviparous, parthenogenetic females may be produced during one growing season. The

first and second generations are usually comprised of wingless individuals; winged individuals usually occur in the third generation. In many species, winged forms migrate from overwintering hosts to other host plants, where the aphids colonize and reproduce. In the latter part of the season, winged aphids migrate to alternate host plants, producing two generations, one consisting of both males and females and one consisting of only females. Males of this bisexual first generation mate with females of the second generation which lay the overwintering eggs (Borror et al. 1981). In the southern United States, most aphid species overwinter as nymphs and adults.

Aphids are one of the most economically important groups of insects, since large populations of aphids can develop in a short period of time. Aphid populations are frequently maintained at low to moderte levels by parasitoids and predators, resulting in a reduction of damage by aphids. The major parasitoid groups attacking aphids are the braconids and chalcids, while the most important predators are lady beetles, lacewings, and the larvae of syrphid flies (Borror et al. 1981).

The green peach aphid (GPA), Myzus persicae (Sulzer), is one of the more serious pests of tobacco, particularly burley tobacco. GPA directly damages tobacco plants by sucking plant juices,and indirectly by depositing honeydew, a medium for the growth of sooty mold. Heavily infested

plants are lower in weight and quality, and more difficult to cure.

The GPA is also a vector of many important plant pathogens, particularly viruses. Outbreaks of GPA-transmitted virus diseases, such as tobacco etch, potato virus Y (PVY) or tobacco vein mottling virus (TVMV), may cause significant economic losses for tobacco producers.

Aphids migrating to plant beds from nearby alternate hosts may result in severe infestations following transplanting (Lawson and Chamberlain 1957). Seasonal fluctuations in infestations of tobacco by GPA following the first outbreaks have varied in several tobacco-producing areas (Chamberlain 1958). The severity of GPA infestations vary within a general locality in some tobacco-growing areas. GPA usually do not occur on burley tobacco until mid-June in eastern Tennessee and during the latter part of the growing season in southern Maryland and Kentucky (Webster and Thurston 1965). In the southernmost United States, a GPA infestation may cause economic loss early in the growing season because they can develop early from colonies originating from numerous overwintering sites located near plant beds or fields.

Tobacco growers rely primarily on chemical insecticides for control of GPA. Possible monetary losses due to damage by GPA encourage growers to apply

insecticides at or prior to the first evidence of infestation. Because growers desire immediate action to reduce insect damage, it has been difficult to integrate biological control, which is normally slow to reduce GPA populations, into tobacco pest management programs. Alternate control methods, such as host plant resistance, may be more economical and permanent than the use of chemical insecticides.

The use of resistant plants as an insect pest management tactic has been known and advocated for many years (Bigger 1943). Researchers, however, have recently intensified their efforts to fully understand the intimate relationship between the insect and its host plant. Some situations are very conducive to the use of plants that exhibit insect resistance (Painter 1941).

Use of host plant resistance has several advantages. A resistant variety, incorporated into a managagement program, may result in fewer chemical insecticide applications, as well as the use of lower rates of insecticides. This reduction in chemical applications may help reduce the incidence of pest resistance to insecticides and minimize residues that could be harmful to non-target organisms, such as wildlife, pollinators, and other beneficial insects.

II. LITERATURE REVIEW

HISTORY

Aphids were reported to infest tobacco, Nicotiana tabacum L., as early as 1899 (Howard 1899). The GPA was first reported to infest tobacco in the greenhouse by Gillette and Taylor (1908), and GPA was later reported to be an economic pest of tobacco in Sumatra (den Doop 1919). Life history studies of GPA were conducted in Missouri (Taylor 1908), Pennsylvania (Horsfall 1924), Maine (Patch 1925) and Washington (Davis and Landis 1951).

Heavy infestations of aphids on tobacco occurred in 1946 in many sections of eastern North Carolina (Chamberlain 1958, Kulash 1949). This species of aphid was identified as the GPA (Kulash 1949). By 1948 heavy infestations were found in the burley-producing areas of western North Carolina. Many tobacco growers had observed aphid infestations much earlier than 1946, but aphids had not been reported to be abundant (Kulash 1949).

Aphids were known to be serious pests of tobacco in other countries prior to the 1946 outbreak in the United States (Chamberlain 1958, Kulash 1949). Because of their feeding activities and transmission of diseases, aphids are considered an economic pest in more than ten countries (Chamberlain 1958).

LIFE CYCLE

The GPA produces only females in the southern United States (Lawson and Chamberlain 1957). Females reproduce parthenogenetically and ovoviviparously. Most nymphs develop into wingless adults, however, winged adults are produced when tobacco plants become overcrowded or saturated with aphids. In Tennessee and Kentucky few aphids survive the winter, but in central North Carolina and southern Virginia they can survive on turnips and collards throughout the fall and winter (Lawson and Chamberlain 1957). Favored host plants in the fall, winter, and spring are cabbage, collard, turnip, wild mustard, and dock (Lawson and Chamberlain 1957).

In colder climates, males and egg-laying females develop in the fall. Eggs are laid mostly on peach, wild plum, and wild cherry trees (Lawson and Chamberlain 1957). Eggs usually hatch in the spring, and the second or third generation of winged individuals infests tobacco (Lawson and Chamberlain 1957).

GENETIC VARIABILITY

More than one hundred different host plants of the GPA were recorded by Horsfall (1924). Weber (1985) reported over 400 plant species in more than 50 families as hosts of the GPA. He contributed this wide host range to phenotypic

plasticity of individuals and genetic variability in the population.

In 1986, a pink aphid appeared on burley tobacco in eastern Tennessee (personal observation). This aphid was believed to be a different color form of GPA, but Blackman (1987) indicated that this aphid was a separate species, M. nicotianae. He reported that both M. persicae and M. nicotianae are frequently heterozygous for apparently the same autosomal translocation, which they must have acquired independently. Populations of pink aphids, M. nicotiana, have 13 or 14 chromosomes in somatic cell nuclei instead of the normal 12. Throughout this manuscript the aphids I studied will be referred to as the GPA, M. persicae, since no species in eastern Tennessee has yet been verified to be M. nicotianae.

HOST PLANT RESISTANCE

The importance of host resistance to insect attack on several crops was stressed by Chaplin et al. (1976). Burk and Dean (1975) stated that incorporation of resistance to the GPA into cultivated tobacco is highly desirable.

Production of toxic materials by tobacco plants may be the cause of resistance to GPA (Thurston and Webster 1962, Thurston et al. 1966). Thurston et al. (1966) reported resistance in some of the tobacco introductions collected by the United States Department of Agriculture from various

tobacco-producing areas of the world. N. gossei was reported to be highly toxic to GPA while susceptibility in N. tabacum resulted from differences in amounts or concentrations of toxicant produced (Thurston and Webster 1962).

Secretions of nicotine, anabasine and probably nornicotine from several Nicotiana species were responsible for mortality of GPA (Thurston et al. 1966). Aphid populations, however, were not affected by the various alkaloid levels in burley tobacco plants in later studies (Thurston et al. 1977). They speculated that trichome density, and not alkaloid level, may be responsible for resistance in tobacco.

Trichomes of tobacco were also reported to have an effect on insect pests and their natural enemies by Roberts et al. (1981), and Thurston and Katanyukul (1973). Trichome density and trichome exudates may be the most important factors affecting oviposition by insects (Roberts et al. 1981). Belcher (1980) reported that tobacco cultivars with sticky trichome exudates decreased movement of larvae of the convergent lady beetle (CLB), Hippodamia convergens Guerin-Meneville. Sticky exudates may trap insects, contain toxic materials, and serve as repellants or attractants (Nielson et al. 1982).

Tobacco trichome exudates were reported to have an effect on several beneficial insect species. Tobacco hornworm, Manduca sexta (Linnaeus), eggs were reported to be attacked more readily by Telenomus sphingus (Ashmead) and Trichogramma minutum Riley on non-secreting than on secreting tobacco introductions (Thurston and Katanyukul 1973). They attributed this difference in parasitism to the sticky exudates of tobacco trapping the adult parasitoids.

Duvatrienediols have been identified as the major chemical compounds present in trichome exudates and have been associated with insect resistance (Johnson and Severson 1982, Severson et al. 1982). Tobaccos with low levels of duvatrienediols exuded a light secretion, if any, and were reported to be resistant to aphids (Johnson and Severson 1982). However, many tobaccos with high levels of diols are resistant (Johnson and Severson 1982); therefore, other factors also affect resistance.

Resistance to GPA is more evident in mature plants of resistant tobacco (Abernathy and Thurston 1969). Older tobacco plants should be used when screening for resistance to GPA because of the lack of toxicity of young plants.

Many N. tabacum entries were reported to be resistant to aphids but the source of resistance was not known (Johnson 1980). Johnson (1980) suggested that

nonpreference and antibiosis may be involved in resistance to aphids.

Tobacco Introduction (TI) 1112 was reported to have numerous simple and branched trichomes without glandular heads or exudates (Johnson et al. 1985). TI 1112 (common name "Blanco") was imported from Venezuela and is classified as a primitive tobacco. Johnson (1978) reported TI 1112 to have a high degree of resistance to aphids. Aphids colonized TI 1112 in the greenhouse but not in the field; therefore, the resistance appeared to be nonpreference (Johnson 1978).

Resistance of TI 1112 to GPA was reported to be due to alate aphids abandoning the plant (Elsey and Chaplin 1978). They observed few colonies of GPA on TI 1112. In comparison to standard flue-cured tobacco cultivars, more coccinellids were present and observed to burrow in the growing tip of TI 1112. They suggested that the coccinelids may be attracted by a plant product.

VIRUS RESISTANCE AND INSECT DAMAGE

TI 1406, a PVY-resistant breeding line developed in West Germany, has been used as the primary source of resistance for the development of new virus-resistant breeding lines (Smeeton 1976). However, TI 1406, which is also known as Virgin A Mutant, has non-secreting trichomes. Alleles at a single locus have been reported to control the

presence or absence of these secreting trichomes (Nielson et al. 1982). PVY-resistant breeding lines developed from TI 1406 have also had non-secreting trichomes and have been unusually susceptible to insect damage (Gupton 1980, Miller 1987, Nielson et al. 1982, Smeeton 1976).

During the development of advanced breeding lines having resistance to the potato virus Y (PVY) complex of viruses, several lines having intermediate levels of resistance to the GPA were identified at the University of Tennessee (R. D. Miller, 1988, pers. com.). These lines have virus resistance derived from TI 1406, but are not greatly susceptible to feeding damage from other insect pests. Based on results of breeding studies at the University of Tennessee, further research was initiated to assess the influence of selected breeding lines on colonization of GPA, as well as the influence on selected predator species.

III. MATERIALS AND METHODS

Field and laboratory studies were conducted to determine if selected breeding lines and cultivars of tobacco were resistant to GPA. Five tobacco breeding lines (GR 107, GR 115, GR 131, GR 132 and PDJA 309) and three burley cultivars ['TN 86' (previously GR 136), 'BU 21' and a standard, 'VA 509'], and TI 1112 were evaluated for colonization by GPA. GR 107 is a PVY-resistant breeding line developed from TI 1406 that has non-secreting (nonsticky) trichomes (Gupton 1980). GR 115 is a doubled haploid PVY-resistant line developed by tissue culture techniques from an F1 cross between GR 107 and KY 14. GR 131, GR 132, and TN 86 are PVY-resistant lines developed by the University of Tennessee from TI 1406, but unlike TI 1406 they have normal secreting (sticky) trichomes. PDJA 309 is a PVY-susceptible flue cured breeding line developed by Albert Johnson at the Pee Dee Experiment Station, Florence, South Carolina. PDJA 309 produces heavy trichome exudates and is reportedly resistant to aphids. VA 509 and BU 21 are PVY-susceptible standard burley cultivars. GR 115 and TN 86 were further evaluated in the laboratory for lack of colonization by GPA due to predation by CLB.

FIELD EXPERIMENTS

Field experiments were designed to allow seasonal evaluation of colonization by GPA on each of the selected tobacco entries. Nymphs and adults were counted every 7-14 days from initial infestation (late June to early July) until plants were topped (mid-August). GPAs were counted on the upper and lower leaf surfaces of 10 plants in the inner two rows of each four-row plot.

GR 107, GR 115, GR 131, GR 132, TN 86 and VA 509 were transplanted during 1985 at the University of Tennessee Tobacco Experiment Station (TES), Greeneville, in eastern Tennessee. GR 115, GR 131, TN 86, VA 509 and BU 21 were transplanted during 1986 at two locations in eastern Tennessee: (1) TES, Greeneville, and (2) the Carter Isaacs Farm, Mountain City. PDJA 309 also was transplanted at location 1.

Treatments (i.e., entries) were arranged in a randomized complete block design with four replications. Each plot was 4 rows x 12.6 m. Rows were spaced 107 cm apart, and plants were spaced 41 cm apart within rows. Management and cultural practices used were those recommended for the production of burley tobacco in Tennessee.

At Greeneville, in 1985, numbers of aphids were recorded on July 10, 17, 25 and August 2. Tobacco plants were rated for aphids on August 14, because secreting

entries were "supersaturated" with aphids, and nonsecreting entries had very few aphids (ca. 100/plant) but were covered with sooty mold. Numbers of CLBs were recorded on July 25 and August 6.

At Greeneville, in 1986, numbers of aphids were recorded on June 8, 16, 22, 30, July 6 and 14. Numbers of alates (migrants) were recorded separately from apterae on June 8 and 16.

At Mountain City, in 1986, because of low aphid populations, ratings were given to plants on June 19 and July 1.

Plants were rated as:
- 0.0 = no aphids present.
- 0.5 = 50% of plants with alates present.
- 1.0 = alates present on all plants.
- 1.5 = colonies of apterae present on 50% of plants.
- 2.0 = colonies of apterae present on all plants.

Numbers of aphids were recorded on July 15 and 29, on which dates aphid populations were well developed.

LABORATORY EXPERIMENTS

Five tobacco breeding lines (GR 107, GR 115, GR 131, GR 132, and TI 1112) and three burley tobacco cultivars (VA 509, BU 21 and TN 86) were monitored in the laboratory for colonization by GPA, in the absence of predators. Aphid-infested leaves of TN 86 and GR 115 were also monitored to

determine the effect of CLB on population dynamics of GPA. GPAs used in this study were obtained from laboratory colonies maintained continuously in growth chambers at The University of Tennessee; CLBs were collected from field tobacco plots. Tobacco plants were grown in pots (10 cm) in the greenhouse using standard greenhouse procedures.

In experiment I, two apterous GPA were transferred from stock plants, using a camel hair brush, to one plant of each entry (GR 107, GR 115, GR 131, GR 132, TN 86 and VA 509) and placed in growth chambers [30±2° and 20±2° day:night, respectively, and 14:10 (L:D) photoperiod]. Total numbers of GPAs were counted on upper and lower leaf surfaces 5, 9, and 15 days after infestation. Each treatment was replicated four times.

In experiment II, two entries (TI 1112 and BU 21) were added and two (GR 107 and GR 132) were removed from the entries used in experiment I. Four apterous GPA were transferred from tobacco plants to one plant of each entry and placed in growth chambers [30±2° and 20±2° day:night, respectively, and 14:10 (L:D) photoperiod]. Total number of GPAs were counted on upper and lower leaf surfaces 3, 8, 13 and 17 days after infestation. Each treatment was replicated two times.

The influence of CLB on reducing populations of GPA was investigated using GR 115 (non-secreting) and TN 86 (secreting). Leaves, measuring ca. 8 cm x 12 cm, were

removed from plants of those two entries and placed in plastic containers (7.5 cm deep x 20 cm diameter). Each leaf contained ca. 260 (205-350) aphids. Five CLB adults, deprived of food for 24 hours, were then placed into each container with one infested leaf of each entry and allowed to prey freely on the aphids for 2 hours. Numbers of GPA and CLB were counted on each leaf after 1 and 2 hours. Each treatment was replicated five times.

All field and laboratory data were subjected to analyses of variance. Significant ($P \leq 0.05$) treatment means were separated by Duncan's (SAS Institute 1985) multiple range test.

IV. RESULTS AND DISCUSSION

FIELD EXPERIMENTS

Tobacco Experiment Station

In 1985 all entries became colonized by GPA. Winged aphids were first observed on plants on July 2, with some dead individuals stuck to the upper leaf surfaces of secreting entries. CLB adults were observed on that same date only on GR 115, a non-secreting line.

By July 10, only light infestations (3.4-7.4 aphids per plant) were observed, and no significant differences in aphid density occurred among entries (Table 1*, Figure 1). On this date, ca. 30% (n=124) of the population consisted of winged aphids. By July 17, GR 115, one of the two non-secreting lines, was colonized by significantly more aphids than all other entries, except GR 107 (non-secreting), which was not significantly different from the remaining entries (secreters) (Table 1, Figure 1). No CLBs were observed in the plots on this date. By July 25, aphid densities were significantly greater on GR 115 than on all other entries (Table 1, Figure 1), and densities of adult CLB were significantly greater on GR 115 than on any other entry (Table 2, Figure 2). By August 2, both non-secreting lines were colonized by significantly more

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*All tables are in the Appendix.

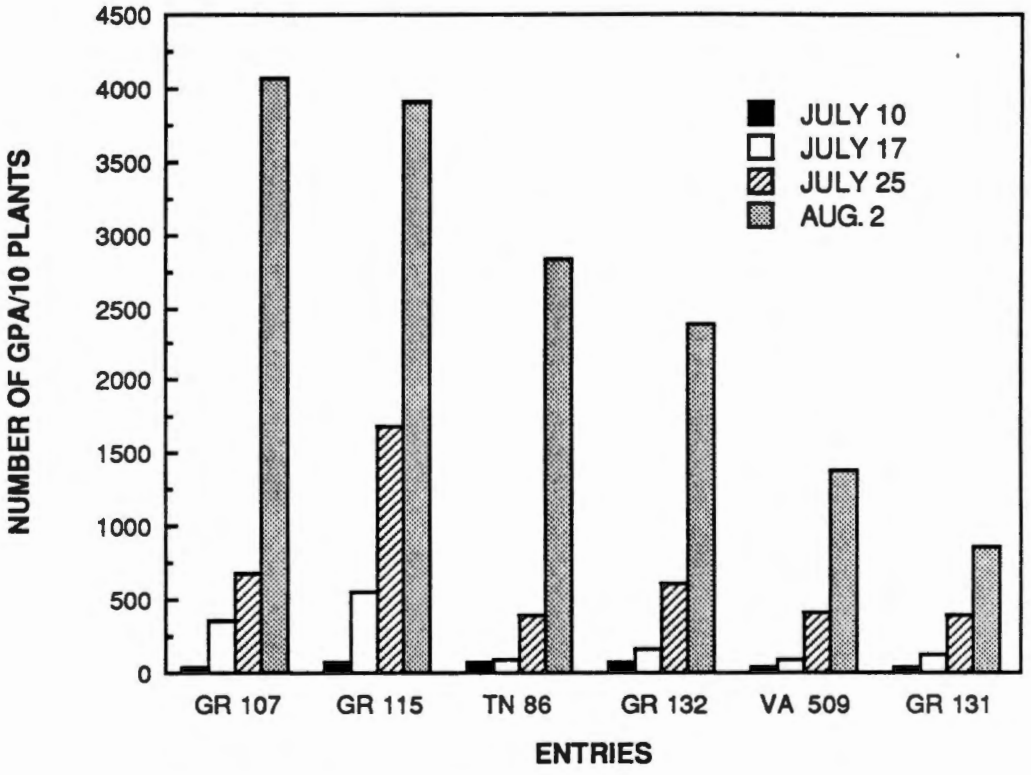

Figure 1. Densities of green peach aphid (GPA) on selected tobacco entries, Greeneville, 1985.

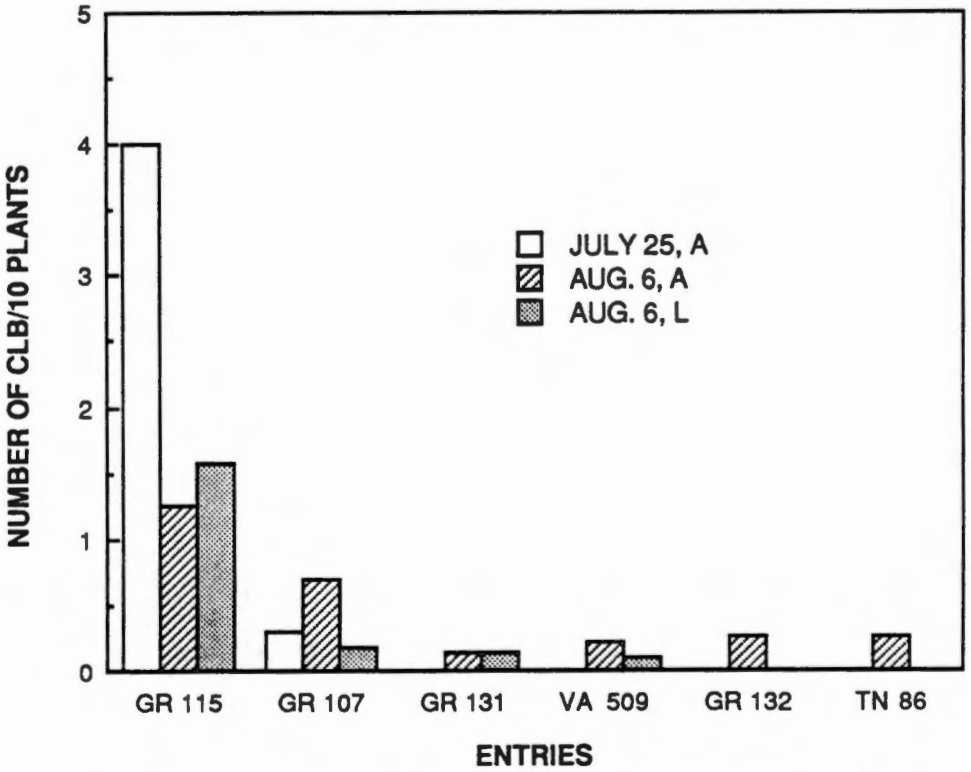

Figure 2. Densities of convergent lady beetle (CLB) larvae (L) and adults (A) on selected tobacco entries, Greeneville, 1985.

aphids than VA 509 and GR 131 but not GR 132 and TN 86 (Table 1, Figure 1). By August 6, densities of adult CLB were significantly greater on GR 115 than on all other entries except GR 107 (Table 2, Figure 2). On this date, densities of CLB larvae were most abundant on GR 115 (Table 2, Figure 2). By August 14, TN 86 had a significantly higher aphid rating than GR 115.

These field plots were isolated from other crops, which could have served as a source of CLB, by woods on three sides and a pasture on the remaining side, which allowed aphid populations to increase in the absence of predators (in June and for three weeks in July). Aphid numbers remained highest on non-secreting lines until August when CLBs appeared in sufficient numbers to suppress aphids. TN 86 and GR 132 were intermediate in population densities while VA 509 and GR 131 were lowest. CLBs were attracted to the non-secreting lines if aphids were present. One reason for CLB numbers being higher on GR 115 than GR 107 could be that GR 107 was found to be heterozygous instead of non-secreting homozygous. All secreting entries supported less than 0.5 CLB per 10 plants. Based on a pre-harvest rating, aphid densities were lowest on non-secreting lines.

In 1986 all entries became colonized by GPA, but GR 115 and PDJA 309 had the least numbers of aphids. By July 8, densities of alates were significantly greater on VA 509

than on GR 115 (Table 3, Figure 3). Eight days later, "supersticky" PDJA 309 had significantly greater numbers of alates than all other entries (Table 3, Figure 3). Not only were alates attracted to PDJA 309, but they apparently could not free themselves easily after they landed on the leaf surface. Numbers of apterae on July 8, 16, 22, 30 and August 6 were not significantly different among any entries (Table 4, Figures 4 and 5). By August 14, BU 21 had significantly greater numbers of aphids than PDJA 309 and GR 115 (Table 4, Figure 5).

By the second sampling date, July 16, aphid numbers were three times higher on GR 131 than the next highest entry (BU 21). By the third and fourth sampling dates, July 22 and 30, aphid numbers were relatively similar among BU 21, TN 86, GR 131 and Va 509, but much higher than PDJA 309 and GR 115. By the fifth sampling date, August 6, BU 21 had the highest aphid population with ca. 6000 aphids per 10 plants. Significant differences were found only for the last sampling date, August 14, with BU 21 having ca. 8000 aphids per 10 plants and GR 115 with the lowest aphid populations, ca. 1000 aphids per 10 plants. These plots were located in an area where predators were abundant.

Mountain City

In 1986 GR 131 had greater aphid ratings or densities until the end of the growing season, at which time BU 21

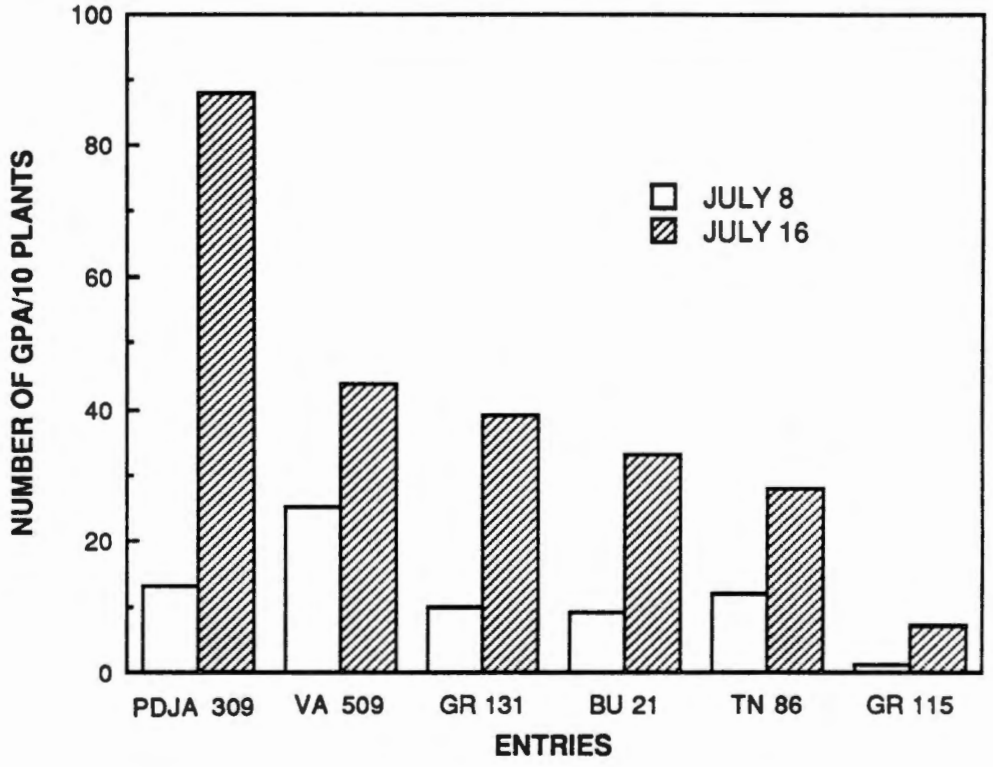

Figure 3. Densities of alate green peach aphid (GPA) on selected tobacco entries, Greeneville, 1986.

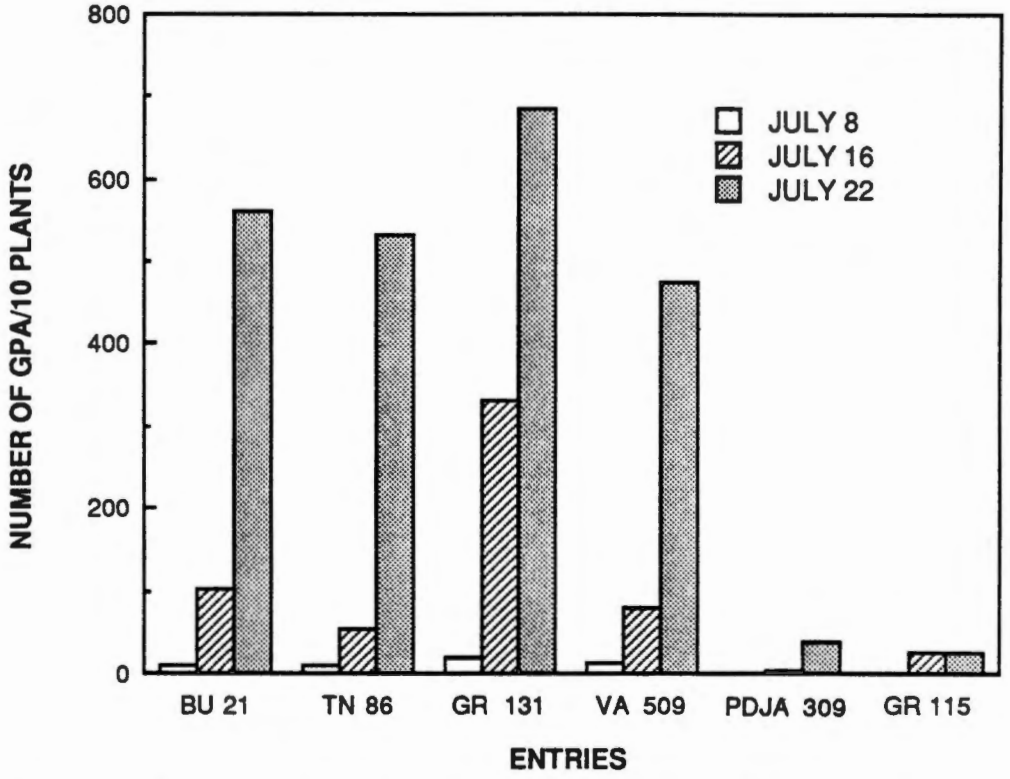

Figure 4. Densities of green peach aphid (GPA) on selected tobacco entries for the first three sampling dates, Greeneville, 1986.

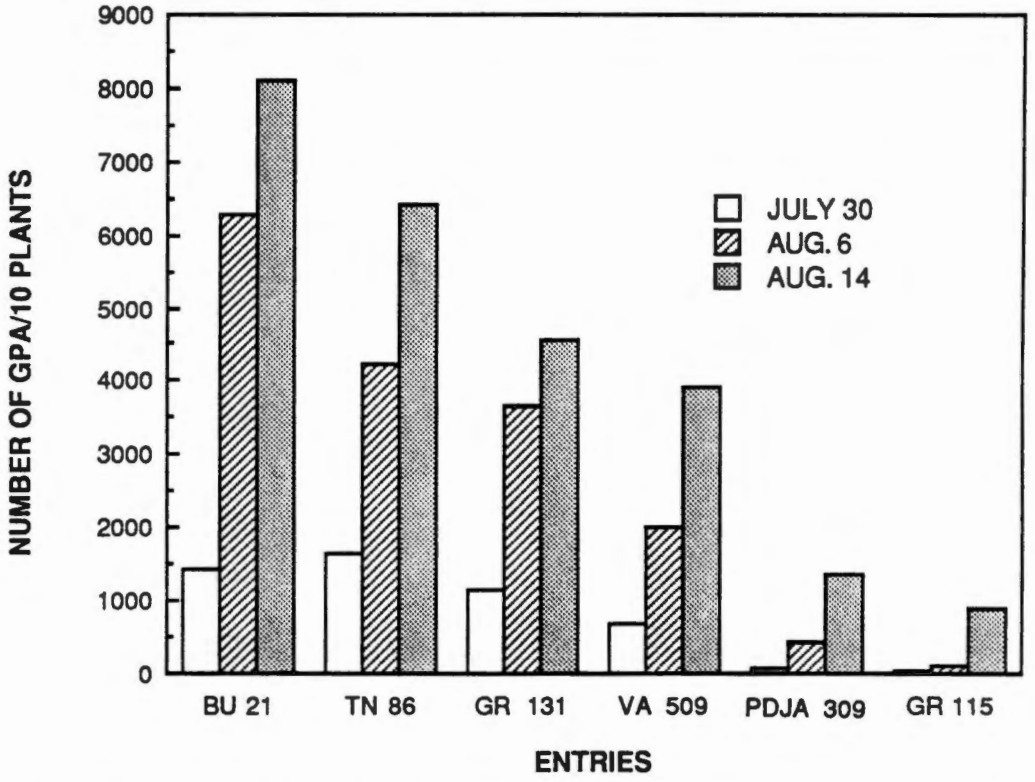

Figure 5. Densities of green peach aphid (GPA) on selected tobacco entries for the last three sampling dates, Greeneville, 1986.

supported the largest colonies. By June 19, only GR 131 had a significantly greater aphid population rating than GR 115 (Table 5, Figure 6). By July 1, both GR 131 and VA 509 had significantly greater aphid ratings than GR 115 (Table 5, Figure 6). By July 15, aphid densities were significantly greater on GR 131 than on all other entries except VA 509 (Table 6, Figure 7). By July 29, BU 21 had significantly greater aphid densities than GR 115 (Table 6, Figure 7). On this date GR 131 was not significantly different from BU 21 or GR 115.

Aphid ratings were much lower for GR 115 than for all other entries. This could be the result of alates being able to move easily on non-secreting plants; therefore, they might have left the plant. On the last two dates, aphid densities were lowest on GR 115, possibly because of the presence of predators (CLB and syrphids) during the growing season which may have suppressed aphids on this non-secreting line.

LABORATORY EXPERIMENTS

Aphids colonized all entries in growth chambers at similar rates in the absence of predators. In experiment I, by day 5 GR 107 was colonized by significantly more aphids than GR 115, GR 131 and VA 509 (Table 7, Figure 8). By day 9, VA 509 had significantly fewer aphids than all entries except GR 131 and GR 132 (Table 7, Figure 8). By

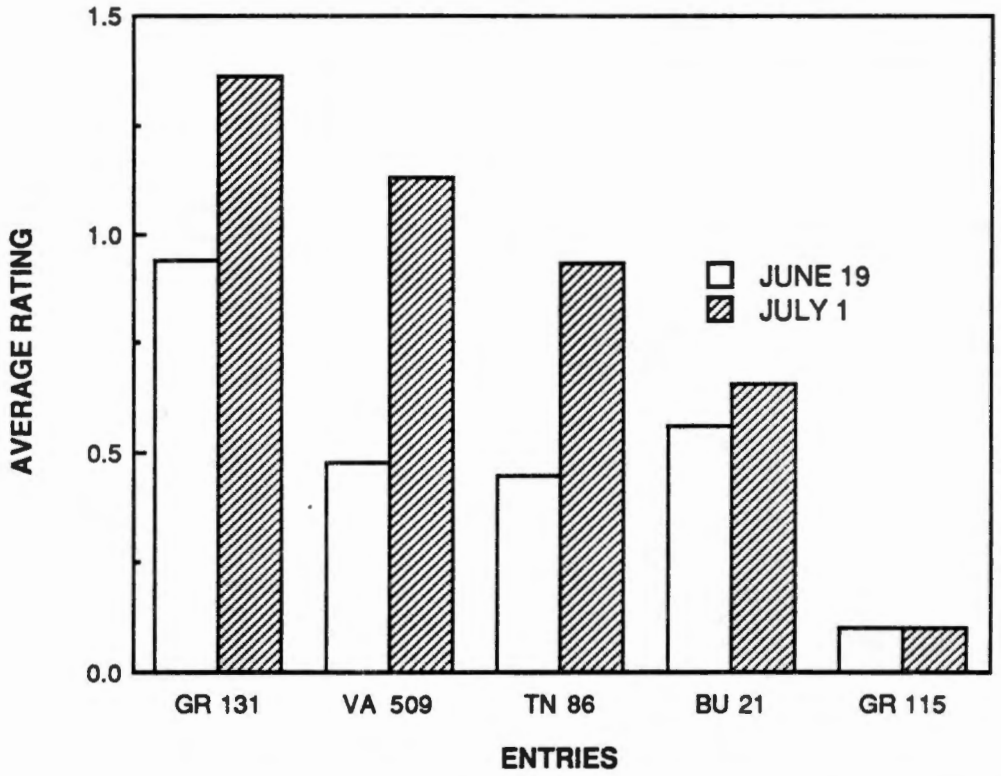

Figure 6. Ratings for green peach aphid populations on selected tobacco entries, Mountain City, 1986.

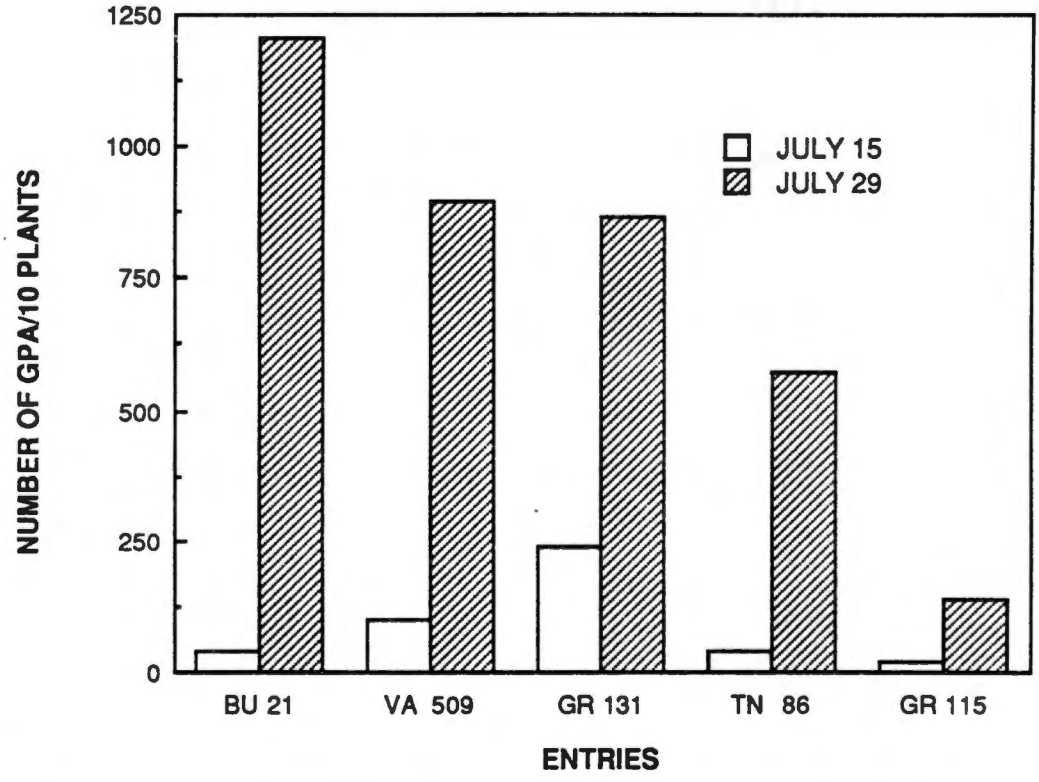

Figure 7. Densities of green peach aphid (GPA) on selected tobacco entries, Mountain City, 1986.

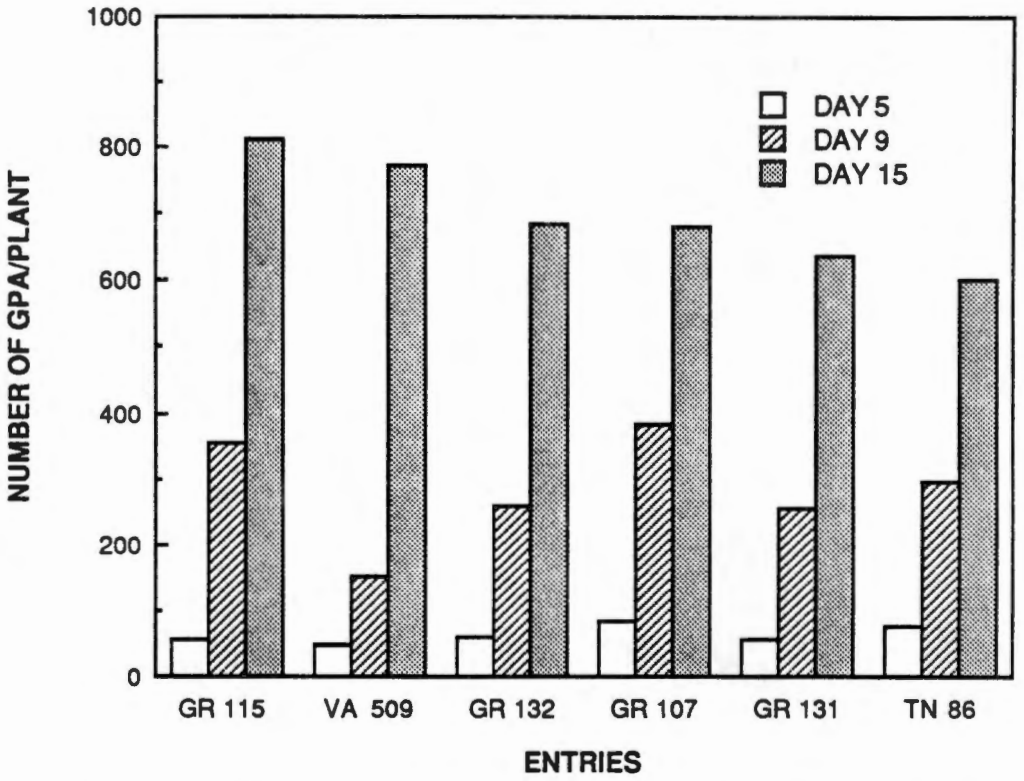

Figure 8. Densities of green peach aphid (GPA), in the absence of predators, on selected tobacco entries in the laboratory, experiment I.

the end of the experiment, day 15, no significant differences in densities of aphids were detected among all entries (Table 7, Figure 8). By the first two dates (days 5 and 9) there was significant variation in densities of aphids, but no significant difference occurred on day 15. Aphids did not have a survival/reproductive advantage on any entry. This experiment demonstrated that all entries could become colonized by aphids in the absence of predators.

In experiment II, by days 3 and 8, no significant differences in aphid densities existed among any entries (Table 8, Figure 9). By day 13, TI 1112 (non-secretor) had significantly greater densities of aphids than all entries except BU 21 and TN 86 (Table 8, Figure 9). By day 17, aphid densities were significantly greater on TI 1112 than on all entries except TN 86 (Table 8, Figure 9).

Due to time constraints this experiment was replicated only twice. The sensitivity of this test was not as high as desired because of the low number of replications.

In laboratory studies more CLBs were found to be on non-secreting leaves. Significantly fewer aphids were present on GR 115 than on TN 86 1 and 2 hours after CLBs were released into containers (Table 9, Figure 10). Within 2 hours after release of CLBs, 80% fewer aphids were present on leaves of GR 115 (non-secretor) than on TN 86 (secretor). No significant differences were detected in

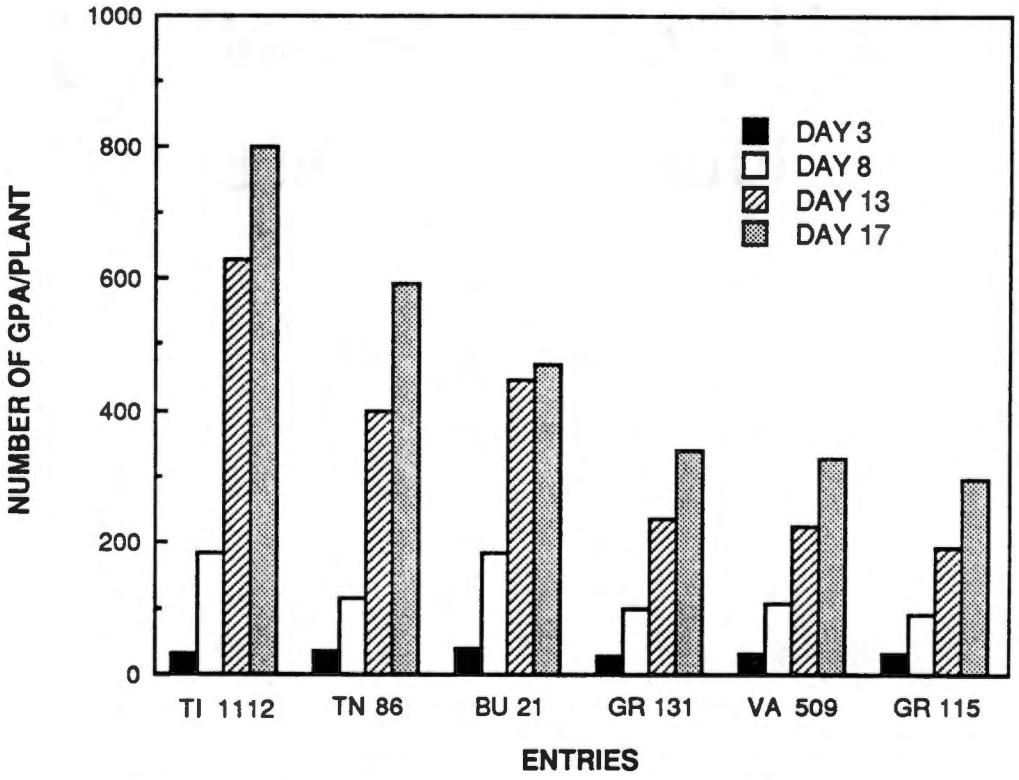

Figure 9. Densities of green peach aphid (GPA), in the absence of predators, on selected tobacco entries in the laboratory, experiment II.

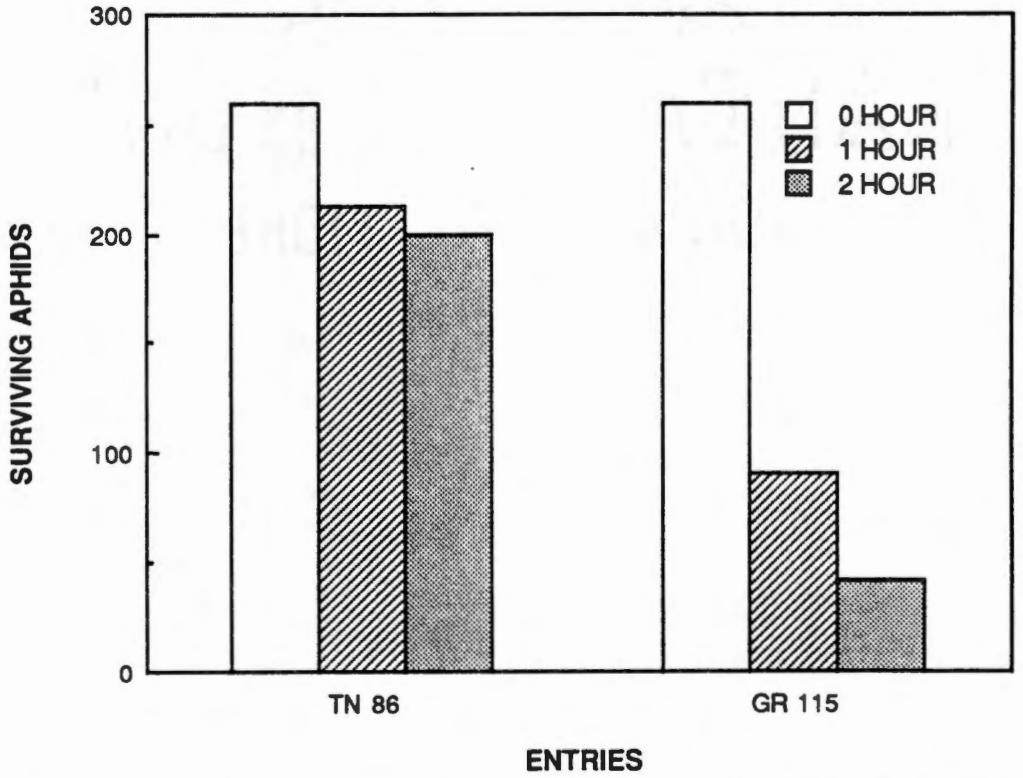

Figure 10. Predation of the green peach aphid by adult convergent lady beetles on sticky (TN 86) and nonsticky (GR 115) tobacco leaves in the laboratory.

numbers of CLBs found on leaves of GR 115 than on TN 86 after 1 hour (Table 10), but GR 115 leaves had significantly more CLBs than TN 86 leaves after 2 hours (Table 10). CLBs were observed to move rapidly and easily on non-secreting lines, but moved more slowly and with difficulty on secreting cultivars.

V. SUMMARY AND CONCLUSIONS

In field studies, presence of trichome secretions had a significant effect on presence of predators on aphid-infested leaves. GR 115 had the lowest aphid populations when CLB were abundant. Lady beetles were much less abundant on plants with secreting trichomes when aphid-infested, non-secreting plants were available to them in nearby plots.

Alates were found stuck to leaf surfaces of entries with secreting trichomes at the beginning of the growing season. Aphids could not move as easily on plant leaves with secreting trichomes as they could on those with non-secreting trichomes. Alates were observed to walk freely on, and sometimes fly away from, non-secreting plants.

Laboratory studies over two years indicate that: (1) aphids colonized all selected entries in the absence of predators and (2) CLBs were more prevalent and more efficient predators on aphid-infested leaves with non-secreting trichomes.

TI 1112 is a non-secreting tobacco which will support aphids in the absence of predators. One proposed reason for the abundant presence of coccinellids on TI 1112 is the non-secreting surface which makes it easier for predators to search for prey.

In choice tests in the laboratory, CLBs were more prevalent and consumed more aphids on the non-secreting leaf surfaces than on the secreting leaf surfaces. If plants are not monitored frequently for predator activity, one might conclude that a line or cultivar is aphid resistant when, in fact, absence of aphids may be a result of predation.

Results obtained in the field study at Greeneville in 1985 demonstrated that aphid populations increased on non-secreting entries in the absence of predators. This location was isolated from predators.

In 1986, at both Mountain City and Greeneville, aphids colonized all entries. The secreting entries had higher aphid populations than non-secreting entries. Predators were present at both locations, but only for a short period of time.

The laboratory studies verified what the field studies had indicated. In the laboratory all entries were susceptible to colonization by aphids in the absence of predators and more CLB were found searching for prey on non-secreting entries.

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APPENDIX

Table 1. Effect of tobacco entries on densities of green peach aphid, Greeneville, 1985[a].

LINE/ CULTIVAR	DATE			
	July 10	July 17	July 25	Aug. 2
GR 107	42a[b]	365ab	683b	4067a
GR 115	65a	548a	1680a	3900a
TN 86	66a	95b	400b	2833ab
GR 132	74a	158b	613b	2383ab
VA 509	34a	88b	408b	1383b
GR 131	31a	130b	403b	857b

[a] Average number of aphids per 10 plants.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 2. Effect of tobacco entries on densities of convergent lady beetle (CLB) larvae (L) and adults (A), Greeneville, 1985[a].

LINE/ CULTIVAR	DATE			
	July 25		Aug. 6	
	A	L	A	L
GR 115	4.00a[b]	0.00a	1.25a	1.58a
GR 107	0.30b	0.00a	0.70ab	0.18b
GR 131	0.00b	0.00a	0.13b	0.13b
VA 509	0.00b	0.00a	0.21b	0.10b
GR 132	0.00b	0.00a	0.25b	0.00b
TN 86	0.00b	0.00a	0.25b	0.00b

[a] Average number of CLB per 10 plants.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 3. Effect of tobacco entries on densities of alate green peach aphid, Greeneville, 1986[a].

LINE/ CULTIVAR	DATE July 8	July 16
PD 309	13ab[b]	88a
VA 509	25a	44b
GR 131	10ab	39bc
BU 21	9ab	33bc
TN 86	12ab	28bc
GR 115	1b	7c

[a] Average number of aphids per 10 plants.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 4. Effect of tobacco entries on densities of green peach aphid, Greeneville, 1986[a].

LINE/ CULTIVAR	DATE July 8	July 16	July 22	July 30	Aug. 6	Aug. 14
BU 21	9a[b]	103a	560a	1420a	6268a	8120a
TN 86	10a	55a	532a	1665a	4232a	6435ab
GR 131	20a	333a	684a	1159a	3644a	4540ab
VA 509	13a	79a	476a	677a	2025a	3927ab
PDJA 309	0a	3a	37a	63a	434a	1352b
GR 115	1a	26a	25a	20a	109a	900b

[a] Average number of aphids per 10 plants.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 5. Effect of tobacco entries on rating of green peach aphid, Mountain City, 1986[a].

LINE/ CULTIVAR	DATE	
	June 19	July 1
GR 131	0.94a[b]	1.36a
VA 509	0.48ab	1.13a
TN 86	0.45ab	0.93ab
BU 21	0.56ab	0.66ab
GR 115	0.10b	0.10b

[a] Average aphid rating per plant.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 6. Effect of tobacco entries on densities of green peach aphid, Mountain City, 1986[a].

LINE/ CULTIVAR	DATE	
	July 15	July 29
BU 21	40b[b]	1203a
VA 509	99ab	895ab
GR 131	237a	869ab
TN 86	42b	571ab
GR 115	21b	139b

[a] Average number of aphids per 10 plants.
[b] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 7. Effect of tobacco entries on densities of green peach aphid (GPA), in the absence of predators, under laboratory conditions, experiment I[a].

LINE/ CULTIVAR	DAYS[b] 5	9	15
GR 115	54bc[c]	355a	811a
VA 509	47c	151b	773a
GR 132	59abc	257ab	685a
GR 107	85a	382a	683a
GR 131	56bc	255ab	639a
TN 86	74ab	295a	600a

[a] Average number of aphids per plant.
[b] Number of days after initial infestation of two GPA per plant.
[c] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 8. Effect of tobacco entries on densities of green peach aphid (GPA), in the absence of predators, under laboratory conditions, experiment II[a].

LINE/ CULTIVAR	DAYS[b] 3	8	13	17
TI 1112	32a[c]	183a	630a	800a
TN 86	34a	115a	400abc	595ab
BU 21	38a	183a	445ab	470b
GR 131	29a	100a	235bc	340b
VA 509	33a	108a	225bc	325b
GR 115	33a	90a	190c	295b

[a] Average number of aphids per plant.
[b] Number of days after initial infestation of four GPA per plant.
[c] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 9. Effect of sticky and nonsticky tobacco leaves on adult convergent lady beetle[a] (CLB) searching for green peach aphid, in the laboratory.

LINE/ CULTIVAR	HOURS[b] 0	1	2
TN 86	259[c]	213a[d]	200a
GR 115	259	91b	42b

[a] One leaf of GR 115 and TN 86 was mechanically infested with the same number of aphids and numbers were recorded after one and two hours.
[b] Number of hours after initial infestation of GPA on tobacco leaves.
[c] Average number of aphids per leaf.
[d] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

Table 10. Densities of adult convergent lady beetle (CLB) on sticky and nonsticky tobacco leaves when offered together in the laboratory.

LINE/ CULTIVAR	HOURS[b] 1	2
GR 115	2.4a[c]	2.6a[d]
TN 86	1.2a	0.4 b

[a] Average number of CLBs present on leaves of GR 115 and TN 86 at 1 and 2 hours.
[b] Number of hours after CLB were placed in containers with green peach aphid-infested leaves.
[c] Average number of CLB per leaf.
[d] Means within a column followed by the same letter are not significantly different (P > 0.05; Waller-Duncan multiple range test [SAS Institute 1985]).

VITA

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