# MASS REARING THE TOBACCO THRIPS, *FRANKLINIELLA FUSCA* (HINDS), AND LABORATORY TECHNIQUES FOR TESTING PEANUT RESISTANCE TO THRIPS

By

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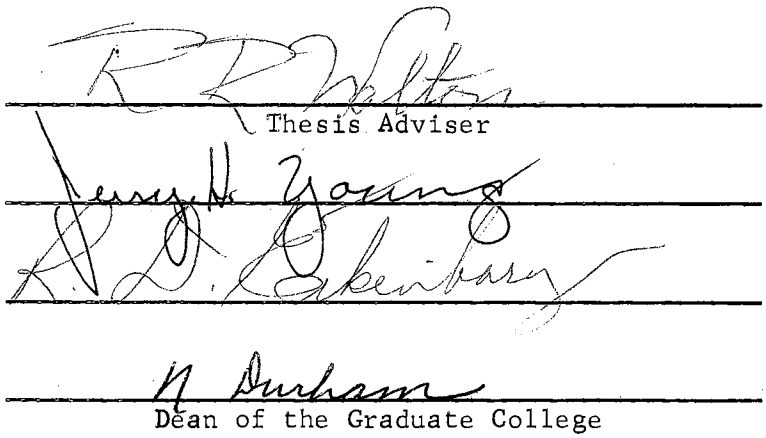

Thesis Adviser

Dean of the Graduate College

## PREFACE

During 1966 and 1967, the Department of Entomology screened 881 peanut entries for thrips resistance in field tests. A second phase of the study involved laboratory evaluation of promising entries to determine their mechanisms of resistance. The author sought, and was assigned, leadership in this portion of the investigation.

Before such a study could be undertaken methods of mass rearing the tobacco thrips in the laboratory and methods of testing peanut entries for the different types of resistance had to be developed. This thesis presents, in two sections, a mass rearing method for thrips and techniques for testing peanut resistance to thrips.

Deep appreciation is expressed to Dr. R. R. Walton, my major advisor, for his guidance throughout this research and for his support in preparation of this manuscript.

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# MASS REARING OF THE TOBACCO THRIPS IN THE LABORATORY

# INTRODUCTION

In field studies conducted to screen peanut varieties for resistance to thrips damage, several varieties were significantly less damaged than the other entries. Before the promising varieties could be tested in the laboratory to determine their mechanism of resistance, whether tolerance, preference or antibiosis, a method of rearing thrips in mass numbers had to be developed.

This study was undertaken to develop a mass rearing technique for the tobacco thrips, Frankliniella fusca (Hinds), is the major thrips pest of peanuts in Oklahoma.

Because of their small size and secretive habits, three problems are commonly encountered in rearing thrips: the development of an adequate cage, the selection of a suitable host plant or food, and the development of efficient manipulation techniques (Bryan and Smith, 1956).

Eddie and Livingstone (1931) reared the tobacco thrips by placing adult thrips in test tubes containing young cotton leaves. The test tubes were closed with absorbent cotton and the cotton leaves removed daily. After removal, the cotton leaves were soaked in distilled water for 24 hours, wrapped in moist absorbent cotton and examined daily for emerging larvae. Emerging larvae were removed with a camel's hair brush and placed in test tubes containing cotton leaves. New leaves were added as needed.

Bryan and Smith (1956) reared thrips by confining adults in lipped vials covered with muslin cloth held in place by rubber bands. Green beans were used as the adult food, oviposition medium, and larval food through the first instar. Larvae in their second instar were transferred from the vials to a "sandwich" cage which confined the larvae on a small portion of a detached host leaf. Munger (1942), Bryan and Smith (1956), Sakimura (1961) and Tashiro (1967) reared thrips in various modifications of the "sandwich" cage. All of these cages consisted of a host leaf forming the floor of the cage and supported underneath by a layer of absorbent material to keep the leaf moist and a layer of rigid material for supporting the lower portion of the cage. A hole, cut in a glass plate or similar material, placed on the upper surface of the leaf, formed the walls of the cage. The opening was covered with fine woven cloth, screen or a glass plate. The upper and lower portions of the cages were held together with rubber bands.

Bailey (1933) developed a very versatile cage for thrips using permeable cellophane envelopes. Envelopes of various sizes were used to enclose a leaf, twig or branch. The open end of the flexible bag was constricted around the petiole or stem and the basal end of petiole or stem left on the growing plant or inserted in water.

Several workers have cultured thrips in the laboratory. Davidson and Bald (1930) maintained cultures of thrips by placing a lamp globe over a host plant. The globe was sealed to a flower pot and the upper end covered with a fine woven cloth. Sakimura (1961) rolled plastic sheeting into a cylinder and fastened it with acetone. The upper end of the cage was covered with cloth and the lower portion pressed into the soil around a host plant. George (1961) sealed an inverted

polyethylene bag over a potted host plant and ventilated the cage with compressed air. This cage had the advantage in that some manipulation could be made through the cage wall.

These methods were inadequate for maintaining a large, continuous culture of thrips or producing large numbers of larvae and adults of a known age for use in resistance studies.

Techniques utilizing peanut leaves for egg deposition and an artificial wheat germ diet developed by Adkisson, et al. (1960) and modified by Vanderzant (1962), for larval rearing were developed. This paper presents a detailed description of these and supplementary techniques and gives a summary of results obtained. A continuous culture cage was also developed.

## METHODS AND MATERIALS

Parent cultures of tobacco thrips Frankliniella fusca (Hinds) were collected from peanut plants at the Perkins Research Farm, Perkins, Oklahoma, in August 1966 by use of a D-Vac vacuum insect collector. The contents of the collection bag were placed in quart ice cream cartons and transported to the laboratory where the tobacco thrips were separated from the other fauna with a camel's hair brush.

Rearing was conducted in a growth chamber maintained at 80 ± 2° F. Light was provided by 150 thirty-watt daylight type fluorescent tubes producing 2000 foot-candles of light at plant height. A photoperiod of 12 hours daily was maintained. The relative humidity ranged between approximately 60% during the lighted period and 80% in the dark period.

Starr, a commercial peanut variety which is one of the two most popular varieties in the state of Oklahoma, was used as an oviposition and rearing media for thrips. Seeds were treated with Arasan seed protectant to reduce mold infection and germinated by placing the seeds between four moist paper towels. The towels containing the seeds were placed on a sheet of wax paper, tightly rolled, and placed in the growth chamber for three days. After three days, when the primary root was about 1 inch long, the seeds were planted in 4-inch pots which contained a growth medium of equal volumes of peat moss and perlite. Peanut plants were grown in a greenhouse until they were ready for use in the growth chamber. Six ounces of a nutrient stock solution, made by dissolving 8 oz. of a 20-20-20 water soluble fertilizer in 20

gallons of water were added to the growth medium at weekly intervals. Plants in the greenhouse and growth chamber were watered daily.

## Egg Deposition

Oviposition cages were made from No. 36, seamless, regenerated, dialysis tubing (Union Carbide Corporation, Foods Product Division, 6711 West 65th Street, Chicago, Illinois) with a flat width of 1.73 inches and a wall thickness of 0.00010 inches. Four-inch sections of the tubing were placed over peanut leaves that had two leaflets removed (Fig. 1). Thin sections of caulking strips were placed around the petiole, ½ inch above the basal leaflet, and one corner of the tubing was pressed firmly against the caulking, sealing the tubing around the petiole. An incision, 1/8 inch deep and parallel to the petiole, was made in the tubing and caulking compound; then the end of the cage was folded over the depth of the incision. Filament tape was placed over the fold sealing the basal end of the cage with no tape exposed to the inside.

Caulking strips manufactured by the Macklanburg Duncan Company in Oklahoma City, Oklahoma was the only one of several commercial brands tested that had no adverse effect on the thrips.

After adult thrips were placed in the cage, the distal end was folded over 1/8 inch and sealed with tape. Filament tape was the only material found that would keep the cages sealed under conditions of high humidity. Three oviposition cages could usually be placed on a one month old peanut plant (Fig. 2).

After one day in the oviposition cages, the adults were removed by cutting off the distal portion of the cage and placing the open end

in a 7-dram plastic vial. Thumping the cage on the caulking caused most of the thrips to fall into the vial. Those remaining in the cage were removed with a No. 0 camel's hair brush. The cage was resealed and left on the plant until after larval emergence. The adult thirps were used to innoculate subsequent oviposition cages.

Fifty to seventy adult thrips were placed in each oviposition cage at a ratio of 15 to 20 females for each male. This range in sex ratio was chosen because it has been shown that an abundance of males will prevent copulation (Bryan and Smith, 1956). Unfertilized females produced only male offspring.

## Larval Rearing

Eight days after the adults were removed from the oviposition cages, the larvae were removed from the cages. The larvae were placed on an artificial wheat germ diet developed by Adkisson, et al. (1960) and modified by Vanderzant (1962), or caged on new peanut leaves. The percent adult emergence and egg production were compared between the two methods.

Larvae placed on artificial diet were transferred in groups of approximately 100 to 1 oz. plastic medicine cups (Premium Plastics Company, Chicago, Illinois) containing approximately ½ oz. artificial diet. Larvae were removed from the oviposition cage by cutting off the distal portion of the cage and placing the open end of the cage in the diet cup. The cage was gently thumped on the caulking compound until the desired number of thrips had fallen onto the diet. The cups were sealed and placed in a constant temperature cabinet maintained at $80 \pm 1°F$ by heat from a 60-watt incandescent light (Fig. 3). The

cabinet was kept in an environment where the temperature was maintained below 80°F and showed a limited fluctuation of relative humidity. A sharp change in the humidity caused moisture to form inside the cups, drowning the thrips. Cages used to confine larvae on peanut leaves were constructed in the same manner as the oviposition cages.

## Continuous Culture Cage

A continuous culture of thrips was maintained in rearing cages (20 x 14 x 24 inches) constructed of 20-mils. cellulose nitrate and 1-inch white pine (Fig. 4). One-eighth-inch masonite was used for the floor. The frame of the cage, constructed of 1 x 1 inch white pine, was connected to a 1 x 2 inch pine base. Sheets of cellulose nitrate were stapled to the frame and base with caulking compound placed inside the cage at all junctions of the cellulose and frame, making the cage escape-proof and leaving no cracks for larval pupation. Twenty peanut plants grown in 4-inch diameter pots were placed in each cage.

An opening (20 x 8 inches) was placed in the top of the cage (Fig. 4) with a ½-inch strip of heavy felt surrounding the edges. A glass plate which covered the felt strips was used as the closure.

Air was forced into the cage by means of a 3/4-inch hose inserted into the bottom of the cage and connected to the opening of a squirrel cage fan (Fig. 5). Six circular 1-inch holes were cut in the top of the cages and a finely woven cloth was glued over the openings allowing air exchange.

Peanut plants in the laboratory were watered by the device shown in Fig. 6. A hand sprayer shut-off valve with the nozzle assembly removed from the wand connected to a garden hose made it possible to

regulate and shut off water flow. Small holes, ½ inch above the pot height, were cut in one side of the culture cage allowing entry of the wand into the cage. The openings were covered with caulking strips when not in use.

## RESULTS AND DISCUSSION

Rearing procedures using peanut leaves caged with dialysis tubing for egg deposition allowed for greater egg production with less labor than previously required. The use of an artificial wheat germ diet as larval food greatly facilitated the rearing program because little time and difficulty were involved in maintaining the larval culture. The synthetic diet retained adequate freshness during a thrips generation, thus eliminating transfer of insects during development. By contrast, age, quality and deterioration were factors of plant condition that required thrips to be transferred to fresh plants one or more times in a life cycle.

The average daily egg production for females grown on an artificial diet was compared to daily egg production of females from the continuous culture cage, field collected females, and females reared on caged peanut leaves. The results are given in Table 1. The number of larvae emerging was used as an index to the rate of egg deposition. The higher egg production of females from an artificial diet and those reared on caged peanut leaves was attributed to the fact that the females were of uniform age and known to be gravid when placed in oviposition cages. By contrast, females from the continuous culture cage and the field were not of a determined age and may have varied in development from the pre-oviposition to post-oviposition periods.

Larvae confined on the wheat germ diet and placed in the constant temperature cabinet required no attention until the adults were ready

to be removed. An average of 87% of larvae placed on artificial diet matured to the adult stage compared to 63% survival of larvae confined on peanut leaves. A modification of the synthetic diet, substituting propionic acid for sodium propionate as a mold inhibitor, reduced the survival to 36%.

The life cycle of the tobacco thrips was approximately the same as that reported by Eddie and Livingstone (1931). The average time from egg to adult was 16.02 days when larvae were placed on artificial diet and 15.8 days when confined on peanut leaves. Females reared on artificial diet had a pre-oviposition period that varied from one to five days with an average of 2.8. The gravid period was approximately 15 days with daily egg production decreasing markedly after 12 days.

Adult thrips were removed from the artificial diet cups and caged on peanut leaves for egg production 20 days after being deposited as eggs. The majority of the females were beginning their gravid period at this age.

A continuous culture of tobacco thrips was maintained throughout this study and used as a reserve culture when more adult thrips were needed than were available from the artificial diet culture. Peanut plants that became infested in the laboratory were placed in these cages. Approximately 15 days after infested plants were placed in the cage, the number of adult thrips in the cage began to visibly increase. Plants in the cage were usually unable to support the population after one month. If these adults were not needed for rearing purposes, the cage was thoroughly cleaned and a new population was established on fresh plants.

## SUMMARY

The use of peanut leaves caged with dialysis tubing for egg deposition and an artificial wheat germ diet for larval rearing, resulted in production of mass numbers of thrips with a minimum of labor and materials. Thirty-two generations of thrips were reared in the laboratory by this method with no apparent loss of vigor or reproductive power. A continuous culture cage, which held 16 peanut plants, was used to maintain a reserve culture of thrips throughout this study.

It is believed that this method of rearing would serve for other species of thrips and that the oviposition cage would be satisfactory for other small insects that lay their eggs within leaf tissue.

# II

# LABORATORY TECHNIQUES FOR TESTING PEANUT RESISTANCE TO THRIPS

# INTRODUCTION

This study was undertaken to develop laboratory methods of testing peanut resistance to thrips. By the use of these methods, entries that showed resistance in the field could be examined to determine their mechanism of resistance. Plant resistance as used here refers to those genetically based factors of the plant that caused it to be resistant to an insect.

Mechanisms of plant resistance to insects can be divided into categories of preference, antibiosis, and tolerance or combinations of these (Painter, 1951). Preference or non-preference is used to denote the group of plant characters and insect responses that lead to or away from the use of a particular plant or variety for oviposition, food or shelter or for combinations of uses. Antibiosis includes those factors in a plant that unfavorably affect the development or survival of insects feeding on the plant. Tolerance has been defined as the basis of resistance by which the plant repairs injury to a marked degree, grows and reproduces itself, while supporting a population approximately equal to that damaging a susceptible host (Painter, 1951).

Although the literature on resistance of plants to insect damage is considerable, very little has been published on peanut resistance to insects. Leuck, et al., (1967) tested resistance of 14 lines of peanuts to insect damage. He reported significant differences in peanut resistance to thrips damage under field conditions. He states that

feeding preferences of thrips should be evaluated before flowering, because thrips will feed on floral parts after anthesis.

This paper describes methods and results of evaluating peanut entries for tolerance, antibiosis and nonpreference.

## METHODS AND MATERIALS

All laboratory testing of peanut entries were conducted in a growth chamber maintained at 80 ± 2°F. Light was provided by 150 thirty-watt daylight type fluorescent tubes producing 2000 foot-candles of light at plant height. A photoperiod of 12 hours daily was maintained. The relative humidity ranged between approximately 60% during the lighted period and 80% in the dark period.

Peanut seeds were treated with Arasan seed protectant to reduce mold and germinated by placing the seeds between four moist paper towels. The towels containing the seeds were placed on a sheet of wax paper, tightly rolled, and placed in the growth chamber for three days. After three days, when the primary root was about 1 inch long, the seeds were planted in 4-inch pots containing a growth medium of equal volumes of peat moss and perlite. Plants were grown in a greenhouse until ready for use in the growth chamber. Six ounces of a nutrient stock solution, made by dissolving 8 oz. of a 20-20-20 water soluble fertilizer in 20 gallons of water, were added to the growth medium at weekly intervals. Plants in the greenhouse and growth chamber were watered daily.

Tobacco thrips used in this study were reared by the methods described in Section I, Mass Rearing of the Tobacco Thrips in the Laboratory. Entries selected for this study were those that were rated as resistant in the field studies. In addition, eight entries that were rated as susceptibles in field studies were included for comparison.

The method of determining field resistance was by visual ratings of leaf damage.

## Manipulation of Larvae and Adults

Larvae were counted and transferred to peanut plants for resistance studies by placing the larvae on a sheet of glass with a black background and picking up the insects in groups of ten with the vacuum "pencil" or aspirator shown in Fig. 7.

An electric Hudson insecticide duster, Model 3210-K, was converted into a vacuum by removing the hose connected to the air outlet and connecting a 1/8-inch rubber hose to the intake.

A 6-inch section of 1/8-inch copper tubing was placed in the distal end of the suction hose, and a finely woven cloth was placed over the open end of pipe to form a surface on which the larvae were trapped by suction.

The amount of vacuum produced could be controlled by varying the length of the hose. A pressure that would remove the larvae from the glass, when the aspirator tip was approximately 1/8 inch above them, caused a mortality rate of less than 3%.

Larvae were removed from the cloth by stopping the vacuum fan and tapping the copper pipe with a pair of forceps. A foot operated switch was used to start and stop the vacuum fan.

A 75 ml test tube placed in the suction hose 2 feet from the motor acted as a surge tank and removed pulsations from the vacuum.

Adult thrips were transferred and counted by the use of a No. 0 camel's hair brush. The desired number of adults were placed in a

plastic vial and then transferred into test cages by tapping the bottom of the vial.

## Tolerance and Antibiosis

Sixty peanut entries from field tests, including 52 rated as resistant and eight classed as susceptible, were tested for tolerance and antibiosis. The commercial variety, Starr, used as the check variety in all field experiments, was also used as the check entry in all laboratory tests. Thrips larvae were confined on a peanut leaf by dialysis tubing. Entry evaluations were based on seven replications.

Leaf cages made of No. 36, seamless, regenerated, dialysis tubing (Union Carbide, Foods Product Division, 6711 West 65th Street, Chicago, Illinois) were placed on the fifth or sixth open leaf of the plant. Two leaflets were removed from the leaf and a 3-inch section of the tubing was placed over the remaining leaflets (Fig. 8). Thin sections of caulking strips were placed around the petiole, ½ inch above the basal leaflet, and one corner of the tubing was pressed firmly against the caulking, sealing the tubing around the petiole. An incision, 1/8 inch deep and parallel to the petiole, was made in the tubing and caulking compound and then the end of the cage was folded over the depth of the cut. Filament tape was placed over the fold, sealing the basal end of the cage with no tape exposed to the inside.

Caulking strips manufactured by the Macklanburg Duncan Company in Oklahoma City, Oklahoma, was the only one of several commercial brands that had no adverse affect on the thrips.

After larvae were placed in the cage the distal end was folded over 1/8 inch and sealed with tape. Filament tape was the only

material found that would keep the cages sealed under conditions of high humidity.

The cages were innoculated with 30 larvae which had been oviposited eight days previously. After one week, the cages were removed and the number of live thrips and their stage of development were recorded as an index of antibiosis. Numerical ratings were given to the damage on each side of both leaflets as a measure of tolerance. The numerical damage scale used gradients of "1" to "8", in which "1" represented no damage, and "8" designated complete erosion of the entire leaf surface.

## Preference

Preference tests made use of a rotating cage which confined adult female thrips with single potted plants of peanut entries. Sixteen entries selected from field studies and laboratory studies on tolerance and antibiosis were tested.

Cage construction-Components of a preference cage are shown in Fig. 9. The cage walls were constructed by gluing the ends of a 20-mil cellulose nitrate sheet together to form a cylinder 3-ft. in diameter and 14 inches in height. The base of the cylinder was glued around the vertical protion of a 16-gauge metal cylinder, 1 inch tall and 3 ft. in diameter that had a ¼-inch flange turned at a right angle. This flange was used to connect the cage wall to a 1/8-inch masonite base. Small stove bolts fastened the flange to the base, and caulking compound was placed inside the cage at the junction of the cage wall and base to seal the seam.

Another metal ring like the one used at the wall base was placed inside the upper end of the cage. This ring was used to hold the cage

walls in a circular position and for attachment of the glass top. Caulking strips placed on the upper surface of the flanges sealed the glass top to the metal ring. This ring was not glued to the cage wall, which allowed the ring to adhere to the glass top when the cage was opened. This reduced movement of the cage during top removal, but the ring had to fit securely inside the cage to make the cage escape-proof.

The cage was centered on a 37-inch turntable that rotated 1/8 rpm. A 12-ft. section of a garden hose was split lenthwise and one of the halves was nailed around the outer edge of the turntable to serve as a pulley groove. A pulley belt, consisting of a small cord, connected the turntable to a 2-inch pulley on a 2-rpm electric motor; this served as the rotating mechanism. A 1¼-inch hole was drilled in the center of the turntable and cage base to allow air entry into the cage.

The bearing mechanism that permitted cage rotation and air entry into the cage consisted of a clutch throw-out bearing with a 1¼-inch shaft opening. A large metal washer was glued to the top of the outer race of the bearing and a 1¼-inch pipe union was glued to the bottom of the inner race of the bearing. The large metal washer was glued to the bottom of the turntable and the pipe union that was inserted through a piece of 1-inch white pine which was 12 inches square. This served as support for the turntable. Steel epoxy glue was used on all connections.

Air from a squirrel cage fan was forced into the cage through a 1¼-inch plastic pipe, which passed through the table top into the pipe union at the base of the bearing mechanism (Fig. 10).

The opening of the fan was covered with masonite which had openings drilled through it for the pipe connection. Air was expelled

from the cage through 16 equally spaced openings near the top of the cage. These openings were covered with finely woven cloth.

Testing Procedure. Single potted plants of 16 peanut entries were arranged in a 30-inch diameter circle within the cage. The metal ring at the top of the cage was placed inside the cage and caulking strips placed on the metal flange. Four hundred adult female thrips were released in a petri-dish placed on a 10-inch high platform in the middle of the cage. The thrips, which were counted in advance and placed in a plastic vial, were emptied into the petri-dish and the glass top quickly placed on the cage.

After two days the plants were removed from the cage and placed in 1-gallon Berlese funnels to determine the number of adults present on each variety. The Berlese funnels were heated by 60-watt light bulbs. Five minutes before removing the top of the cage, the air current into the cage was stopped.

Plants were left in the funnels for one hour. Thrips were collected in a vial containing 60% alcohol. Before removal of the vial, the funnels were sprayed with water to remove any remaining thrips. Samples were filtered and examined under the microscope to determine the number of adults present. This experiment was replicated six times.

## RESULTS AND DISCUSSION

In the tolerance tests the three least damaged entries, PI268741, PI268734 and PI268740, were significantly different from the two most damaged entries (Table 2). The average damage rating varied from 2.58 to 3.32.

In the antibiosis tests the entry that showed the greatest antibiosis, PI268649, was significantly different from the five entries that showed the least antibiosis (Table 3). The average recovery of thrips per variety varied from 5.14 for the variety with the greatest antibiosis to 19.14 for the entry showing the least antibiosis.

The preference tests showed significant differences between the two entries least prefered and the four most preferred entries (Table 4). The mean number of adult female thrips that were recovered varied from 10.50 to 24.33.

PI268661 and PI268740 were the least preferred entries in the preference test. PI268661 was rated as a resistant in field studies, but had the highest damage rating and lowest antibiosis rating in the laboratory tests, indicating that its mechanism of field resistance is nonpreference. PI268740, the second least preferred entry, sustained the least damage in the tolerance tests and was rated as average in the antibiosis tests, suggesting its field resistance was due to a combination of tolerance and nonpreference.

PI268648, the third least preferred entry, was rated as a susceptible in field tests. This entry was heavily damaged in the tolerance

tests, and an average level of antibiosis, suggesting that the plant was extremely sensitive to thrips damage, causing the plant to be rated as a susceptible under field conditions.

PI268282, the fourth least preferred entry in the preference tests, suffered a high level of damage in the tolerance test and showed a low level of antibiosis in this type of test indicating its field resistance was due to nonpreference.

PI268804, the sixth least preferred entry, had a damage rating in the tolerance test that was above average. The mean number of surviving thrips of 8.14 in the antibiosis test was low, suggesting that antibiosis and perhaps nonpreference were resistance factors.

PI268777 was significantly more attractive for oviposition than all other entries in the preference test and it also had a high level of damage in the tolerance tests. The antibiosis level of this entry was relatively high with 8.85 thrips surviving the test period, indicating antibiosis was an important factor in its field resistance.

PI268554, the second most preferred entry, received only moderate damage in the tolerance tests and showed the lowest level of antibiosis. It was classed as a susceptible in the field tests. It would appear that the high level of damage received under field conditions resulted from abnormally high populations due to attractiveness and to a high level of thrips survival.

PI868734, the sixth most preferred entry, was the third least damaged entry in the tolerance test and had a high level of antibiosis. Its classification as a resistant in field tests apparently resulted from a combination of tolerance and antibiosis.

Starr, the common check variety in all laboratory and field studies, was the fifth most preferred variety in the preference tests. It received a low damage rating in tolerance tests and had a relatively high level of antibiosis, indicating that the field resistance of this important commercial variety is due to a combination of tolerance and antibiosis.

## SUMMARY

Tests which measured the tolerance and antibiosis of a peanut entry were conducted by confining 30 thrips larvae on a caged peanut leaf for one week. After one week, the cages were removed and the number of live thrips recorded as an index of antibiosis. Numerical ratings were given the damage on each leaflet as a measure of tolerance.

Preference tests made use of a rotating cage that confined 400 adult female thrips with single potted plants of 16 peanut entries. After two days, the plants were removed from the cage and placed in Berlese funnels to determine the number of thrips present.

Results from the resistance studies indicate that all three factors of resistance play an important part in peanuts' resistance to thrips.

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# APPENDIX A

Table 1. - The daily egg production of tobacco thrips from four different environmental conditions.

| Source of thrips | Thrips tested | Total progeny | Average egg production |
|---|---|---|---|
| Artificial diet | 4,359 | 12,923 | 2.96 |
| Caged peanut leaves | 471 | 1,324 | 2.81 |
| Continuous culture cage | 3,302 | 6,306 | 1.91 |
| Field collected | 1,637 | 4,012 | 2.45 |

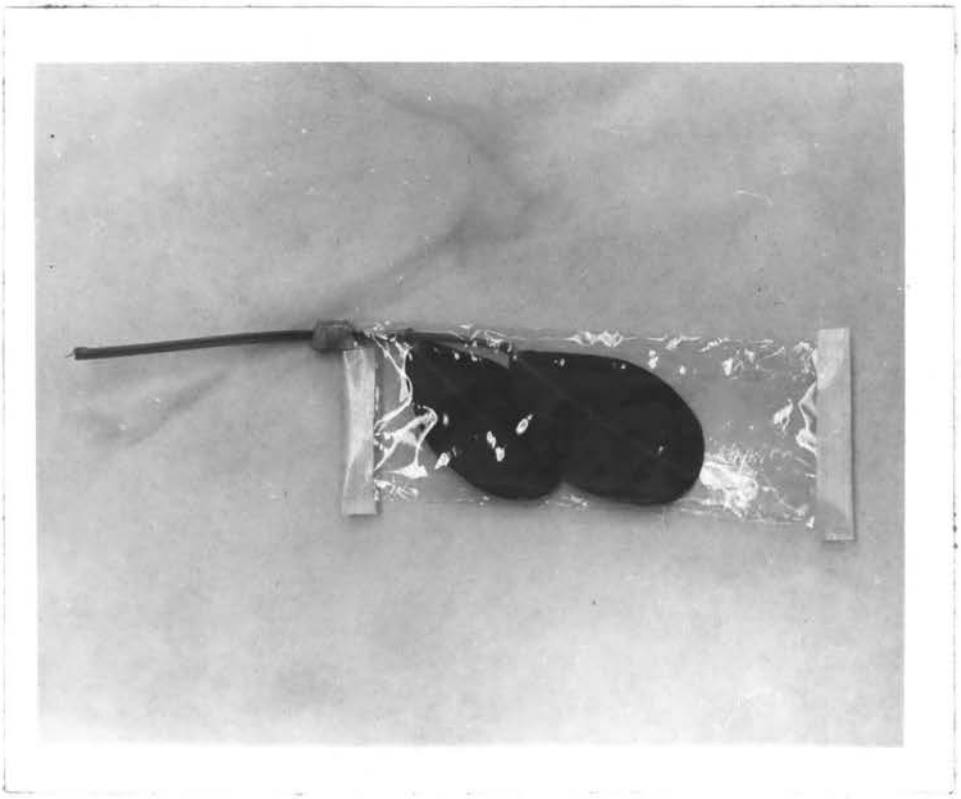

Fig. 1. Oviposition cage.

Fig. 2. One month old peanut plant with three oviposition cages in place.

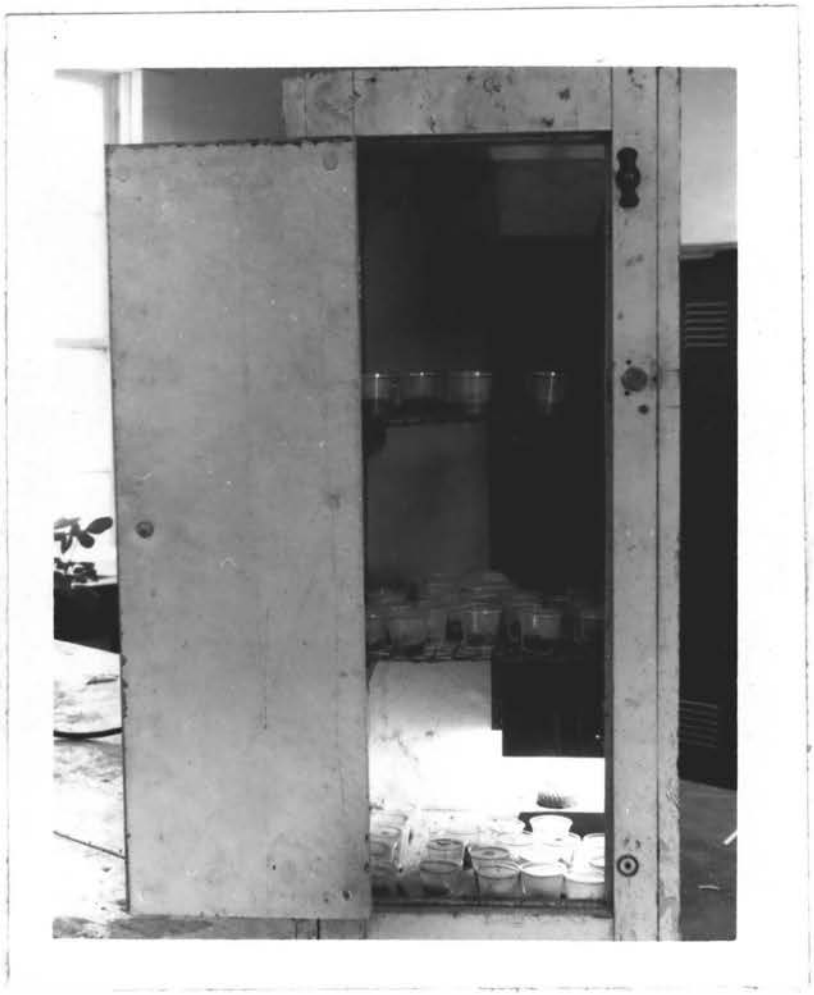

Fig. 3. Cabinet used to maintain larval culture.

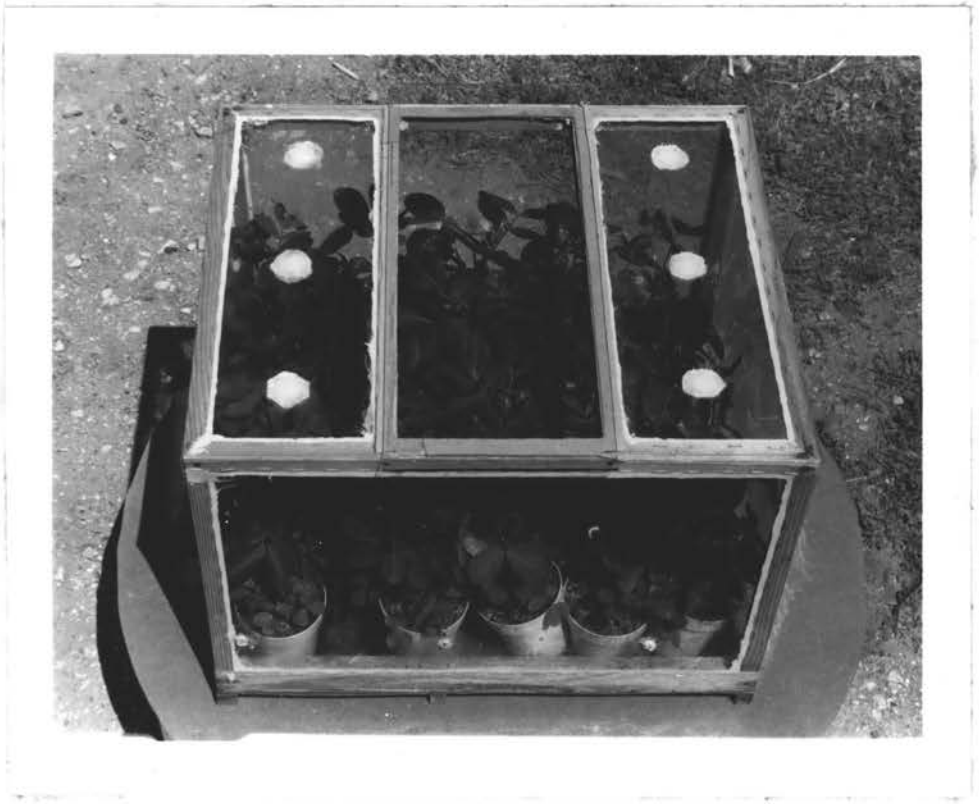

Fig. 4. Cage used to maintain continuous culture of thrips.

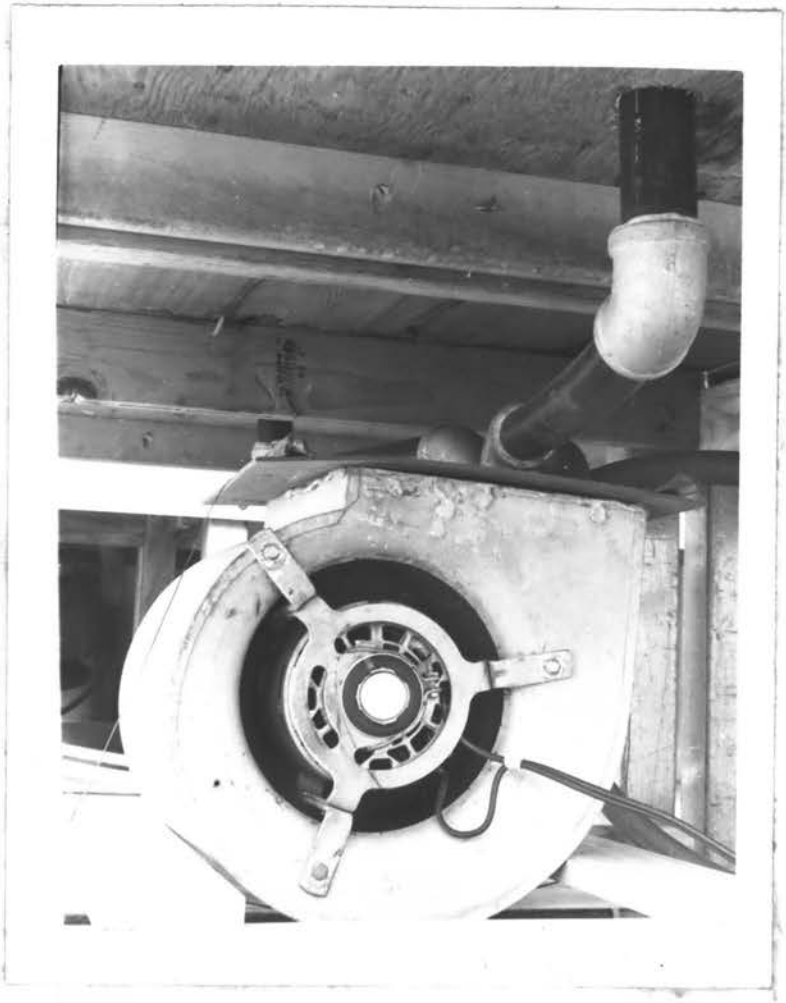

Fig. 5. Squirrel cage fan used to supply air to continuous culture cage.

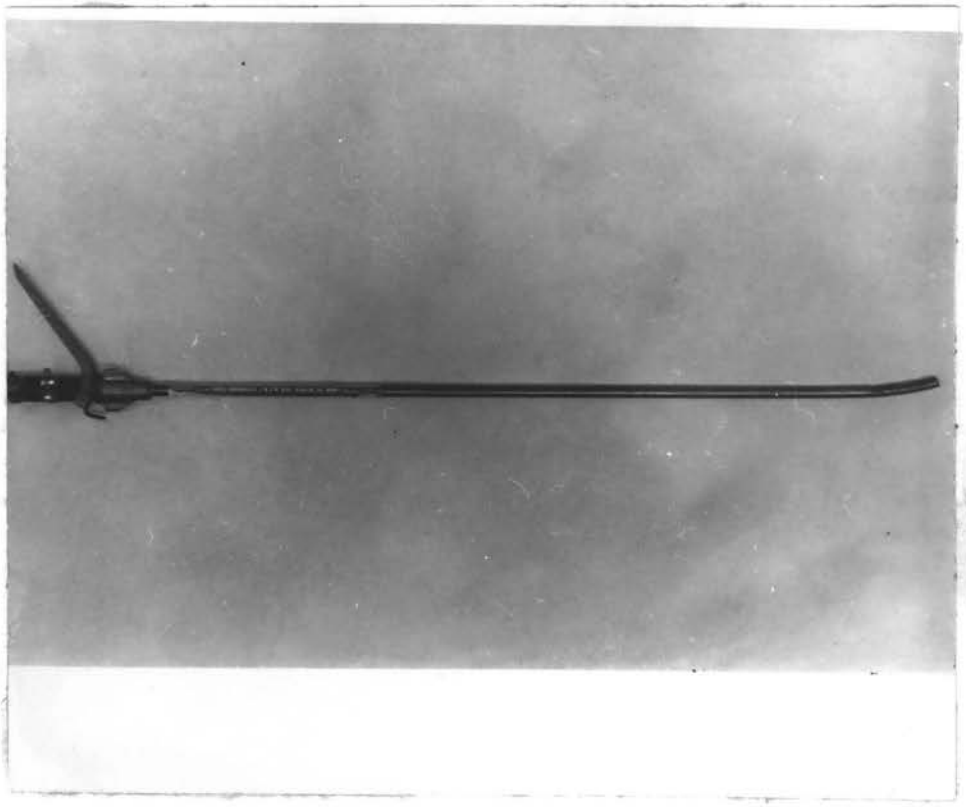

Fig. 6. Watering device used in this study.

# APPENDIX B

Table 2. - Damage ratings in tolerance tests on peanut entries in the growth chamber, 1967.

| P.I. No.[a] | Rank | Mean | 5% level[b] | P.I. No. | Rank | Mean | 5% level |
|---|---|---|---|---|---|---|---|
| 268740 | 1 | 2.58 | a | 270857 | 31 | 2.92 | abc |
| 268741 | 2 | 2.59 | a | 259834 | 32 | 2.94 | abc |
| 868734 | 3 | 2.60 | a | 268654 | 33 | 2.94 | abc |
| 268678 | 4 | 2.62 | ab | 268598 | 34 | 2.96 | abc |
| 268796 | 5 | 2.63 | ab | St.Sp.[c] | 35 | 2.98 | abc |
| 268726 | 6 | 2.64 | abc | 268724 | 36 | 2.98 | abc |
| 268767 | 7 | 2.65 | abc | 259753 | 37 | 2.99 | abc |
| Starr | 8 | 2.69 | abc | 270857 | 38 | 3.00 | abc |
| 161300 | 9 | 2.69 | abc | 268597 | 39 | 3.01 | abc |
| 259800 | 10 | 2.69 | abc | 268804 | 40 | 3.01 | abc |
| 299469 | 11 | 2.71 | abc | 268746 | 41 | 3.01 | abc |
| 268795 | 12 | 2.73 | abc | 268787 | 42 | 3.02 | abc |
| 278708 | 13 | 2.73 | abc | 262000 | 43 | 3.03 | abc |
| 274267 | 14 | 2.73 | abc | 158838 | 44 | 3.05 | abc |
| 248762 | 15 | 2.73 | abc | 268764 | 45 | 3.07 | abc |
| 259771 | 16 | 2.74 | abc | 268721 | 46 | 3.08 | abc |
| Argentine | 17 | 2.74 | abc | 259860 | 47 | 3.09 | abc |
| 268725 | 18 | 2.74 | abc | 268791 | 48 | 3.10 | abc |
| 268729 | 19 | 2.75 | abc | 268773 | 49 | 3.12 | abc |
| 268706 | 20 | 2.76 | abc | 268777 | 50 | 3.12 | abc |
| 268790 | 21 | 2.76 | abc | 268708 | 51 | 3.14 | abc |
| 268711 | 22 | 2.80 | abc | 141345 | 52 | 3.14 | abc |
| 234420 | 23 | 2.82 | abc | 268643 | 53 | 3.14 | abc |
| 268823 | 24 | 2.82 | abc | 268802 | 54 | 3.14 | abc |
| 221708 | 25 | 2.82 | abc | 259775 | 55 | 3.17 | abc |
| 268710 | 26 | 2.85 | abc | 268782 | 36 | 3.18 | abc |
| 155053 | 27 | 2.86 | abc | 268769 | 57 | 3.19 | abc |
| 268633 | 28 | 2.89 | abc | 268634 | 58 | 3.23 | abc |
| 161868 | 29 | 2.89 | abc | 268778 | 59 | 3.24 | abc |
| 268716 | 30 | 2.90 | abc | 290599 | 60 | 3.30 | bc |
| | | | | 268661 | 61 | 3.32 | c |

[a] Plant introduction numbers.

[b] Means not followed by the same letter differ significantly at the 5% level (Duncan's new multiple range test).

[c] Stratford Spanish.

Table 3. - Number of thrips surviving on peanut entries in antibiosis test, 1967.

| P.I. No.[a] | Rank | Mean | 5% level[b] | P.I. No. | Rank | Mean | 5% level |
|---|---|---|---|---|---|---|---|
| 268654 | 1 | 5.14 | a | 145045 | 31 | 11.42 | abcde |
| Argentine | 2 | 5.71 | ab | 268716 | 32 | 11.71 | abcde |
| 268706 | 3 | 6.42 | abc | 268710 | 33 | 11.85 | abcde |
| 268734 | 4 | 6.57 | abc | 299469 | 34 | 12.14 | abcde |
| 268796 | 5 | 6.85 | abc | 299469 | 35 | 12.14 | abcde |
| 221408 | 6 | 6.85 | abc | 268823 | 36 | 12.28 | abcde |
| 268767 | 7 | 7.42 | abc | 268648 | 37 | 12.28 | abcde |
| 268678 | 8 | 7.71 | abc | 145045 | 38 | 12.28 | abcde |
| 268804 | 9 | 8.14 | abc | 259800 | 39 | 12.42 | abcde |
| 274267 | 10 | 8.85 | abcd | 270857 | 40 | 12.85 | abcde |
| 268777 | 11 | 8.85 | abcd | 270857 | 41 | 13.00 | abcde |
| 268769 | 12 | 9.00 | abcd | 268787 | 42 | 13.00 | abcde |
| 268596 | 13 | 9.28 | abcd | 155053 | 43 | 13.00 | abcde |
| Starr | 14 | 9.71 | abcd | St.Sp. | 44 | 13.14 | abcde |
| 161868 | 15 | 9.71 | abcd | 268708 | 45 | 13.14 | abcde |
| 268725 | 16 | 9.85 | abcd | 268740 | 46 | 13.14 | abcde |
| 268726 | 17 | 10.14 | abcde | 268711 | 47 | 13.28 | abcde |
| 268778 | 18 | 10.14 | abcde | 268862 | 48 | 13.28 | abcde |
| 268795 | 19 | 10.14 | abcde | 234420 | 49 | 13.42 | abcde |
| 268746 | 20 | 10.28 | abcde | 259860 | 50 | 13.75 | abcde |
| 268597 | 21 | 10.42 | abcde | 268724 | 51 | 13.85 | abcde |
| 262000 | 22 | 10.42 | abcde | 250599 | 52 | 13.85 | abcde |
| 268741 | 23 | 10.71 | abcde | 268790 | 53 | 14.14 | abcde |
| 268773 | 24 | 10.85 | abcde | 268764 | 54 | 14.14 | abcde |
| 259834 | 25 | 11.00 | abcde | 268782 | 55 | 14.42 | bcde |
| 248762 | 26 | 11.14 | abcde | 259753 | 56 | 14.57 | bcde |
| 259771 | 27 | 11.28 | abcde | 268721 | 57 | 15.14 | cde |
| 268633 | 28 | 11.28 | abcde | 268729 | 58 | 15.42 | cde |
| 161300 | 29 | 11.42 | abcde | 268654 | 49 | 15.57 | de |
| 268791 | 30 | 11.42 | abcde | 268706 | 60 | 19.14 | e |
| | | | | 268661 | 61 | 19.14 | e |

[a] Plant introduction numbers.

[b] Means not followed by the same letter differ significantly at the 5% level (Duncan's new multiple range test).

[c] Stratford Spanish.

Table 4. - Number of adult female thrips recovered from peanut entries in the preference test, 1968.

| P.I. No.[2] | Rank | Mean | 5% level[b] |
|---|---|---|---|
| 268661 | 1 | 10.50 | a |
| 268740 | 2 | 10.50 | a |
| 268648 | 3 | 10.83 | ab |
| 259745 | 4 | 10.83 | ab |
| 155053 | 5 | 11.00 | ab |
| 268804 | 6 | 12.00 | abc |
| 268683 | 7 | 12.00 | abc |
| Argentine | 8 | 12.66 | abc |
| 259594 | 9 | 12.66 | abc |
| 268760 | 10 | 12.83 | abc |
| 868734 | 11 | 12.83 | abc |
| Starr | 12 | 13.00 | abc |
| 268232 | 13 | 14.00 | c |
| 268794 | 14 | 15.33 | cd |
| 268654 | 15 | 17.50 | d |
| 268777 | 16 | 24.33 | e |

[a] Plant introduction numbers.

[b] Means not followed by the same letter differ significantly at the 5% level (Duncan's multiple range test).

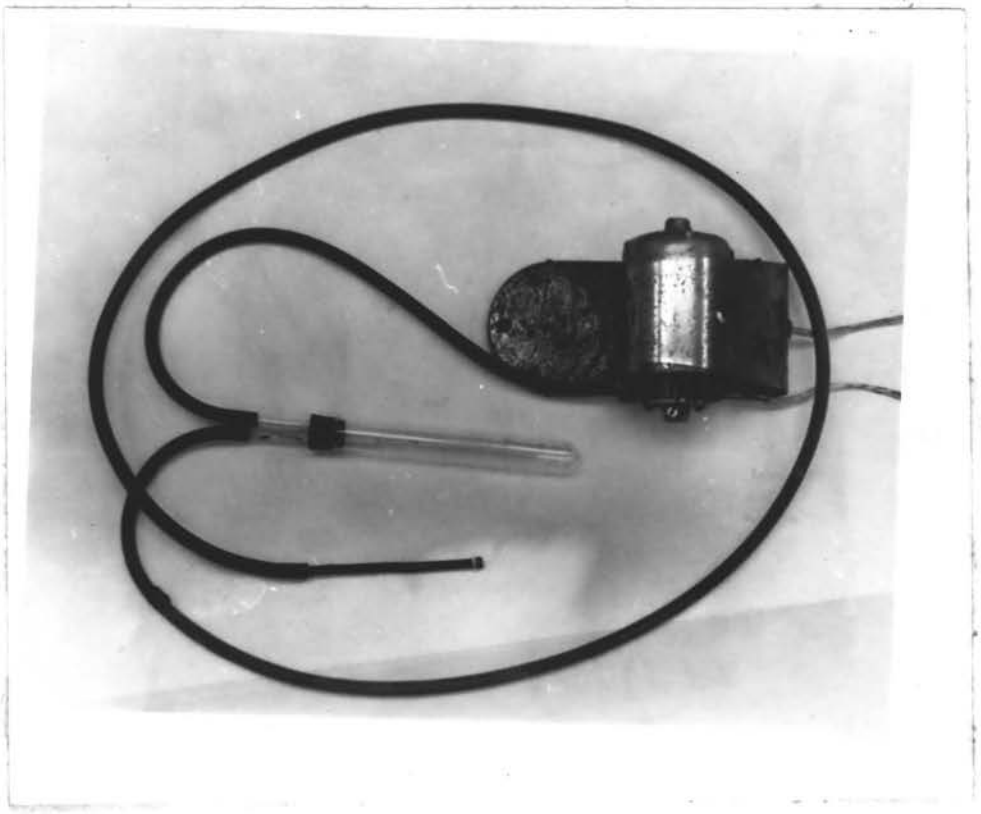

Fig. 7. Vacuum aspirator used to manipulate larvae.

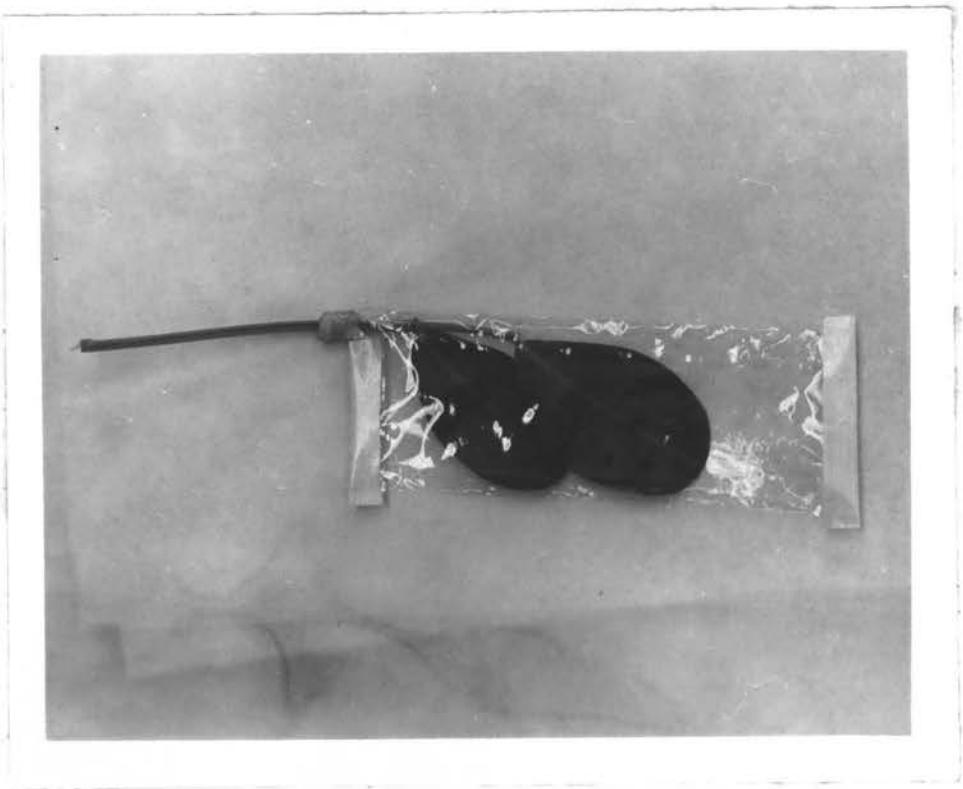

Fig. 8. Leaf cage used to test for tolerance and antibiosis.

Fig. 9. Rotating cage used to test for nonpreference.

Fig. 10. Squirrel cage fan used to supply air to preference cage.

VITA

Richard Evans Kinzer

Candidate for the Degree of

Master of Science

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