PEANUT RESISTANCE TO THRIPS

By

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CHAPTER I

INTRODUCTION

The tobacco thrips *Frankliniella fusca* (Hinds) is the most important thrips species on peanuts. It is found on peanuts in all growing areas of the United States. Thrips larvae rasp the epidermis of the foliar buds causing curled and malformed leaves. This damage continues from the seedling stage to anthesis. Under heavy infestations the loss of photosynthetic area may be high and result in severe stunting of the plant. Loss of vigor due to heavy damage retards development and could make plants more susceptible to disease.

Thrips may be controlled by insecticides, but insecticide costs and toxic effects are disadvantageous. Resistant varieties, not having these disadvantages, require a long period of controlled experiments for development (Painter 1951). A resistant variety reduces or eliminates the problem of continual insecticide control programs.

After resistant germ plasm has been found, discovering the basis of resistance should make it possible to combine two kinds of resistance in the same variety (Painter 1968).

The purpose of this study was to screen peanut entries for tobacco thrips resistance and identify the germ plasm for further testing.

The entries that appeared to be most resistant from the field test were selected for further testing in the laboratory. Several entries that showed resistance in laboratory tests in 1968 and 1969 were also used plus one mutant of a previous laboratory resistant variety.

The purpose of this study was to develop more accurate laboratory testing techniques and to test field resistant entries to determine their resistance mechanisms.

Inheritance studies were undertaken to determine if thrips resistance can be inherited in peanuts. Two peanut accessions, P-947 and P-844, their F_1's and F_2's plus the reciprocals and the check variety Starr were tested for preference, tolerance, and antibiosis in the laboratory. Tests were run on the five genetic types in an effort to establish the mode of inheritance of thrips resistance in peanuts. The plants used in these tests were crosses made by Sung (1969) in the greenhouse. Tests for preference, tolerance, and antibiosis in the laboratory were conducted by the author.

P-844 is susceptible to thrips damage and P-947 has a low level of resistance due to non-preference.

Several studies have been done on resistance of peanuts to thrips damage. However, no literature was found on the inheritance of resistance to the tobacco thrips, *Frankliniella fusca* (Hinds) in peanuts.

CHAPTER II

LITERATURE REVIEW

Field Tests

Thrips damage was first reported by the Florida Agricultural Experiment Station in 1922 (Watson 1922). Farmers called the damage "possum ear" due to the shape of the damaged leaves (Wilson and Arant 1949). Pouts was another name applied to the damage (Poos 1941). The causal agent was not known until thrips were caged on peanut leaves in controlled experiments, proving that thrips were responsible (Shear and Miller 1941).

Adult female thrips overwinter on weeds and grass and start reproducing early in the spring on weeds and volunteer peanut plants. The offspring migrate to seedling plants (Arant 1951, Poos et al. 1947, Eddy and Livingston 1931). Damage is most severe on the seedlings and will continue until blooming (Eden and Brogden 1960, Poos 1945). Oviposition is into the foliar buds, and the larvae feed inside the closed bud by rasping the epidermis and sucking the sap. When the leaf opens, the damage is usually visible on the upper leaf surface (Poos 1945).

Some damage is present every year. It may vary from moderate damage with scarred and misshapen leaves to heavy damage with all terminal buds black as if they had been burned (Poos et al. 1947).

Most investigators report that leaf damage decreases after blooming, due to feeding preference for pollen.

The data correlating insecticidal control with yield is contradictory. Where thrips were controlled, increases in yield varied from nothing to 617 lb./acre (Hyche and Mount 1956).

Insecticidal protection of plants on poor soil increased the yield, but on fertile soil there was no increase (Poos 1947). Poos (1945) reported an increase of 35% in total weight of green vines and pods using DDT for control. Increases ranging from 0 to 92 lb./acre were reported by Wilson and Arant (1949). In a 4 year study with phorate, Eden and Brogden (1960) reported an increase of 191 lb./acre in pod yield. Several workers reported yeild decreases with thrips control (Arthur and Arant 1954, Leuck et al. 1967). Leuck et al.(1967) attributed the decrease to the fact that thrips damage is avoided by worms. Several studies revealed no significant yield increases from thrips control (Arant 1950, 1954, Arthur and Arant 1954, King et al. 1961, and Harding 1959).

Soil fertility, weather and the thrips population level are variables that influence the amount of damage to seedlings and the extent to which the plant can recover. Varietal reaction with thrips may affect the population level, damage, and yield (Leuck et al. 1967). Young (1969) and Pitts (1970) found significant differences in varieties tested at the Oklahoma Agricultural Experiment Station.

Resistant crops, once developed, require little expense or effort of the grower (Packard and Martin 1952). Resistant crops provide more permanent control than insecticides and are especially valuable where the margin of profit of a crop is small and the acreage large (Painter 1951). The degree of resistance may vary from low to a high level. There are only a few cases where complete control is achieved by the resistant crop alone. Varieties with a low level of resistance provide some protection but are best utilized as part of an integrated control program.

Plant resistance to insects was defined by Snelling (1941) as including "those characteristics which enable a plant to avoid, tolerate, or recover from the attacks of insects that would cause greater injury to other plants of the same species". Painter (1951) defined resistance as "the relative amount of heritable qualities possessed by the plant which influence the ultimate degree of damage done by insects". According to Beck (1965), it is defined "the collective heritable characteristics by which a plant species, race, clone, or individual may reduce the possibility of successful utilization of that plant as a host by an insect species, race, biotype, or individual".

Painter (1951) divided resistance, as seen in the field, into 3 mechanisms - preference, tolerance, and antibiosis. Preference denotes the group of plant characters that lead to or away from the use of a particular plant or variety for oviposition, food, or shelter or a combination of the three. Antibiosis denotes the ability of the plant to prevent injury or to destroy insect life. Tolerance is the ability the plant shows to grow and reproduce itself or to repair injury to a marked degree while supporting a population approximately equal to that damaging a susceptible host. Antibiosis is the most permanent type of resistance because it renders a specific insect unable to maintain a population. Tolerance is more susceptible to environmental variation.

Resistance may be evaluated by measuring the insect damage or measurement of the numbers of insects present on different plant varieties (Young 1969). Resistance and its categories are relative terms and can best be defined by comparison of a variety with more susceptible varieties in that species (Painter 1951).

Preference, tolerance and antibiosis are all characteristics of light field damage. A low population could indicate preference or antibiosis. Tolerance may be distinguished from antibiosis in the field if population and damage can both be accurately measured (Painter 1951).

In studies of varietal resistance, yield is not a valid measure of insect damage because yield is highly variable among varieties (Young 1969).

Leuck et al. (1967) evaluated thrips damage to 14 lines of peanuts. By estimating the percentage of leaves showing thrips damage they found Starr, Argentine, and NC-2 to be less preferred.

Young (1969) and Kinzer (1968) made comparative adult number counts on different varities in the laboratory by use of 1-gal Berlese funnels for extraction. Matlock (1966) rated plots of approximately 40 plants by scanning and rated them using a 10-point scale.

Young (1969) evaluated differences in thrips damage to 872 peanut accessions and Pitts (1970) evaluated 289 accessions. Both researchers used an 8-point leaf damage rating scale with "1" indicating no damage and "8" complete destruction. Both studies revealed significant differences ($p \leq .05$) among the entries tested. Young (1969) reported P.I. 268611 and P.I. 280688 as appearing most resistant with the latter being non-preferred by thrips in laboratory tests. The Argentine variety showed antibiosis. P.I. 155053 and P.I. 268633 were consistently susceptible in field experiments. Pitts (1970) reported entries P.I. 268661, P.I. 259745, P.I. 268771, P.I. 199468, and P.I. 314895 as having a moderate level of resistance.

Laboratory Tests

Most resistance studies involve host selection and insect nutrition. Results indicate a complex interaction may influence resistance (Thorsteinson 1960 and Schoonhoven 1968).

Any one of the resistance mechanisms (preference, tolerance, or antibiosis) may operate through morphological, chemical or physiological aspects of plant (Jones et al. 1934). Preference of insects for some plants over others for food or oviposition may depend on visual, tactile, gustatory, or olfactory stimuli. Antibiosis may result from lack of nutrients, feeding deterrants or the deleterious effects of specific chemicals, or other insect behavior stimulants. Tolerance is affected by the plant's gross morphology, cell structure, and growth hormones (Painter 1951).

The specific method to be used in determining which type of resistance a plant possesses depends upon the insect and the level of resistance (Painter 1954). Because of their small size, thigmotropic nature, and the difficulty of handling them, thrips require special testing methods (Bryan and Smith 1956). The technique used most in handling thrips has been to pick them up individually with a small moistened brush (Samuel et al. 1930, Bailey 1933, Bryan and Smith 1956, and Callen 1943). Munger (1942) anesthetized thrips and brushed them off leaves with a powdered brush. George (1961) used an aspirator to transfer thrips from one cage to another.

Wardle (1927), in glass house experiments, found population differences among cotton varieties in tests with Thrips tabaci. The number of thrips per 100 cm^2 were counted on uncaged plants. In similar tests Wardle and Simpson (1927) found two Egyptian cotton varieties to be most resistant in a five variety test. They also correlated the tendency of thrips to prefer the lower epidermal surface for feeding and oviposition with epidermal thickness. Epidermal thickness was also correlated with amount of plant injury.

Callen (1943) tested field resistant cacao plants in the laboratory for preference and antibiosis to thrips. Preference tests were conducted with leaf discs 4.8 inches in diameter in a 4 x 4 alternating pattern. Each disc was inoculated with 10 larvae. Counts of the distribution of larvae were made after 24 and 48 hour periods. In antibiosis tests, leaves were inoculated with 50 to 100 first instar larvae and the larvae remaining alive were counted after 3, 5 and 7 day intervals.

Kinzer (1968) did laboratory studies on peanut resistance to the tobacco thrips in conjunction with technique development studies. Young (1969) used the same techniques in laboratory tests with field resistant peanut entries. Both workers tested field resistant entries for preference, tolerance, and antibiosis. Preference was measured by confining a known number of adult thrips with single potted plants of different varieties and counting the number of adults on each plant at the end of the testing period. Tolerance and antibiosis levels were obtained from a single test in which 30 larvae were caged on the fifth or sixth leaf with two leaflets removed. The number of live larvae at the end of the test period indicated the antibiosis level. Tolerance was recorded as the leaf damage sustained in the above test using the 8-point scale as in the field tests.

CHAPTER III

METHODS AND MATERIALS

Field Tests

During the summer of 1969, 99 peanut cultivars and selections were field tested for resistance to the tobacco thrips, *Frankliniella fusca* (Hinds). Tests were conducted in three Oklahoma peanut growing areas: Perkins Agronomy Research Station, Perkins, Oklahoma; Caddo County Research Station, Ft. Cobb, Oklahoma; and Peanut Experiment Station, Stratford, Oklahoma. The cultivars were tested in 11 experiments. Spantex, Starr, Argentine, Dixie Spanish, P-0074, National Spanish, and Preliminary Spanish experiments were run at all three locations. Valencia and White Seeded experiments were run at Perkins and Fort Cobb. The P-0112 experiment was run at Perkins and Stratford, and the P-0548 experiment was run at Stratford and Fort Cobb. The entries were identified by the plant introduction numbers (P.I.) or the Oklahoma peanut accession number (P.-No.). When available, the commercial names of entries were used. If other identification was not established, a selection number was used. In each location the individual varietal tests were set up in a randomized block design.

The natural population of thrips was used for the test insects. Several workers have verified that over 95% of the naturally occurring thrips population on peanuts is the tobacco thrips, *Frankliniella fusca* (Hinds).

One or more of several factors may cause the overall damage level to differ among locations. All locations could not be evaluated at the same time, so uniform thrips population, equal plant maturity, and similar weather conditions could not be assumed. Soil differences have influenced yield tests (Poos et al. 1947), and soil differences between the three locations can be assumed. Prevailing winds and surrounding crops can also affect thrips dispersion (Young 1969).

Damage Rating Scale

Leaves were evaluated on an 8-point scale with "1" indicating no damage and "8" complete leaf destruction. Fig. 1 illustrates damage for each point.

Method of Evaluation

Damage was evaluated by rating the most damaged leaf on each of 10 plants per plot, five plants being rated from each end of the plot. Thumb punch tally counters were used to accumulate the 10 leaf rating total and the total number of damage points was recorded for each plot.

Damage ratings for all experiments were analyzed as described by Snedecor and Cochran (1967) and adjusted means were compared by use of Duncan's New Multiple Range Test (1955).

Laboratory Tests

All tests were conducted in a growth chamber maintained at 80 $\pm$ 2°F. The chamber was lighted by 150 30-watt fluorescent tubes (daylight type) producing 200 foot-candles of light at plant height.

Fig. 1. Eight-point damage rating scale.

The commercial variety Starr was used as the rearing material to maintain the thrips culture. All plants were raised in a green house and taken to the growth chamber as needed. Plants were watered weekly with a nutrient solution containing 3 oz of Peter's 20-20-20 fertilizer in 20 gal water. Six ounces of this solution were added to each pot at weekly intervals. Peanut seeds were germinated by placing them between four moist paper towels on a piece of Saran wrap and rolled into a cylinder. Arasan seed treatment prohibited mold development during germination. After 3 days, the seeds were planted in 4-inch pots containing equal amounts of peat moss and perlite saturated with nutrient solution.

The thrips used in laboratory tests were *Frankliniella fusca* (Hinds) reared in the laboratory as described by Kinzer (1968).

The test material consisted of the 13 entries that appeared most resistant in the 1969 field studies, 4 varieties that were found resistant in field studies in 1967 and 1968, plus Starr as a resistant check and P.I. 268777 as a susceptible check. The entries were tested in three groups. Each group consisted of 3 replications of 6 entries plus the 2 checks for a total of 24 plants tested per group. The same two checks were included in each group.

Preference - Tolerance Tests

Preference and tolerance were tested in combination utilizing the same plants as test material.

These tests were conducted in a circular rotating cage that was continuously ventilated by a squirrel cage fan which forced air through a 2-inch pipe in the center of the cage bottom. The rotating cage helped equalize light intensity and cancel any other biasing factors. The top of the cage was glass, the walls were of transparent cellulose nitrate plastic, and the bottom was of masonite. The cage was 14 inches high and 36 inches in diameter. The cage walls were supported by two metal rings at top and bottom. The metal rims had a 90° flange giving a horizontal surface for attachment to the masonite at the bottom and the glass at the top. The glass top was sealed to the metal strip with caulking compound to allow easy removal. Sixteen cloth-covered holes evenly spaced around the top served as the air outlets. The cage was mounted on a turntable and rotated at 1/3 rpm.

The tests were conducted in three groups. Each group contained six varieties plus the two standard check varieties, Starr and P.I. 268777. Due to poor germination the last group tested five varieties plus the two standard checks. The number of test insects was reduced accordingly.

Plants were randomized in two circles in the cage. Replications 1 and 2 consisting of 16 plants were placed in the outer circle close to the edge of the circular cage. The third replication of eight plants was placed as the inner circle. Entries were randomized within their respective circle.

To test for preference 600 adult female thrips were released into the test cage. The last opened leaf on each plant was marked with a ring of caulking compound on the petiole just below the basal leaflets prior to placement in the cage. After 5 days in the test cage the lid was removed, and the bud which opened during the test period was rated for damage using the eight-point scale as in the field tests. This damage rating was recorded as the index of preference. At this stage the adults were removed from the plants and the cage. The plants were individually shaken over a white cloth and visually inspected to insure removal of all adult thrips. After vacuuming the cage the plants were replaced in the cage and the lid was again sealed in place. At this time the eggs oviposited by the adults on the first day of the preference test were beginning to hatch. The larvae from the eggs oviposited during the preference test were allowed to feed for 10 days on the entries as a test of their tolerance. Using the same rating scale, the damage on the first three leaves opened since the beginning of the test was recorded for each plant. The average of the three ratings was considered the tolerance level of the plant.

Antibiosis

Antibiosis was tested by confining 30 larvae on the bud of each plant and counting the number of surviving larvae at the end of the test period.

The larvae were confined on the fifth or sixth open leaf 8 days after oviposition using dialysis tubing as described by Kinzer (1968). After 1 week the cages were removed and the number of live thrips was recorded as the index of antibiosis.

Inheritance Studies

Two plant introductions, P.I. 268633 (P-844) and P.I. 290597 (P-947), were hand crossed in the greenhouse. In the F_1 and F_2

progeny the term cross was used to designate that P-947 is the female and P-844 is the male, and the term reciprocal was used to designate that P-844 was used as the female and P-947 was used as the male. F_1 hybrids, including the reciprocals, were obtained and grown to the F_2 generation. To facilitate testing the parents and F_1's and F_2's concurrently, vegetative cuttings were taken from the two parents and the F_1 hybrids to maintain them while getting the F_2 seed.

P-947 is a runner type peanut having relatively small leaflets and dark green color while P-844 is a Spanish type having leaflets relatively larger than P-947 but a lighter green color than P-947. Segregation in the F_2 was easily distinguished thus verifying that the test plants were crosses. According to Young (1969), P-844 is susceptible to thrips damage and P-947 has a low level of resistance due to non-preference.

Cuttings were used for testing the F_1's in all tests. The F_2 materials tested were young plants. The tests were run in segments with the two parents and the commercial variety Starr in each segment. A total of 149 plants were tested during the spring of 1969.

These tests were conducted in the growth chamber described above. The thrips used in these tests were reared in the growth chamber as described by Kinzer (1968).

Preference

Plants were tested in the fifth or sixth leaf stage by confining them in the cylindrical rotating cage with adult female thrips. At the end of the test period the number of thrips per plant was counted. The three check varieties, two parents, and Starr, plus 17 F_2 plants were tested in each segment of the test. The 20 plants were randomized in a circle in the cage with all entries equidistant from the center of the cage and from adjacent plants in the circle. Seven hundred adult female thrips were released into a petri dish supported by a platform in the center of the cage. The glass top was quickly sealed. After two days the top was removed and each plant was carefully cut off above the crown and placed in a berlese funnel. A 60-watt light bulb in the funnel lid provided heat to drive the thrips down into a vial of 60% alcohol. After 1-hr the lids were removed and each funnel was sprayed inside with a fine spray of water to wash any dead thrips from the funnel into the alcohol. Each vial was filtered and the thrips on the filter paper were counted using a binocular scope and thumb punch tally.

Antibiosis and Tolerance

Antibiosis and tolerance were tested in conjunction by confining 30 larvae on a leaf for 7 days. The number of surviving larvae was recorded as the index of antibiosis. Tolerance was also measured on the same leaf after 7 days by giving the leaf a visual damage rating. A "1" rating indicated no damage and an "8" indicated complete destruction. All readings were between these two extremes. The cage was placed on the fifth or sixth leaf with the two leaflets removed as described by Kinzer (1968).

Thrips larvae oviposited 8 days previously were inoculated into the cages with the aid of an electric powered vacuum aspirator.

After 1 week the bags were cut open and the number of live and dead thrips were counted as they were removed with a camel's hair brush. One day later the leaves were rated for damage.

CHAPTER IV

RESULTS AND DISCUSSIONS

Field Tests

Significant differences ($p \leq .05$) were found among entries in all experiments except Valencia, P-0112, and Spantex experiments. In all experiments the differences among locations were significant and the variety x location interaction was non-significant in all but one of the experiments. This would indicate that the thrips population level varied with location, but the performance of the entries was approximately the same in all locations.

In the Starr experiment, Starr was the least damaged entry being significantly better than 16 other entries (Table 1).

The commercial variety Spanhoma was the only entry having a significantly low damage rating in the Argentine experiment (Table 2).

Two selections, P-3-65-154-67-1 and P-3-65-154-67-2, from the Dixie Spanish experiment (Table 3) were significantly better than eight other entries.

In the P-0074 experiment, Spanhoma was the least damaged entry with P-74-67-B being the second least damaged entry (Table 4).

The P-0112 experiment (Table 5) showed no significant differences among entries, however, the overall damage level for the experiment was lower than the other experiments indicating that all the

P-0012 selections may have a damage level as low as the significantly better entries in the other experiments.

In the Preliminary Spanish experiment (Table 6), Spanhoma was the least damaged entry. The second least damaged entry was P.I. 161317 and the third least damaged entry was P-741-64-1.

In the P-0548 experiment only one entry, P-548-67-2 was significantly less damaged than the others (Table 7).

The least damaged entry in the White Seeded experiment was P-1273 with Spanhoma being the second least damaged entry (Table 8).

Five entries were less damaged than Spanhoma in the National Spanish experiment. These were P-6-65-20, P-6-65-168, P.I. 268644, P-6-62-4, and Starr.

All entries tested are listed in the appendix. Mean damage ratings are shown for each entry by location (Table 1-11). All non-significant ranges are indicated so that significant differences among entries may be determined.

Laboratory Tests

Significant differences among entries were found in the preference test, but not in the tolerance and antibiosis tests. Coefficients of variation were high: 25% in the preference test, 30% in the tolerance test, and 45% in the antibiosis test.

In the preference test the three least damaged entries, P.I. 280688 (P-326), a mutant from P.I. 280688 (P-1287), and P-1005-67-1, were considerably less damaged than the most damaged entry (Table 12). The average leaf damage rating varied from 1.6 to 5.3.

The most tolerant entry in the tolerance tests had a much lower damage rating than most of the other entries. The damage rating in the tolerance test varied from 2.4 to 5.5. P.I. 280688 (P-0326) was the most tolerant entry (Table 13).

In the antibiosis tests the two entries having the highest levels of antibiosis and lowest number of thrips were P.I. 268777 and 280688 (P-0326). The average number of surviving thrips varied from 8.9 to 19.0 (Table 13).

P.I. 280688 (P-1287) was one of the least preferred entries, but it received heavy damage in the tolerance test and a very low level of antibiosis, indicating that its mechanism of field resistance is non-preference. This entry is a mutant from P.I. 280688. P.I. 280688, a resistant variety from tests in 1967 and 1968 both in field and laboratory, seemed to possess all three resistance mechanisms. It was one of the least preferred entries while having the lowest damage rating in the tolerance tests plus a high level of antibiosis.

P-1005-67-1, one of the three least preferred entries, had the second highest tolerance level and a fairly high antibiosis level. Its field resistance was probably due to non-preference and antibiosis.

P-1440, the fourth least preferred entry receiving moderate damage in the tolerance tests and showed the high level of antibiosis, indicating its field resistance is due to antibiosis and non-preference.

P-0483, the fifth least preferred entry, had an average damage rating in the tolerance test and the number of surviving thrips was below average suggesting that non-preference and antibiosis were resistance factors.

P-0036, being the sixth least preferred entry, still had a below average preference rating. It was the third most tolerant entry.

P.I. 268777, the susceptible check was the seventh most preferred entry having a high level of damage in the tolerance tests and the highest antibiosis level of all entries tested. Tests by Kinzer (1968) have shown this entry to be field resistant due to antibiosis, but attractive for oviposition in laboratory tests.

The commercial variety Spanhoma was moderately non-preferred, but had heavy damage in the tolerance tests and the highest number of surviving larvae in the antibiosis tests. Its field resistance is probably due to non-preference.

All entries tested are listed in the appendix (Tables 12 and 13). Means are compared in the preference test so significant differences among entries may be determined.

Inheritance Studies

Results from all tests involving antibiosis, preference, and tolerance tests were compared (Table 14). Data presented are an average of the experimental readings of all plants in each test.

No significant differences were found between the mean number of surviving thrips on the two parents.

P-844 had a significantly better tolerance reading than P-947. The damage range from obligatory feeding (3-7 for P-947 and 2-4 for

P-844) indicated that P-844 was better able to withstand thrips damage.

P-844 was the more perferred parent with P-947 attracting a significantly smaller number of thrips. Young (1969) also found P-947 moderately resistant due to non-preference. Even though P-844 was tolerant, it suffered heavy trhips damage, probably due to its weak antibiosis and high preference. P-947, having low tolerance, appeared to get its resistance from non-preference.

F_1's Derived from P-947 x P-844 and their Reciprocal

The F_1's used in these tests were cuttings. The F_1 reciprocals (P-844 x P-947) had significantly higher antibiosis, better tolerance response, and lower preference than either parent and the F_1 crosses (P-947 x P-844).

The F_1 crosses had significantly higher antibiosis and stronger tolerance response than either parent.

Since tolerance in the F_1's seemed to be inherited from P-844, it is possible that tolerance was inherited as a dominant characteristic. The F_1's tended toward the parent (P-947) with low preference. Thus, non-preference might also be controlled by dominant genes. When P-844 was used as the female parent, considerably more antibiosis was obtained.

F_2's Derived from P-947 x P-844 and their Reciprocal

The F_2's were useful to identify dominant or recessive characters. For a character to be dominant, most of the F_2 plants should show it. However, F_2 progenies showed differences in a specific character as did the F_1's.

The F_2's from P-947 x P-844 had less antibiosis than those derived from P-844 x P-947, which was similar to the F_1's.

Tolerance of both F_2 groups tended slightly toward the more tolerant parent P-844, indicating that tolerance may have been dominant over non-tolerance.

F_2's derived from P-947 x P-844 had a damage range of 2-6 while those derived from P-844 x P-947 had a range of 3-7. Both ranges were larger than these shown by the parents or the F_1's. This could be due to segregation.

From the analysis of variance of both parents, F_2's, and Starr, the only significant value was the tolerance of P-947 which was the least tolerant of all materials tested.

The ranges from the F_2 tolerance and antibiosis tests indicated that progeny from selected F_2 plants probably would not improve the levels of tolerance or antibiosis. The preference ranges did indicate a possibility of higher non-preference in the F_3 from selective F_2 breeding.

CHAPTER V

SUMMARY

Field Tests

Ninty-nine peanut cultivars and selections were tested for thrips resistance by measuring leaf damage. The entries were divided into 11 experiments, and each experiment was conducted in three peanut growing areas of Oklahoma.

Significant differences among entries were found in eight of the 11 experiments.

The commercial variety Spanhoma indicated presence of thrips resistant germ plasm.

Several other entries indicated a low level of thrips resistance. Among these were P.I. 161317, P-3-65-154-67-1, P-1005-67-1, Ga 61-42, P-548-67-2, P-74-67-13, and Starr.

Laboratory Tests

Preference and tolerance were measured by confining 600 adult females in a ventilated cage with 24 plants. The damage rating on the first opened bud on each plant was recorded as the index of preference. After five days of oviposition the adults were removed and the subsequent larval damage to the three leaves opened since the beginning of the test was recorded as the level of tolerance.

Antibiosis was measured by confining 30 in a leaf cage. The number of live larvae were counted at the end of 1 week.

Results from laboratory tests indicate that a combination of resistance mechanisms may be responsible for the level of resistance observed in some of the test entries.

Inheritance Studies

In the tests which were conducted to determine the mode of inheritance of resistance of peanuts to thrips, two peanut accessions plus their F_1 and F_2 progeny and reciprocals were used as test material. The two accessions were the susceptible P-844 and the moderately resistant P-947.

Although P-844 was more preferred it was significantly more tolerant than P-947.

P-947 has a weak tolerance response and probably owes its resistance to non-preference.

The antibiosis level of the two parents was not significantly different.

Results from the reciprocal crosses gave differences in antibiosis and tolerance levels and the inheritance seemed to follow the maternal line. This may indicate cytoplasmic influence on inheritance.

Most of the plants were more tolerant than the parental average which may indicate dominance for tolerance over non-tolerance.

The F_1 reciprocals gave results significantly better than the other materials tested.

The low tolerance of P-947 was the only value significantly different from the other materials tested in the F_2 portion of the study. The ranges of the experimental data from the F_2 tests indicated that selected F_2's could possibly be selfed or intercrossed to produce progeny having non-preference higher than the original parents. The F_2 distribution indicated that this procedure probably would not improve the tolerance of antibiosis levels.

LITERATURE CITED

Arant, F. S. 1950. Control of peanut insects. Alabama Agr. Exp. Sta. Annu. Rep. 58/59. 43-44.

Arant, F. S. 1951. Insect pests, p. 230-235. In, The peanut, the unpredictable legume: a symposium. Nat. Fertilizer Assoc., Washington, D.C.

Arant, F. S. 1954. Control of thrips and leafhoppers on peanuts. J. Econ. Entomol. 47: 257-268.

Arthur, B. W. and F. S. Arant. 1954. Effect of systemic insecticides upon certain peanut insects and upon peanuts. J. Econ. Entomol. 47: 1111-1114.

Bailey, S. F. 1933. The biology of the bean thrips. Hilgardia 7: 467-522.

Beck, S. D. 1965. Resistance of plants to insects. Ann. Rev. Entomol. 10: 207-232.

Bryan, D. E. and R. F. Smith. 1956. The Frankliniella occidentalis (Pergande) complex in California. Univ. California Pub. Entomol. 10: 359-410.

Callen, E. M. 1943. Thrips resistance in cacao. Trop. Agr. 20: 127-135.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 1: 1-42.

Eddie, C. O. and E. M. Livingston. 1931. Frankliniella fusca Hinds (Thrips) on seedling cotton. So. Carolina Agr. Exp. Sta. Bull. 271: 1-23.

Eden, W. G. and C. A. Brogden. 1960. Systemic insecticides for thrips control on peanuts. Alabama Agr. Exp. Sta. Progress Rep. 77. 3 p.

George, J. A. 1961. A pneumatic laboratory cage for Thysanoptera. Can. Entomol. 93: 564-565.

Harding, J. A. 1959. Effects of thrips on peanut yields. Texas Agr. Exp. Sta. Progress Rep. 2116. 4 p.

Hyche, L. L. and R. H. Mount. 1956. Control of peanut insects. Alabama Agr. Exp. Sta. Annu. Rep. 66/67. 52.

Jones, H. A., S. F. Bailey, and S. L. Emsweller. 1934. Thrips resistance in the onion. Hilgardia 8: 215-232.

King, D. R., J. A. Harding, and B. C. Langley. 1961. Peanut insects in Texas. Texas Agr. Exp. Sta. Misc. Pub. 550. 14 p.

Kinzer, R. E. 1968. Mass rearing the tobacco thrips, Frankliniella fusca (Hinds), and laboratory techniques for testing peanut resistance to thrips. M.S. Thesis. Oklahoma State Univ. 42 p.

Leuck, D. B., R. O. Hammons, L. W. Morgan, and J. E. Harvey. 1967. Insect preference for peanuts. J. Econ. Entomol. 60: 1546-49.

Matlock, R. S. 1966. A method of evaluating thrips damage to peanuts. Unpublished Rep. Dep. Agronomy. Oklahoma State Univ.

Munger, F. 1942. A method of rearing citrus thrips in the laboratory. J. Econ. Entomol. 35: 373-375.

Packard, C. M., and J. H. Martin. 1952. Resistant crops, the ideal way, p. 429-436. In U. S. Dept. Agr. Yearbook, Washington, D.C.

Painter, R. H. 1951. Insect resistance in crop plants. MacMillan Co., New York. 520 p.

Painter, R. H. 1954. Some ecological aspects of the resistance of crop plants to insects. J. Econ. Entomol. 47: 1036-1040.

Painter, R. H. 1968. Crops that resist insects provide a way to increase world food supply. Kansas Agr. Exp. Sta. Bull. 520. 22 p.

Pitts, J. T. 1970. Genetic resistance of peanuts to the tobacco thrips, Frankliniella fusca and the red-necked peanut worm, Stegasta bosqueelia. M.S. Thesis. Oklahoma State Univ.

Poos, F. W. 1941. On the causes of peanut "pouts". J. Econ. Entomol. 34: 727-728.

Poos, F. W. 1945. Control of tobacco thrips on seedling peanuts. J. Econ. Entomol. 38: 446-8.

Poos, F. W., J. M. Grayson, and E. T. Batten. 1947. Insecticides to control tobacco thrips and potato leafhopper on peanuts. J. Econ. Entomol. 40: 900-905.

Samuel, G., J. G. Bald, and H. A. Pittman. 1930. Investigations on "spotted wilt" of tomatoes. Commonwealth Australia Council Sci. Ind. Res. Bull. 44. 64 p.

Schoonhoven, L. M. 1968. Chemosensory bases of host plant selection. Annu. Rev. Entomol. 13: 113-136.

Shear, G. M., and L. I. Miller. 1941. Thrips injury of peanut seedlings. Plant Dis. Reporter. 25: 470-474.

Snedecor, G. W. and W. G. Cochran. 1967. Factorial experiments p. 339-380. In Statistical Methods. 6th ed. Univ. Iowa Univ. Press.

Snelling, R. O. 1941. Resistance of plants to insect attack. Bot. Rev. 7: 543-586.

Sung, Chi-Hsiu. 1969. Inheritance of resistance to thrips in peanuts. M.S. Thesis. Oklahoma State Univ.

Thorsteinson, A. J. 1960. Host selection in phytophagous insects. Annu. Rev. Entomol. 5: 192-218.

Wardle, R. A. 1927. The biology of Thysanoptera with reference to the cotton plant. 1. The relation between the degree of infestation and water supplied. Ann. Appl. Biol. 14: 482-500.

Wardle, R. A. and R. Simpson. 1927. The biology of Thysanoptera with reference to the cotton plant. 3. The relation between feeding habits and plant lesions. Ann. Appl. Biol. 14: 513-528.

Watson, J. R. 1922. The flower thrips. Florida Agr. Exp. Sta. Bull. 162. 51 p.

Wilson, C. and F. S. Arant. 1949. Control of insects and diseases of peanuts. Alabama Agr. Exp. Sta. Leaflet 27.

Young, S. C. 1969. Field and laboratory tests for genetic resistance of peanuts to the tobacco thrips, Frankliniella fusca (Hinds). Ph.D. Thesis. Oklahoma State Univ.

APPENDIX

Table 1. Mean leaf damage by thrips to peanuts in the Starr field experiment.

Entry: P.I. or Strain No.	Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
P-6-65-28-67-5		4.93	3.37	4.46	4.26	a
P-6-65-49-67-1		4.87	3.57	4.33	4.26	a
P-6-65-49-67-3		5.03	4.00	4.23	4.42	a
P-6-65-49-67-5		5.10	3.93	4.29	4.43	a
P-6-65-49-67-6		4.97	3.77	4.60	4.44	a
P-6-65-49-67-7		5.06	3.83	4.40	4.43	a
P-6-65-67-67-1		4.87	3.53	4.37	4.26	a
P-6-65-67-67-3		5.10	3.50	4.47	4.36	a
P-6-65-67-67-6		4.73	3.60	4.53	4.29	a
P-6-65-67-67-7		5.07	3.57	4.37	4.33	a
Starr	0006	4.90	3.27	4.30	4.16	b
P-6-65-28	1442	4.73	3.57	4.33	4.21	ab
P-6-65-20	1443	4.96	3.73	4.46	4.39	a
P-6-65-84	1744	4.90	3.63	4.23	4.26	a
P-6-65-168	1745	4.70	3.57	4.37	4.21	a
P-6-65-205	1746	4.90	3.90	4.67	4.49	a
P-6-65-208	1747	5.03	3.63	4.30	4.32	a
P-6-62-4	1743	4.93	3.87	4.30	4.37	a

[a] Means not followed by the same letter are significantly different.

Table 2. Mean leaf damage by thrips to peanuts in the Argentine field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
Argentine	0002	4.60	3.60	4.40	4.20	a
OAEP-58-16	0074	4.63	3.43	4.57	4.21	a
OICB1271	0112	4.80	3.37	4.33	4.17	a
P-262-65-1-67B		4.70	3.73	4.80	4.41	b
P-993-67-3		4.60	3.67	4.77	4.34	ab
P-998-67-9		4.67	3.57	4.40	4.21	a
P-1005-67-1		4.80	3.20	4.97	4.16	a
P-1005-67-2		4.70	3.53	4.43	4.22	

[a] Means not followed by the same number are significantly different.

Table 3. Mean leaf damage by thrips to peanuts in the Dixie Spanish field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
P-3-65-154-67-1		4.73	4.03	4.40	4.39	a
P-3-65-154-67-2		4.63	4.03	4.77	4.48	a
P-3-65-154-67-5		4.80	4.27	4.47	4.51	ab
P-3-65-175		4.93	4.43	4.63	4.67	b
P-3-65-178-67-4		4.77	4.60	4.60	4.66	b
P-3-65-178-67-6		4.63	5.03	4.63	4.78	b
P-3-65-178-67-12		4.67	4.77	4.70	4.71	b
Dixie Spanish	0003	4.73	4.53	4.50	4.59	b
P-3-65-15	1436	5.07	4.67	4.70	4.81	b
P-3-65-50	1437	4.87	4.77	4.80	4.81	b

[a] Means not followed by the same letter are significantly different.

Table 4. Mean leaf damage by thrips to peanuts in the P-0074 field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
P-74-67-1		5.23	3.13	4.33	4.23	a
P-74-67-3		4.93	3.53	4.33	4.27	a
P-74-67-4		5.20	3.37	4.33	4.30	a
P-74-67-5		4.87	3.47	4.37	4.23	a
P-74-67-11		5.13	3.57	4.40	4.37	a
P-74-67-14		5.03	3.17	4.27	4.16	ab
P-74-67-18		5.20	3.43	4.50	4.38	a
P-74-67-20		5.37	3.17	4.33	4.29	a
P-74-67-22		5.20	3.43	4.47	4.37	a
P-74-67-24		4.90	3.43	4.30	4.21	a
OEAP58-16	0074	5.03	3.50	4.40	4.31	a
P-74-67-B		4.83	3.40	4.10	4.11	b
Argentine	0002	5.07	3.47	4.27	4.27	a
Spanhoma	0112	4.77	3.07	4.23	4.02	b

[a] Means not followed by same letter are significantly different.

Table 5. Mean leaf damage by thrips to peanuts in the P-0112 field experiment.

Entry					
P.I. or Strain No.	Okla. P-No.	Per-kins	Strat-ford	Com-bined	Signif.[a] $p \leq .05$
P-112-68-1		4.93	3.40	4.17	a
P-112-68-2		4.77	3.50	4.13	a
P-112-68-3		4.80	3.20	4.00	a
P-112-68-4		4.80	3.37	4.08	a
P-112-68-5		4.77	3.53	4.15	a
P-112-68-6		4.80	3.43	4.12	a
P-112-68-7		5.00	3.33	4.17	a
P-112-68-8		4.93	3.13	4.03	a
P-112-68-9		4.97	3.17	4.07	a
OICB1271	0112	4.77	3.23	4.00	a

[a] Means not followed by the same letter are significantly different.

Table 6. Mean leaf damage by thrips to peanuts in the Preliminary Spanish field experiment.

Entry						
P.I. or Strain No.	Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
Spanhoma	0112	4.63	4.26	4.33	4.41	a
P-741-64-1		4.96	4.66	4.30	4.64	bc
P.I. 268754	0676	5.10	4.70	4.70	4.83	cd
P-588-64-1		5.10	4.43	4.73	4.16	bcd
P.I. 161317	0331	4.96	4.20	4.63	4.60	ab
P.I. 288151	1288	5.30	4.70	4.80	4.93	d

[a] Means not followed by the same letter are significantly different.

Table 7. Mean leaf damage by thrips to peanuts in the P-0548 field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
	0548	3.65	4.25	3.95	ab
P-548-67-2		3.35	4.50	3.93	a
P-548-67-3		3.45	4.60	4.03	b
P-548-67-4		3.90	4.65	4.28	b
P-548-6-67-6		4.00	4.60	4.30	b
P-548-6-67-12		3.95	4.45	4.20	b

[a] Means not followed by the same letter are significantly different.

Table 8. Mean leaf damage by thrips to peanuts in the White Seeded field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
Pearl	0012	5.06	5.03	5.05	c
Dirty White	0029	5.00	4.70	4.85	b
OICB1271	0112	4.66	4.46	4.57	a
Ga. 61-42	1273	4.76	4.10	4.43	a
P-30-1-2-32-62-6	1446	5.33	4.93	5.13	c
P-292-65-11	1447	5.16	5.03	5.10	c
P-292-65-12	1448	5.20	4.96	5.08	c
P-29-65-13	1449	5.00	4.80	4.90	bc
P-29-65-46	1451	4.90	4.63	4.78	ab

[a] Means not followed by the same letter are significantly different.

Table 9. Mean leaf damage by thrips to peanuts in the National Spanish field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] p ≤ .05
Argentine	0002	4.98	4.10	4.49	4.48	a
Starr	0006	5.07	3.97	4.35	4.46	a
Spanhoma	0112	5.02	4.00	4.31	4.44	a
P.I. 268771B	0931	5.12	4.43	4.55	4.70	a
P.I. 268644	0370	4.92	4.20	4.25	4.45	a
P.I. 268684	0385	5.27	3.90	4.25	4.47	a
P.I. 268689	0389	4.92	4.57	4.47	4.65	a
P.I. 248759	0548	5.35	3.97	4.40	4.57	a
Ga. C1-27	1258	5.30	4.07	4.38	4.58	a
Ga. C325	1259	5.08	4.33	4.55	4.65	a
Dixie Spanish	0003	4.82	4.03	4.25	4.36	a
Spantex	0004	4.83	4.07	4.38	4.57	a
Stratford Spanish	0011	5.02	4.27	4.40	4.56	a
OAEP58-16	0074	5.02	4.13	4.52	4.56	a
Spanhoma (OICB1271)	0112	5.02	4.10	4.37	4.50	a
P-3-65-15	1436	5.08	4.10	4.67	4.62	a
P-3-65-50	1437	5.13	4.43	4.67	4.74	a
P-4-65-25	1439	4.75	4.17	4.45	4.46	a
P-4-65-29	1440	4.78	4.40	4.50	4.56	a
P-4-65-28	1442	5.00	4.20	4.48	4.56	a
P-6-65-20		4.78	4.03	4.37	4.39	a
P-6-65-84		5.13	4.33	4.57	4.67	a
P-6-65-168		4.75	4.20	4.37	4.44	a
P-6-62-4		4.92	3.97	4.50	4.46	a

[a] Means not followed by the same letter are significantly different.

Table 10. Mean leaf damage by thrips to peanuts in the Valencia field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
Tenn Red	0161	5.27	4.93	5.10	a
P.I. 262020	0483	5.07	4.63	4.85	a
P.I. 259598	0776	5.07	4.77	4.92	a
P-606-64-1	1521	5.17	4.77	4.97	a
P-161-67-B		5.43	4.73	5.08	a
Code - 10 (Tripp)		5.23	4.87	5.05	a

[a] Means not followed by the same letter are significantly different.

Table 11. Mean leaf damage by thrips to peanuts in the Spantex field experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	Per-kins	Strat-ford	Fort Cobb	Com-bined	Signif.[a] $p \leq .05$
P-4-65-115-67-2		4.83	5.40	4.23	4.82	a
P-4-65-115-67-3		4.90	5.47	4.27	4.88	a
P-4-65-147-67-5		4.67	5.60	4.40	4.89	a
P-4-65-147-67-6		4.80	5.50	4.47	4.92	a
P-4-65-147-67-7		4.57	5.43	4.37	4.79	a
P-4-65-191-67B		4.87	5.37	4.33	4.86	a
Spantex	0004	4.73	5.70	4.23	4.89	a
P-4-65-25	1439	4.73	5.60	4.57	4.97	a
P-4-65-29	1440	4.80	5.60	4.10	4.83	a
P-4-65-91	1441	4.90	5.57	4.43	4.97	a
P-4-65-45		4.86	5.63	4.33	4.95	a

[a] Means not followed by the same letter are significantly different.

Table 12. Mean leaf damage by thrips to peanuts in the laboratory preference experiment.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	$\bar{X}$ Leaf Damage	Signif.[a] $\underline{P} \leq .05$
P.I. 280688	1287[b]	1.6	a
P.I. 280688	0326	1.6	a
P-1005-67-1		1.6	a
P-4-65-29	1440	2.0	a
P.I. 262020	0483	2.0	a
NC-2	0036	2.3	a
P.I. 268777	0695	2.6	ab
Spanhoma	0112	2.6	b
P.I. 314895	1113	2.6	b
P.I. 259745	0779	2.6	b
P-3-65-154-67-2		3.0	b
P.I. 268649	0375	3.0	b
Starr	0006	3.1	b
P-548-67-4		3.6	bc
P-3-65-154-67-1		4.0	c
P-4-65-147-67-7		4.3	c
P(1262 x P-36)68-20		4.3	c
Georgia 61-42	1273	4.6	cd
P.I. 268661	0971	5.3	d

[a] Means not followed by the same letter are significantly different.

[b] P-1287 is a mutant from P-0326.

Table 13. Mean leaf damage by thrips to peanuts in the tolerance experiment and mean number of surviving thrips larvae in the laboratory antibiosis test.

Entry: P.I. or Strain No.	Entry: Okla. P-No.	$\bar{X}$ Leaf Damage	$\bar{X}$ Surviving Larvae
P.I. 280688	1287[a]	5.4	15.3
P.I. 280688	0326	2.4	9.0
P-1005-67-1		3.4	10.3
P-4-65-29	1440	3.9	10.6
P.I. 262020	0483	3.9	12.6
NC-2	0036	3.5	14.6
P.I. 268777	0695	4.1	8.9
Spanhoma	0112	5.1	21.0
P.I. 314895	1113	3.8	12.0
P.I. 259745	0779	5.0	13.0
P-3-65-154-67-2		4.0	14.0
P.I. 268649	0325	3.5	14.3
Starr	0006	4.4	13.2
P-548-67-4		4.2	19.0
P-3-65-154-67-1		5.4	18.0
P-4-65-147-67-7		5.3	10.3
P(1262 x P-36)68-20		5.8	11.3
Georgia 61-42	1273	4.7	14.3
P.I. 268661	0971	5.5	16.7

[a] P-1287 is a mutant from P-0326.

Table 14. Results of inheritance studies in the laboratory.

Okla. P-No.	Antibiosis: $\bar{X}$ No. Surviving Thrips	Tolerance: $\bar{X}$ Leaf Damage Rating	Preference: $\bar{X}$ No. Thrips Recovered
947	20.26	4.60	8.44
844	19.89	3.00	11.60
$\frac{947}{844}$[a] (F_1)	10.20	2.90	8.73
$\frac{844}{947}$ (F_1)	2.25	2.00	4.00
$\frac{947}{844}$ (F_2)	19.05	3.76	8.55
$\frac{844}{947}$ (F_2)	17.80	3.48	9.97
Starr	18.75	3.30	8.70

[a] Numerator parent indicates female and denominator parent indicates male.

VITA

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Master of Science

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