duplicate

BULLETIN 381 **SEPTEMBER 1968**

The PICKLEWORM: Its CONTROL On CUCURBITS In ALABAMA

AGRICULTURAL EXPERIMENT STATION
AUBURN UNIVERSITY
E. V. Smith, *Director* Auburn, Alabama

CONTENTS

PHOTO CREDITS. Figures 1A, 1B, and 1C were supplied by Dupree et al *(3),* University of Georgia Agricultural Experiment Station. Other photos supplied by the authors.

FIRST PRINTING 3M, SEPTEMBER 1968

The PICKLEWORM:
Its CONTROL on CUCURBITS in ALABAMA

T. DON CANERDAY, *Assistant Professor of Entomology-Zoology**

JAMES D. DILBECK, *Graduate Assistant of Entomology-Zoology*

INTRODUCTION

THE PICKLEWORM, *Diaphania nitidalis* (Stoll), is the most destructive insect pest of cucurbits in Alabama. This insect regularly causes serious damage in the South Atlantic and Gulf States and occasionally as far west as Oklahoma and Nebraska and as far north as Iowa and Connecticut. It has also been reported from Canada, Puerto Rico, Panama, Brazil, Colombia, French Guiana, and Peru *(3)*.

Cantaloupe, cucumber, and summer squash are primary host plants of the pickleworm in Alabama. Maximum yields of these crops in summer and fall are deterred by the pickleworm. Gourds, pumpkins, and watermelons are also occasionally attacked. The larva reduces plant vigor and destroys market value of the crop by feeding on buds, flowers, vines, stalks, and fruits.

Walsh and Riley *(8)* gave the first account of pickleworm injury in the United States in 1869. Investigations on the insect were begun in 1899 by Quaintance (1901) in Georgia. A number of entomologists have since reported on the pickleworm and its control. The most recent comprehensive account was by Dupree *et al. (3)*.

---

* Resigned.

Investigations directed primarily at control of the pickleworm were conducted in Alabama during the period 1964-67. These investigations also included observations on life history and field experiments with insecticides and other control measures. In addition to personal observations, the authors have drawn from the reports of Dupree *et al.* *(3)* and Reid and Cuthbert *(7)* certain observations on life history of the pickleworm.

Life History

Egg: The pickleworm adult deposits eggs singly or in small groups on leaves, stems, flowers, or buds of the host plant. The small, irregularly-shaped eggs, Figure 1A, are pale-yellow, resem-

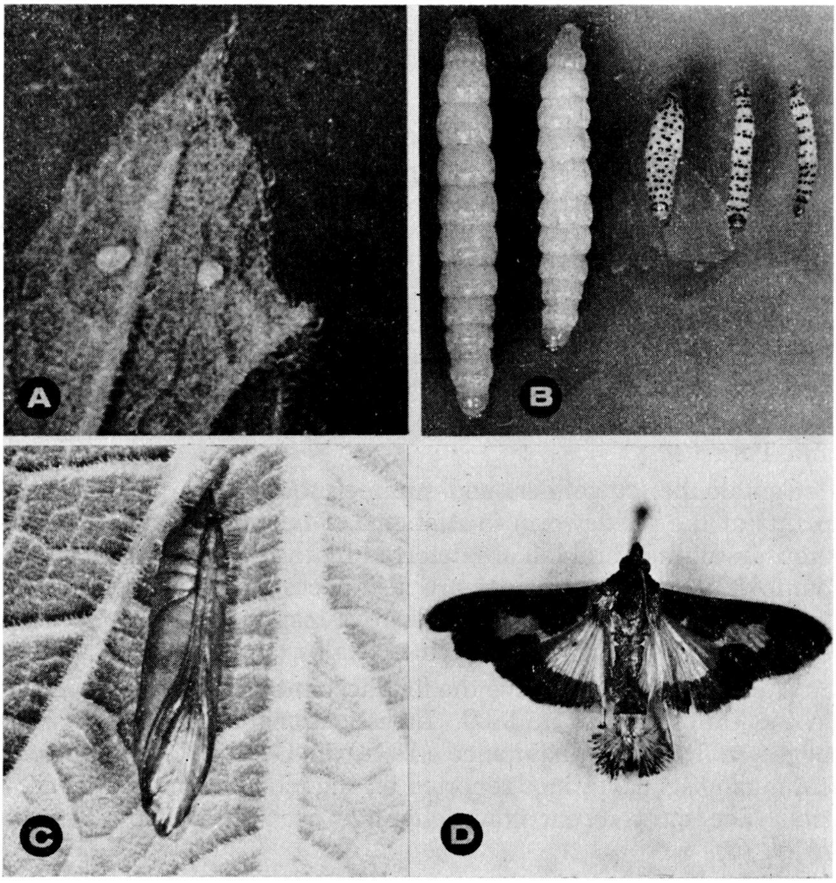


FIGURE 1. Life stages of the pickleworm: A. egg; B. larva; C. pupa; D. adult.

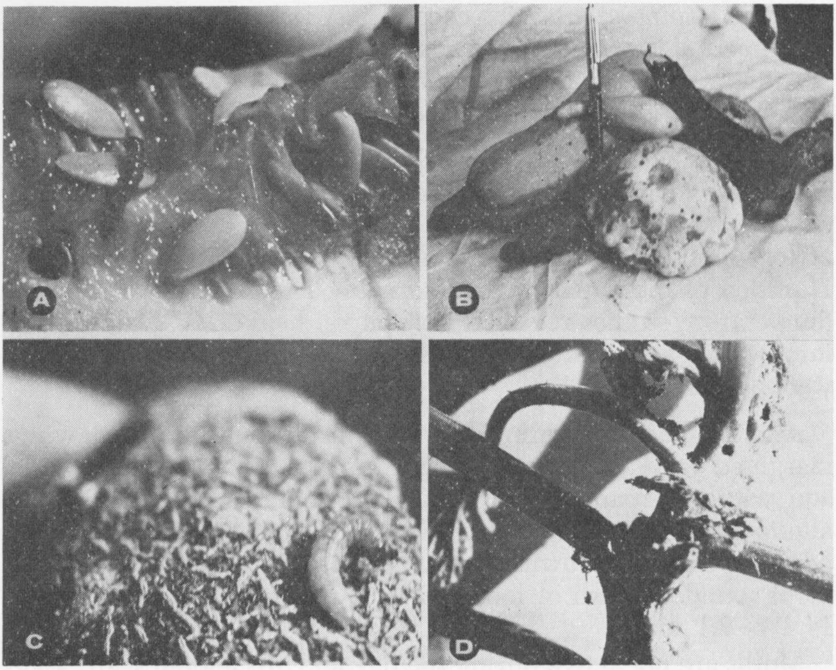


FIGURE 2. Pickleworm damage: A. young larva feeding in fruit; B. injury to mature squash fruit; C. pickleworm feeding into cantaloupe; D. injury to squash plant.

ble a grain of sand, and are often difficult to see. Eggs are most readily seen among the hairs on the lower surface of leaves. The eggs normally hatch in 3 to 4 days.

Larva: The newly hatched larva is cream-colored with long white hairs on several segments of the body. Soon after eclosion, reddish-brown spots appear on the body and remain through the fourth instar. Each abdominal segment has six of these spots. The fifth instar is uniformly green or coppery with no spots on the body, Figure 1B. Larvae feed first in the buds, blossoms, and tender terminals and some may complete development in the vegetative part of the plant. In most instances, larvae soon find their way to the fruits. Several fruits may be damaged by a single caterpillar and several larvae may be found in a single fruit, especially when populations are high. Pickleworm damage is shown in Figure 2.

At cessation of feeding, the larva assumes a pink to pale green color and spins a thin silk cocoon just prior to pupation. The larval period is passed in 10 days to 2 weeks.

Attempts were made to rear field-collected larvae in the laboratory on a variety of artificial media with no success even when extracts of the natural host were incorporated into the diet.

Pupa: Pupation generally takes place on the leaf of the host plant. The brown pupa, Figure 1C, is frequently found in a roll of leaf of the host plant supported by the thin web or cocoon. Duration of the pupal stage is normally 7 to 10 days. Controlled temperature studies revealed that pupae held at 60°F developed into normal adults in 4 to 6 weeks but temperatures below 50°F were lethal.

Adult: The pickleworm adult is a conspicuous moth with wings margined with a band of yellowish-brown, about ⅛ inch wide, and with transparent yellowish-white centers, Figure 1D. The adults are strong fliers with a wing span of 28.8 ± 1.77 mm. The body is yellowish-brown and the tip of the abdomen has a prominent rounded brush of long hair-like structures. Body length is 14.4 ± 2.1 mm.

Moths are not active during the day and are seldom seen. Eggs are deposited at night. The moths apparently are not attracted to light. Only rarely were moths collected in a black-light trap operated nightly for a 3-year period at Auburn.

Attempts to obtain eggs from adults in the laboratory were unsuccessful unless the natural host plant was used as a substrate for oviposition.

Total Life Cycle: The life cycle from egg to adult varies according to environmental conditions, being completed in 22-55 days. Several overlapping generations of the pickleworm occur each year in the South. It is estimated that four generations normally occur in Alabama.

Apparently the pickleworm does not hibernate in any form and is able to survive the winter only in subtropical areas where suitable hosts are available. Fulton *(4)* reported that the insect did not overwinter in North Carolina, and attempts to overwinter this insect in Georgia were unsuccessful *(3)*. No evidence was found during Auburn studies to suggest that the pickleworm overwintered in Alabama.

Records from South Florida show this insect to be active on wild and cultivated host plants throughout the winter. It appears that the pickleworm is a subtropical insect, migrating north when environmental conditions become favorable. The first generation or brood of larvae in Alabama generally appears in June in small numbers and seldom causes serious damage.

CONTROL METHODS EVALUATED

Many destructive insects are often kept below the economic-injury level by natural enemies, i.e., predators, parasites, and pathogens. Natural enemies appear to be of no significant benefit in suppressing pickleworm populations; consequently, populations usually increase rapidly and often destroy the crop if no control measures are applied.

Experiments were conducted on the outlying units of the Auburn University Agricultural Experiment Station System at Belle Mina, Clanton, Cullman, and Headland from 1964 to 1967 to evaluate various means of controlling pickleworms on cucurbits. Studies were made to determine the influence of planting date on pickleworm damage. Experiments were conducted to determine the most effective means of chemical control, and varieties of squash and cantaloupe were evaluated for resistance to the pickleworm.

Planting Dates

Because of the migratory nature of the pickleworm, damage to cucurbits always increases during late summer and fall. Experiments were conducted in 1965-67 to determine the influence of planting date on pickleworm injury to squash.

Plantings of Early Summer Crookneck squash, *Cucurbita pepo,*

TABLE 1. INFLUENCE OF PLANTING DATE ON PICKLEWORM DAMAGE TO SUMMER CROOKNECK SQUASH, ALABAMA, 1965-67

Planting date	Pickleworm infested fruit[1]	
	Cullman	Clanton
	Pct.	*Pct.*
April 1-15	3.3	----
May 1	2.0	----
June 1-15	13.4	16.4
June 15-30	28.8	50.0
July 1-15	55.1	51.6
July 15-30	80.3	----
August 1-15	59.1	81.4

[1] Data shown are means of approximately 4,600 squash examined during the course of this study.

were made at approximately 2-week intervals from April to August at Clanton and Cullman. Ten to 45 hills were field-seeded on these dates and the stand thinned to two plants per hill. Squash were harvested weekly from June to mid-October and examined for pickleworm injury.

Results of these experiments are summarized in Table 1 and Figure 3. Squash planted prior to June escaped serious pickleworm injury, whereas, plantings made after June 15 sustained heavy damage. Squash crops planted after July 1 were destroyed by pickleworms.

As shown in Figure 3, pickleworm damage was first encountered about mid-June and tended to increase rapidly thereafter. Pickleworm-damaged squash ranged from 50 to 93 per cent from mid-August to early October. During this period of heavy infestations plants were often destroyed by pickleworms.

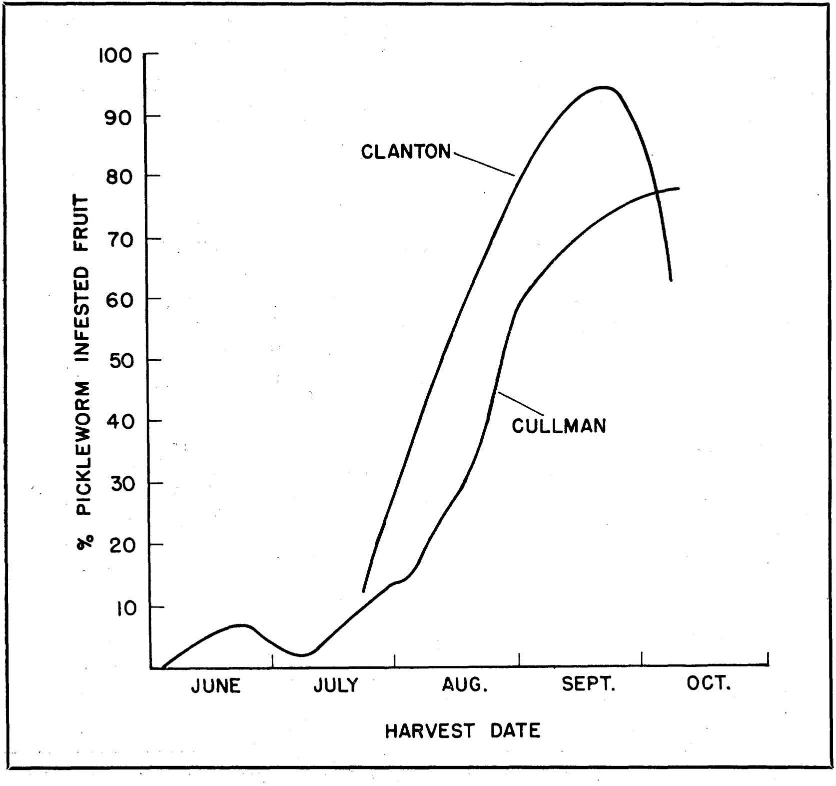


FIGURE 3. Influence of planting date on pickleworm damage.

These data indicate that squash planted during the spring in northern and central Alabama will largely escape pickleworm damage. However, profitable production of cucurbits planted during the summer and fall will be impractical unless effective control measures are employed.

Insecticides

The tendency for pickleworm larvae to move from leaf and flower buds where most of the eggs are laid provides an opportunity to control the insect with an insecticide before they begin tunneling in fruits. Insecticides were first used to control pickleworms in experiments in 1901 *(6)*, and a number of workers have since reported on pickleworm control with insecticides. In recent years, however, little work has been reported on the effectiveness of newer insecticides against the pickleworm.

Several conventional and systemic insecticides were evaluated for control of pickleworm on squash, cantaloupes, or cucumber from 1964 to 1966. Also, plant response to repeated insecticidal applications was measured.

For insecticide evaluations, all crops were field-seeded in June or July. These planting dates were used to encourage a pickleworm infestation on the crops. Early Sumer Crookneck squash, Hales Best Jumbo cantaloupe, and Boston Pickling cucumber varieties were used. Plot size varied among the experiments from 1 to 3 rows, 25 feet long. A randomized complete block design was used, and plots were replicated at least four times in all experiments. Each crop was planted to a stand and thinned to two plants per hill. Approximately 40 gallons of finished spray material were applied per acre with a knapsack sprayer. Treatments on squash were initiated at bloom in most experiments, and the first application to cantaloupes and cucumbers was made at early fruit-set. Insecticides were applied weekly. Three to six applications were made in each test. A fungicide, maneb, was added to most insecticides tested on cantaloupes and cucumbers. Additionally, dinocap and Morestan were used for mildew control in 1965 and 1966, respectively. Two other fungicides, Difolatan and Dyrene, were tested for effectiveness against the pickleworm on cantaloupes in 1966.

Fruits were harvested at 3- to 7-day intervals and examined for pickleworm injury as a measure of insecticidal effectiveness. The center row in each plot was used as the data row when three-row plots were used. Squash were harvested at bloom-drop, cantaloupes at half-slip, and cucumbers when they reached marketable size.

Several systemic insecticides applied as seed treatments were tested for pickleworm control on squash. The insecticides were suspended in adequate water to coat the seed and pylac was added to make a 5 per cent suspension. Seed were placed in a container, coated, and allowed to dry. Those receiving no insecticide were treated with the solvent. Seed were treated approximately 6 hours before planting and the seeding rate was 6 pounds per acre. Sidedress treatments were applied just prior to bloom. Stand counts were made weekly after planting and insecticidal effectiveness was evaluated as previously described.

An experiment was conducted at Cullman in 1964 to assess the monetary value of pickleworm control on Summer Crookneck squash. This planting was made August 4 and an attempt was made to ensure maximum production by maintaining high soil fertility and optimum soil moisture with periodic irrigation. Other procedures were as prevously described except squash were weighed and graded to meet U.S. No. 1 standards. Marketable squash were sold on the Birmingham market for $2 per 12-quart basket after shipping cost. Average weight of these 12-quart baskets and the market price were used as the base in converting plot yield to number of baskets per acre and in calculating per acre value.

Experiments were also conducted to determine the effect of recommended and accelerated rates of insecticides on yield of squash and cantaloupe. For these tests, spring plantings were generally used in an attempt to escape pickleworm damage. Procedures followed with cantaloupes were generally the same as previously described. Treatments were initiated at first bloom and applied every 3 to 6 days. Ten applications were made.

Both dust and spray formulations were tested on squash. Dusts were applied with a hand-operated rotary duster. Each 10-foot plot was covered with a polyethylene cage during treatment to eliminate drift. Plots were dusted four times. Spray treatments were initiated at bloom and applied during a 4-week period. Some treatments were applied daily for 20 successive days during the major fruiting period. Plots receiving daily applications were treated at 7 a.m. or 5 p.m. depending on treatment schedule.

Summarized results of insecticide evaluations for pickleworm control on squash are presented in Table 2. Pickleworm damage in the untreated check plots in these 5 experiments ranged from 22.5 to 75 per cent. Most insecticides applied as foliar sprays afforded a high degree of protection in each experiment. In addition to the recommended insecticides – carbaryl, lindane, and parathion – the candidate materials found to be highly effective against the pickleworm included endosulfan at 1 pound per acre, GC 6506 at 0.5 pound per acre, and GS 13005 at 1 pound per acre. Other materials tested significantly reduced pickleworm injury in most experiments but were not usually as effective as the materials just mentioned, Table 2. Results indicate that three to six applications of an effective insecticide applied at weekly intervals, beginning at bloom, will ensure pickleworm control on squash.

TABLE 2. EFFECTIVENESS OF SEVERAL INSECTICIDES FOR PICKLEWORM CONTROL ON CROOKNECK SQUASH, CULLMAN AND CLANTON, ALABAMA, 1964-1966

Treatment	Active per acre	Fruit damaged by pickleworms[1]				
		Experiment				
		No. 1	No. 2	No. 3	No. 4	No. 5
	Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Carbaryl	4.0	0.6ab				
Carbaryl	2.0	0.0a	6.0a	5.1ab		
Carbaryl	1.0	1.8a-c				4.8a
Parathion	0.5	3.8bc				
GS 13005	1.0			4.7a	6.1ab	3.4a
GS 13005	0.5			6.7a-c		
GC 6506	0.5			5.2ab	2.0a	4.5a
TDE	1.0				11.3a-c	
Lindane	0.25			4.7a	20.9bc	
Malathion	1.5	5.9c	39.0b		24.1bc	
ACy. EIC	1.0			12.6bc		
ACy. EIC	0.5			13.4bc	25.2bc	
Diazinon®	1.0			13.9bc	31.0c	
Naled	1.0			15.7cd		
Naled	0.5			23.4de		
Endosulfan	1.0					4.5a
Endosulfan	0.5			26.8de		
Thuricide 90T®	1 qt.					13.9a
Untreated check	0	22.5d	75.0c	31.5e	63.1d	54.2b

[1] Means that share a common letter do not differ significantly at the 0.05 level by Duncan's test.

As shown in Table 3, none of the insecticides applied as seed treatments significantly reduced pickleworm injury to squash. Seed treatment with Hercules 13462 and dimethoate at indicated rates adversely affected stand establishment. Other seed treatments appeared to have no adverse effect. Plots treated with NIA-10242 as a foliar or granular sidedressing yielded significantly

TABLE 3. EFFECTIVENESS OF INSECTICIDES APPLIED AS SEED TREATMENTS FOR PICKLEWORM CONTROL ON SQUASH, CLANTON, ALABAMA, 1966

Material	Method of treatment	Active per acre	Squash examined	Damaged by pickleworms[1]
		Lb.	*No.*	*Pct.*
Nia. 10242	foliar	0.5	149	9.5a
Nia. 10242	seed & sidedress	0.25 + 2.0G[2]	174	22.4ab
Nia. 10242	sidedress	2.0G[2]	193	23.4a-c
Azodrin	seed	0.50	141	38.7b-d
Nia. 10242	seed	0.25	194	40.1d
Cygon 267®	seed	0.25	77	48.2d
Untreated	--------	----	152	50.6d
Her. 13462	seed	0.10	99	53.8d
Azodrin®	seed	0.25	153	55.5d
Her. 13462	seed	0.25	11	45.5d

[1] Means followed by the same letter do not differ significantly at the 0.05 level by Duncan's test.

[2] Granular formulation.

fewer damaged squash than the untreated check. The foliar treatment was not begun until after the first harvest and most of the damage recorded occurred prior to treatment. It appeared that NIA-10242 as a granular sidedressing was translocated in sufficient quantity to afford some control, but none of the seed treatments was effective as a means of pickleworm control.

Pickleworm damage to untreated cantaloupes was severe in all

TABLE 4. EFFECTIVENESS OF VARIOUS INSECTICIDES AND FUNGICIDES FOR PICKLEWORM CONTROL ON CANTALOUPES, CULLMAN AND CLANTON, ALABAMA, 1964-1966

Treatment	Active per acre	Pickleworm damaged melons[1]		
		1964	1965	1966
	Lb.	*Pct.*	*Pct.*	*Pct.*
Carbaryl + fungicide	4.0	0.0a	----	----
Carbaryl + fungicide	2.0	0.0a	----	----
Carbaryl + fungicide	1.0	0.0a	8.7a	6.4
Carbaryl	1.0	4.6a	----	6.2
Lindane + fungicide	0.25	7.6a	8.4a	0.0
Lindane	0.25	2.1a	----	0.0
GS 13005 + fungicide	1.0	----	9.0a	----
Fungicide	----[2]	27.0b	74.4b	35.7
Difolitan®	2.0	----	----	30.8
Dyrene®	2.0	----	----	38.9
Maneb + Morestan®	1.6 + 0.25	----	----	52.5
Untreated check	0	77.6c	100.0b	93.3

[1] Means that share a common letter do not differ significantly at the 0.01 level by Duncan's test. Sample size in 1966 considered inadequate for analysis.

[2] The fungicide was Maneb 1.6 lb/acre; Karathane and Morostan, 0.25 lb/acre, was added in 1965 and 1966, respectively.

experiments, Table 4. A plot of cantaloupes treated with an effective insecticide is compared with one receiving no treatment in Figure 4. Pickleworm damage tended to be lighter in plots treated with a fungicide, and this treatment resulted in a highly significant reduction in pickleworm damage in 1964. Several fungicides tested for pickleworm control in 1966 appeared to reduce the percentage of damaged melons, but yields from this experiment were quite low and melons failed to reach maturity because of a severe epiphytotic in all plots.

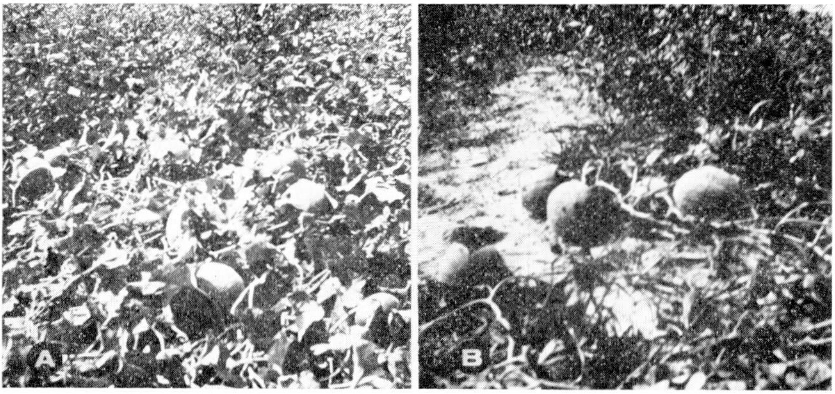


FIGURE 4. Cantaloupe field (A) treated for pickleworm control compared to untreated check plot (B) shows extent of damage the insect causes.

All materials tested, including the fungicide check, resulted in a highly significant degree of pickleworm control on cucumbers, Table 5. Light to moderate phytotoxicity was noted on cucumbers treated with American Cyanamid EIC. Pickleworm damage was not heavy in these experiments, and the lack of damage was apparently because of a preference for squash that were grown adjacent to the cucumber test both years.

A significant gross monetary gain of $274 to $421 per acre was realized from pickleworm control on squash, Table 6. This is especially significant because the damage in the check was not heavy compared to most experiments. These data serve to demonstrate the insect's economic importance and value of adequate control.

Results of experiments designed to measure effect of insecticides on plant growth revealed no apparent adverse effect on squash and cantaloupes. No plant inhibition was noted on can-

TABLE 5. EFFECTIVENESS OF VARIOUS INSECTICIDES FOR PICKLEWORM CONTROL ON CUCUMBERS, CULLMAN, ALABAMA, 1965-1966

Treatment	Active per acre	Pickleworm damage[1]	
		1965	1966
	Lb.	*Pct.*	*Pct.*
Lindane	0.25	0.0a	0.0a
ACy-EIC	1.0	0.0a	----
Endosulfan	0.5	0.0a	----
GC 6506	0.5	----	0.0a
Thuricide 90TS®	2 qts.	----	0.0a
Malathion	1.5	0.0a	0.24a
Carbaryl	1.0	0.3a	2.65a
GS 13005	1.0	0.4a	1.85a
Fungicide check	----[2]	----	2.85a
Untreated	0	5.1b	17.25b

[1] Means that share a common letter do not differ significantly at the 0.01 level by Duncan's test.

[2] The fungicide check received Maneb and Morostan 2.0 and 0.25 lb/acre. In 1966 insecticides applied with Maneb and Karathane, 2.0 and 0.25 lb/acre.

TABLE 6. YIELD AND VALUE OF SQUASH FOLLOWING TREATMENT FOR PICKLEWORM CONTROL, CULLMAN, ALABAMA, 1964

Treatment	Active per acre	Pickleworm damaged fruit[1]	Yield of marketable squash per acre[1]		
			12-qt. baskets	Gross value	Increase over check
	Lb.	*Pct.*	*No.*	*Dol.*	*Dol.*
Parathion	0.5	3.4bc	439a	$878a	$421a
Malathion	1.5	5.0c	373a	747a	290a
Carbaryl	2.0	0.0a	366a	731a	274a
Carbaryl	4.0	0.8ab	336ab	673ab	216ab
Carbaryl	1.0	2.0a-c	324ab	648ab	191ab
Carbaryl[2]	1.0	5.2c	305ab	610ab	153ab
Untreated check	0	17.7d	228b	457b	------

[1] Means that share a common letter are not significantly different at the 0.05 level by Duncan's test.

[2] This treatment delayed until one week after bloom.

taloupes treated weekly with carbaryl or lindane. No significant differences were detected in number or weights of melons treated with these materials alone or in combination with maneb, Table 7. Pickleworm damage in this experiment was light and was not considered as a variable.

Squash yields following treatment with recommended and accelerated rates of insecticides applied as dusts are given in Table 8. No significant differences were recorded in yield (number and weight) of squash among the various treatments even at rates up to 80 pounds of 5 per cent carbaryl per acre. Pickleworm damage was less than 5 per cent on untreated plots, and degree of control

TABLE 7. INFLUENCE OF CARBARYL AND LINDANE ON CANTALOUPE YIELD, AUBURN, ALABAMA, 1965

Treatment	Active per acre	Melons per hill		Av. melon wt.
	Lb.	*No.*	*Wt.*	*Lb.*
Carbaryl + maneb	2.0-1.6	1.3	2.7	2.03
Carbaryl	2.0	1.9	4.3	2.12
Carbaryl + maneb	1.0-1.6	1.6	2.8	1.29
Carbaryl	1.0	2.1	3.8	1.83
Lindane + maneb	0.25-1.6	2.7	4.9	1.81
Lindane	0.25	2.5	5.2	2.07
Maneb	1.6	1.9	3.8	1.98
Untreated	0	1.6	3.3	1.86
	LSD .05	NS	NS	NS

TABLE 8. YIELD OF SQUASH FOLLOWING TREATMENT WITH RECOMMENDED AND ACCELERATED RATES OF INSECTICIDES APPLIED AS DUSTS, CULLMAN, ALABAMA, 1964

Treatment	Dust per acre	Active per acre	Av. plot yield	
	Lb.	*Lb.*	*No.*	*Lb.*
Zineb 6%	33	2	62	6.82
Parathion 2%	25	0.5	53	7.48
Carbaryl 5% + zineb 6%	20	1 + 1	52	7.19
Malathion 5%	30	1.5	51	6.96
Carbaryl 5%	40	2	51	6.55
Lindane 1%	25	0.25	48	6.27
Carbaryl 5%	20	1	48	6.23
Lindane 1% + zineb 6%	25	0.25 + 1.25	47	6.20
Carbaryl 5%	80	4	46	5.50
Untreated	0	0	48	6.12
LSD .05			NS	NS

probably had very little effect on yields. Phytotoxicity was not observed in any treatments.

Squash yields following repeated insecticidal treatments applied as sprays are given in Table 9. Plot yields ranged from 192 to 254 squash that weighed 28.4 to 52.8 pounds. However, there were no significant differences in yield. Pickleworms damaged 7 per cent of the fruit in the untreated plots and probably had only a moderate effect on total yield.

Insecticides applied daily during the major fruiting period had no significant effect on squash yield as compared with weekly treatments and no treatments, Table 9. However, there was a trend toward lower yields in plots treated daily a.m. as compared with those treated daily p.m. Squash flowers tagged in the p.m. were found open at daylight on clear, sunny days and most were closed by 8 to 9 a.m. Inasmuch as the squash plant is dependent

TABLE 9. INFLUENCE OF REPEATED APPLICATIONS OF INSECTICIDES ON YIELD OF SQUASH, CULLMAN, ALABAMA, 1965

Treatment	Active per acre	Application schedule	Total squash yield	
	Lb.		*No.*	*Lb.*
Carbaryl + malathion	1.0-1.25	Weekly	259	39.4
Lindane	0.25	Daily-p.m.	254	42.7
Carbaryl	2.0	Weekly	254	40.4
Carbaryl	1.0	Daily-p.m.	253	52.8
Lindane	0.25	Weekly	236	43.1
Carbaryl	1.0	Daily-a.m.	231	41.9
Carbaryl	1.0	Weekly	218	36.2
Malathion	1.25	Weekly	207	36.7
Lindane	0.25	Daily-a.m.	196	28.4
Untreated	0	--------	192	29.9
	LSD .05		NS	NS

primarily on honey bees for pollination, early-morning insecticide applications may have adversely affected pollination, resulting in subsequent deformation or abortion of unpollinated fruits.

Resistant Varieties

It has been demonstrated that properly timed applications of effective insecticides will ensure control of the pickleworm on cucurbits. However, because of the cost involved and the residue problems often associated with the frequent use of certain insecticides on vegetable crops, an alternate means of reducing pickleworm injury is desirable.

Importance of the pickleworm as a pest of cucurbits, the lack of an alternate means of control, and the demonstration of resistance in certain varieties of squash to the pickleworm (1) prompted an investigation of resistance in cantaloupes, *Cucumis melo,* and squash, *Cucurbita* spp. The objectives of these experiments were to determine the degree of susceptibility of commonly grown varieties of squash and cantaloupes, and to select for resistance in cultivars and plant introductions of each.

Cantaloupes: Several cantaloupe varieties are available that possess certain disease resistance so it was decided to determine if any varieties possessed inherent resistance to the pickleworm. Some of the varieties commonly grown in Alabama were tested in 1965 and several introductions of foreign origin were evaluated in 1967.

Six small-plot field experiments were conducted in 1965 at four substations — Belle Mina, Clanton, Cullman, and Headland. Twenty-three varieties or breeding lines were evaluated for pickleworm resistance. Commonly grown varieties were procured from various seed companies. Breeding lines were supplied by plant breeders at various Land Grant universities.

Plantings were made from May to July. All varieties were field-seeded, thinned to two plants per hill, and treated to control diseases. Ten hills spaced 40 inches apart in 44- or 88-inch rows comprised a sample plot. A randomized complete block design was used and all varieties were replicated 4 or 5 times. One variety, usually Hales Best Jumbo, was treated with a recommended insecticide to serve as a control. Generally, melons were harvested at half-slip and examined for pickleworm damage.

In 1967, 59 introductions of *C. melo* from a total of 30 countries were screened for pickleworm resistance at Clanton and Cullman. These accessions, chosen for evaluation on the basis of certain desirable characteristics, were supplied by the Plant Introduction Station at Experiment, Georgia. Tests were conducted in the same manner as those in 1965 except they were not replicated. Accessions were tested in groups according to maturity date and at least three commonly grown varieties were included in each test to serve as a standard in selecting for resistance.

Summarized results of three experiments conducted in 1965 are presented in Table 10. At Belle Mina and Cullman, all varieties were severely damaged by pickleworms in the absence of

TABLE 10. EVALUATION OF CANTALOUPE VARIETIES FOR RESISTANCE TO THE PICKLEWORM, ALABAMA, 1965

Variety	Melons damaged by pickleworms[1]			
	Belle Mina	Cullman	Clanton	Av.
	Pct.	*Pct.*	*Pct.*	*Pct.*
Smiths Perfect	49.6b	62.7cd	5.5	38.3b
Edisto 47	66.4bc	52.6bc	13.0	43.6b
Edisto	77.6c	51.2bc	14.3	49.9b
Golden Perfection	81.5c	----	----	
Perfected Perfecta	82.3c	----	----	
Hales Best Jumbo	83.2c	50.4bc	12.7	51.3b
Seminole	83.2c	88.1e	25.6	71.9c
Rocky Ford	84.2c	----	----	
Texas Resistant	86.9c	----	----	
Florida #1	----	62.2cd	19.1	
A-63-11-4	----	46.0b	----	
A-63-11	----	68.2d	17.7	
Florisun	----	68.3d	14.1	
A-63-10	----	----	14.7	
Control	25.0a	7.6a	3.4	10.5a

[1] Means that share a common letter are not significantly different at the 0.05 level of probability by Duncan's test. Data presented in the average column are means of a combined analysis.

insecticidal control; damage ranged from 50 to 88 per cent. Significant differences were detected in degree of injury among varieties at both locations. Damage was lighter in the experiment at Clanton and no significant differences were noted among varieties. Melons escaped serious injury in this experiment because of an earlier planting and maturity date. The number of feeding holes per damaged melon ranged from 1.6 to 4.8 among varieties, but this difference is of no immediate practical significance since only one feeding hole destroys market value of the melon.

Five common varieties were evaluated in all three experiments and data from these were combined for analysis. Seminole variety sustained significantly more injury than Smith's Perfect, Edisto 47, Edisto, and Hales Best Jumbo, which were found to be equal in resistance at the 0.05 level of probability. Differences were highly significant between location ($F = 26.4$) but not significant in interaction ($F = 1.95$).

Severe epiphytotics resulted in poor yields in three of the experiments conducted in 1965. Data were taken but the sample size was considered inadequate for a valid comparison of varietal resistance. All varieties sustained moderate to heavy pickleworm injury in these tests. Varieties, other than those shown in Table 10, which were found to be susceptible to pickleworms in one or more experiments included A-63-59, Banana, Delicious 51, Hales Best 36, Hales Best 45 SJ, Honey Dew, Honey Rock, and Schoons Hardshell.

None of the varieties evaluated in these six experiments appeared to possess the degree of resistance to the pickleworm necessary to eliminate the use of insecticides.

The resistance of a variety is definable only in terms of other and usually more susceptible varieties. A division in respect to the level of resistance or susceptibility usually is purely arbitrary. Resistance has been defined by Painter *(5)* as the relative amount of heritable qualities possessed by the plant that influences the ultimate degree of damage done by the insect. In practical agriculture, it represents the ability of a certain variety to produce a larger crop of good quality than do other varieties at the same level of insect population. Painter *(5)* suggested five levels with regard to resistance: immunity, high resistance, low resistance, susceptibility, and high susceptibility. It does not appear to be completely valid to classify plant material as resistant if the amount of injury sustained by a given variety surpasses the economic injury level, especially when evaluated in plantings with other genetic material of the same genus or species. The exception would be when a factor of antibiosis is present. It is the authors' contention that the term susceptibility at various levels would be more appropriate when this economic injury level is surpassed in a variety thus giving a more finite description of resistance.

Because the degree of injury sustained surpassed the economic level, it appears logical to classify all cantaloupe varieties considered in these experiments as susceptible to the pickleworm. There were, however, significant differences in degree of susceptibility and the use of less susceptible varieties, other characters being equal, appears advisable.

Selection for resistance in Plant Introductions tested in 1967 was inhibited by poor yield and small samples from many of the accessions. A large number of the accessions failed to yield an adequate number of melons for a valid evaluation. Thus, tabular data from these tests are not given. Several accessions sustained less injury than the varieties used as standards. The following Plant Introductions appeared to be less susceptible than the standards and are considered worthy of further evaluation: 102077, 162668, 207009, 255478, 269474, and 273438.

Squash: Many squash varieties are grown commercially and by the home gardener. Squash varieties of a single species vary considerably in color and morphology. Most squash cultivars are *Cucurbita pepo, C. maxima,* or *C. moschata.* A majority of the "winter vining" or "baking squash" are *C. maxima* or *C. moschata.* However, several large-fruited, vining varieties, often referred to as pumpkins, are classified as *C. pepo* along with small-fruited, bush varieties, such as Summer Crookneck.

A large majority of the squash varieties grown in Alabama are *C. pepo.* The most popular varieties of commercial growers as well as home gardeners are Early Summer Crookneck and Yellow Straightneck. Both are highly productive bush varieties with fruits with strong consumer appeal. Because of the demand for these two varieties, experiments were conducted in 1965 to select for resistance in breeding lines of the Crookneck and Straightneck type squash. Subsequent experiments involved evaluation of commonly grown varieties of *Cucurbita* to determine the degree of susceptibility to the pickleworm and to select for resistance in cultivars and plant introductions.

Methods used to evaluate *Cucurbita* for pickleworm resistance were very similar to those employed in experiments on cantaloupes. A total of 15 experiments were conducted from 1965-1967 on the Substations at Clanton, Cullman and Headland. All varieties and lines were field-seeded in 1-row plots, 30 feet long. Planting dates of the various experiments were varied from June to August to expose varieties to varying levels of pickleworms. Eighty-eight-inch rows were generally used, and hills were spaced 3 feet apart. Plots were replicated four to five times in a randomized complete block design. This basic design was used in all but four experiments conducted with Plant Introductions in 1967. These tests were conducted with nonreplicated plots to consider a large number of accessions.

Unless otherwise indicated, seed of cultivars were procured from Montgomery Seed Company and plant introductions were supplied by the Plant Introduction Stations at Experiment, Georgia, and Ames, Iowa.

Data were collected for a period of approximately 6 weeks in each test. Squashes were harvested every 3 to 7 days at bloom-drop and examined for pickleworm injury.

In 1967, isolated plantings of a resistant and susceptible cultivar were made for further evaluation of pickleworm resistance.

A comparison of varieties of Crookneck and Straightneck squash in 1965 revealed that none of the varieties or lines were resistant. However, the Crookneck-type squash appeared to be somewhat less susceptible than the Straightneck, Table 11. Four of the Crookneck varieties sustained significantly less damage than two of the three Straightneck varieties tested. No real differences were detected in number of feeding entries per damaged squash.

Commonly grown squash varieties were compared for pickleworm resistance in 10 replicated experiments from 1965-1967. Results of these experiments are summarized in Table 12. Significant differences in degree of pickleworm damage to squash cultivars were detected in each experiment. These differences were very distinct between the more resistant and susceptible cultivars.

Pickleworm infestations varied somewhat during a single experiment. It should be noted that data in Table 12 are means of several samples for each test. Because of differences in planting date and location, infestations were also variable among experiments. Consequently, the rank of certain cultivars varied some-

TABLE 11. EVALUATION OF CROOKNECK AND STRAIGHTNECK SQUASH FOR PICKLEWORM RESISTANCE, CULLMAN, ALABAMA, 1965

Variety or line[1]	Squash examined	Pickleworm damaged squash[2]	Feeding entries damaged squash
	No.	*Pct.*	*No.*
Early Summer Crookneck	472	13.5a	1.7
SC-5	444	13.5a	2.2
Golden Summer Crookneck	407	15.0a	1.7
Seneca Butterbar Straightneck	294	15.1a	2.9
SC-8	470	17.2ab	2.0
SC-6	493	17.8a-c	1.9
SC-7	399	19.2a-c	1.9
Seneca Baby Crookneck Hybrid	490	26.4a-c	1.7
Early Prolific Straightneck	354	28.7bc	2.8
Seneca Prolific Straightneck	395	30.5c	2.3

[1] Lines coded SC were supplied by W. R. Sitterly, Clemson, S.C. and are the Crookneck type.

[2] Means followed by the same letter do not differ significantly at the 0.05 level by Duncan's test.

what during the course of a given experiment, as well as among experiments. However, the general pattern of response was relatively consistent for most cultivars in all experiments irrespective of population levels. Varieties such as Butternut, Golden Hubbard, and Improved Hubbard received the least amount of damage in all tests while Early Straightneck, Cozini, Zucchini, and others received a much greater degree of injury.

Observation of data from cultivars tested in these experiments indicates distinct and separable levels of damage sustained in each experiment. This division with respect to varietal susceptibility was evident when data from cultivars compared in at least seven common experiments were combined and analyzed, Table 13.

Butternut squash sustained an average of 7.0 per cent damaged fruit as compared with 40.1 per cent in the Crookneck variety that ranked second. The degree of injury to Butternut was no greater than that to a susceptible variety, Crookneck, which was treated weekly with an insecticide for pickleworm control. In general, there was a positive relationship between per cent fruit injury and number of feeding entries per damaged fruit.

The authors chose to classify varieties as resistant, susceptible, or highly susceptible, based on response in mixed plantings. Therefore, each cultivar evaluated in at least three experiments was classified accordingly. This classification is shown in Table 14. Only three cultivars, Butternut, *C. moschata,* Golden Hub-

TABLE 12. RESISTANCE OF CUCURBITA CULTIVARS TO PICKLEWORMS, ALABAMA, 1965-67

Cultivar—species	Pickleworm infested squash[1]									
	1965 test no.		1966 test no.					1967 test no.		
	1	2	1	2	3	4	5	1	2	3
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Butternut—*moschata*		28.8a	2.0a	6.5a	5.6a	0.0a	8.8	6.3a	11.7ab	16.6a
Golden Hubbard—*maxima*			2.1a	8.6a		3.0ab		11.3ab		
Imp. Green Hubbard—*maxima*			6.3ab	15.0ab		8.3ac				
Early Summer Crookneck—*pepo*[2]	3.4a		7.1ab	16.8ac	9.5ab	4.8ab	17.8	10.9ab	6.6a	9.2a
Saticoy Hybrid—*pepo*			10.8bd	42.5bd	49.2ac	18.3ch	58.9			
Acorn—*pepo*			11.0bd	55.7cf		13.0bf			70.5d	
Yellow Bush Scallop—*pepo*	87.7b		15.1cf	56.3df		11.4bc		45.4bc	45.0d	58.1b
Greyzini—*pepo*			9.9bc	50.4cf	63.1bd	20.7dh	79.8	57.6c		
Early Summer Crookneck—*pepo*	88.3b	88.6bc	13.0ce	55.1cf	59.1bc	16.4cg	78.2	35.2ac	49.3bd	52.7b
Storr's Green Hybrid—*pepo*			10.5bd	48.3ce		37.6fi				
Cocozelle Long Type—*pepo*			15.1cf	62.5df	68.3cd	19.4ch	63.9	33.3ac	32.2ab	
Black Zucchini—*pepo*	100.0b		28.0cg	57.0df	81.0cd	13.6bc	71.4	83.3d	72.5d	68.1b
Beautini Fl Hybrid—*pepo*			18.2cg	55.5cf		26.9ch		25.6ac	43.6bd	
Black Beauty—*pepo*			16.5cf	66.9dg		21.0dh				
Dark Green Zucchini—*pepo*		99.0c	21.2dg	62.4df		26.8eh				
Early White Bush Scallop—*pepo*	97.7b	88.0bc	18.6cg	70.8dg		23.4dh			68.9cd	61.0b
Cozini—*pepo*			28.7fg	45.6ce	100.0d	43.4hi	100.0	48.5bc		
Cocozelle Green Bush—*pepo*			20.8dg	51.7bd		53.4i				
Caserta Bush—*pepo*			21.5dg	73.6dg		27.9eh				
Morrow Green Bush—*pepo*			18.5eg	81.2fg		25.0dh				
Early Straightneck—*pepo*		83.1bc	21.3dg	82.1eg	63.2bc	24.0dh	78.7	57.4c	63.3cd	73.8b
Grey Zucchini—*pepo*			13.3ce	91.2g		27.0eh			35.6ac	
Blackini Fl Hybrid—*pepo*			29.7fg	80.2eg		37.6fi				
Marrow White Bush—*pepo*			33.3g	76.7dg		41.9gi		46.3bc	54.2cd	
Table Queen—*pepo*		69.5b								
Chefini Hybrid—*pepo*							59.7			
Ambassador Hybrid—*pepo*							71.3			
Butternut 23—*moschata*								12.3ab		19.2a

[1] Percentages were transformed to angles for analysis; means followed by the same letter do not differ significantly at the 0.05 level of probability by Duncan's test.

[2] Treated weekly with a recommended insecticide for pickleworm control.

TABLE 13. COMPARISON OF LEVELS OF RESISTANCE IN EIGHT CULTIVARS OF CUCURBITA COMPARED IN SEVEN COMMON EXPERIMENTS, ALABAMA, 1966-67

Cultivar	Squash examined	Pickleworm damage[1] Mean	Pickleworm damage[1] Range	Entries per damaged squash
	No.	*Pct.*	*Pct.*	*No.*
Butternut	1130	7.0a	0.0- 16.6	1.8
Early Summer Crookneck[2]	1898	8.9a	4.8- 16.8	1.7
Early Summer Crookneck	1685	40.1b	13.0- 59.1	3.2
Cocozelle Long Type	359	40.3b	15.1- 68.3	3.4
Yellow Bush Scallop	1444	40.6b	15.1- 56.3	4.0
White Bush Scallop	1052	49.1bc	18.6- 68.9	4.6
Early Straightneck	890	55.0c	21.3- 82.1	3.5
Black Zucchini	340	57.6c	13.6- 83.3	3.6
Cozini	194	58.3c	28.7-100.0	3.8

[1] Data shown are means of 5 to 8 samples from each of 7 replicated field experiments. Means followed by the same letter do not differ significantly at the 0.05 level by Duncan's test.

[2] Treated weekly with an insecticide for pickleworm control.

bard, and Improved Green Hubbard, *C. maxima,* were classified as resistant. All three are considered winter, baking-type squash, and are of the vining type. Eight cultivars were classified as susceptible and six as highly susceptible. Because of variability, it was necessary to classify six additional varieties as intermediate, i.e., susceptible to highly susceptible. All *C. pepo* cultivars were susceptible to the pickleworm and were severely damaged when population pressure was intense.

A comparison of certain cultivars in each class revealed that pickleworm injury was 6.6 ± 4.1 and 10.1 ± 6.4 times greater to Early Summer Crookneck and Early Straightneck, respectively, than to the resistant Butternut irrespective of population pressure. The Straightneck variety sustained 1.43 ± 0.16 times more injury than the Crookneck variety.

Since Butternut squash was found to be resistant to pickle-

TABLE 14. SQUASH CULTIVARS CLASSIFIED ACCORDING TO THEIR RESISTANCE TO THE PICKLEWORM IN ALABAMA, 1965-67

Resistant	Susceptible	Intermediate	Highly susceptible
Butternut	Acorn	Cocozelle, Bush	Blackini
Golden Hubbard	Beautini	Greyzini	Caserta
Improved Green Hub.	Black Beauty	Marrow, Green Bush	Cozini
	Cocozelle, Long	Marrow, White Bush	Early Straightneck
	Summer Crookneck	Zucchini, Green	White Bush Scallop
	Saticoy Hyb.	Zucchini, Grey	Zucchini, Black
	Storrs Green Hyb.		
	Yellow Bush Scallop		

worms in mixed plantings with other cultivars, an attempt was made to determine if this cultivar would respond in a similar manner in isolated plantings. Results, Table 15, revealed that Butternut was more resistant than Crookneck, and the magnitude of difference in infestation levels was similar to that observed in mixed plantings. Both fruit and flowers of Butternut were relatively free of damage until the last observation. On September 8, population pressure and subsequent damage had become so intense in the Crookneck planting that the adults likely migrated to the Butternut planting and caused the rapid increase in degree of damage. These data suggest that even the more resistant cultivars may be heavily damaged when in the same general area of more susceptible ones.

TABLE 15. PICKLEWORM DAMAGE TO BUTTERNUT AND CROOKNECK SQUASH GROWN IN ISOLATED PLANTINGS, CULLMAN, ALABAMA, 1967

Date of observation	Cultivar	Fruit examined	Infested fruit	Plants with infested flowers
		No.	*Pct.*	*Pct.*
8/23	Butternut	190	2.6	0.0
	Crookneck	110	25.6	46.0
8/30	Butternut	263	5.7	3.0
	Crookneck	194	45.9	92.0
9/8	Butternut	278	60.4	20.0
	Crookneck	299	96.0	100.0
Total	Butternut	731	Av. 25.7	----
	Crookneck	603	67.0	----

Combined results of nonreplicated tests with 130 *Cucurbita* plant introductions are given in Table 16. Pickleworm damage ranged from 0 to 100 per cent and a total of 22 accessions sustained less injury than Butternut — the resistant standard. Some accessions may have escaped injury because of low yield and the nonreplicated nature of these tests. Both factors enhance the

TABLE 16. SELECTION OF CUCURBITA PLANT INTRODUCTIONS FOR PICKLEWORM RESISTANCE, ALABAMA, 1967

Location	Tested	Pickleworm damaged fruit			Accessions with less damage than Butternut		
		Accessions (range)	Crookneck	Butternut	*C. maxima*	*C. moschata*	*C. pepo*
	No.	*Pct.*	*Pct.*	*Pct.*	*No.*	*No.*	*No.*
Clanton I	23	0-100	45	23	1	0	0
Clanton II	43	0-100	0	53	7	6	2
Cullman	28	13-100	31	11	0	4	1
Headland	36	25-100	50	25	--	--	1

chances for error in selection for resistance. Nevertheless, it appears that *Cucurbita* introductions of foreign origin may serve as a source of resistant material. In general, the accessions of *C. maxima* and *C. moschata* sustained less damage than those of *C. pepo.* A similar pattern was observed in extensive evaluation of cultivars. Only 4 of 80 *C. pepo* accessions tested were considered worthy of more extensive evaluation for pickleworm resistance.

Results from larval preference tests conducted in the laboratory revealed that larvae made no significant distinction between fruits and flowers of a resistant and susceptible cultivar. Thus, larval preference was not considered to be a primary factor in *Cucurbita* resistance. Ovipositional preference of the adult appears to be a significant factor in resistance, *(2)*.

SUMMARY

The pickleworm. *Diaphania nitidalis* (Stoll), is the most destructive insect pest of cucurbits in Alabama. Larvae regularly cause serious injury to cantaloupes, cucumbers and squash by feeding in the vegetative and reproductive parts of these plants.

The pickleworm apparently does not overwinter in Alabama but migrates from Florida. The first brood of larvae generally appears in June in Alabama in small numbers and seldom causes serious injury. Subsequent generations are much larger in number and cause serious injury. Results from date of planting studies revealed that squash planted after June 15 was heavily damaged by pickleworms and plantings made prior to June escaped serious injury in central and northern Alabama.

Results from a series of field experiments confirmed the effectiveness of carbaryl and lindane for control of the pickleworm on cucurbits. Other materials found to be highly effective against the pickleworm were endosulfan, GC 6506, GC 13005, and NIA 10242 applied weekly as foliar sprays. Certain fungicides reduced pickleworm injury to cantaloupes and cucumbers. Seed treatments with systemic insecticides failed to control the pickleworm on squash.

Effective control of the pickleworm on squash resulted in a two-fold increase in monetary value of the crop even when damage was rather light.

Repeated applications of insecticides at recommended and accelerated rates had no adverse effect on squash or cantaloupe yield. It appears advisable to apply insecticides late in the afternoon to minimize destruction of natural pollinators such as honey bees.

Cultivars, breeding lines, and plant introductions of cantaloupe and squash were evaluated for pickleworm resistance in a series of field experiments. Significant differences were detected in degree of pickleworm damage to varieties of cantaloupes but none of the varieties possessed the necessary degree of resistance to eliminate the need for insecticidal control.

Very distinct differences were detected in degree of pickleworm damage to squash varieties. Butternut, Golden Hubbard, and Improved Green Hubbard were classified as resistant, whereas all cultivars of *C. pepo* were susceptible to highly susceptible to the pickleworm. Pickleworm damage to a resistant cultivar, Butternut, was greater in isolated plantings than in mixed plantings with more susceptible cultivars.

Based on results obtained with plant introduction accessions, it appears that introductions of foreign origin may serve as a source of material resistant to the pickleworm.

ACKNOWLEDGMENT

Field experiments reported were conducted on the Substations of Auburn University Agricultural Experiment Station System located at Belle Mina, Clanton, Cullman, and Headland. The cooperation and assistance of J. K. Boseck, C. C. Carlton, M. H. Hollingsworth, and C. A. Brogden, Superintendents of these respective units, and their staffs is gratefully acknowledged by the authors.

Portions of the research were supported by grants from Geigy Agricultural Chemical Company; Hercules Powder Company; Niagara Chemical Division, Food Machinery and Chemical Corporation; and Shell Chemical Company.

LITERATURE CITED

(1) BRETT, C. H., C. L. COMBS, AND D. M. DAUGHERTY. 1961. Resistance of Squash Varieties to the Pickleworm and the Value of Resistance to Insecticidal Control. J. Econ. Entomol. 54: 1191-97.

(2) DILBECK, J. D. AND T. D. CANERDAY. 1968. Resistance of *Cucurbita* to the Pickleworm. J. Econ. Entomol. (In press).

(3) DUPREE, M., T. L. BISSELL, AND C. M. BECKMAN. 1955. The Pickleworm and Its Control. Ga. Agr. Exp. Sta. Bul. N.S. 5.

(4) FULTON, B. B. 1947. Biology and Control of the Pickleworm. N.C. Agr. Exp. Sta. Tech. Bul. 85.

(5) PAINTER, R. H. 1951. *Insect Resistance in Crop Plants.* MacMillan Co.

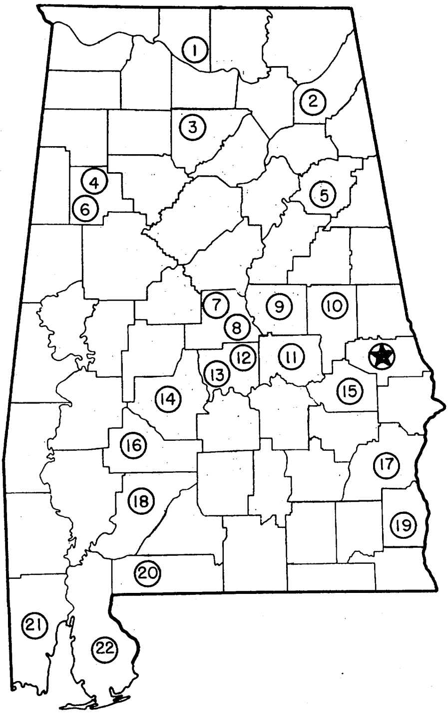
(6) QUAINTANCE, A. L. 1901. The Pickleworm. Ga. Exp. Sta. Bul. 54.

(7) REID, W. J. AND F. P. CUTHBERT, JR. 1956. Biology Studies of the Pickleworm. J. Econ. Entomol. 49: 870-73.

(8) WALSH, B. D. AND C. V. RILEY. 1869. Worm Boring Into Cucumber. Amer. Entomol. 2:31.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Alexandria Experiment Field, Alexandria.
6. Forestry Unit, Fayette County.
7. Thorsby Foundation Seed Stocks Farm, Thorsby.
8. Chilton Area Horticulture Substation, Clanton.
9. Forestry Unit, Coosa County.
10. Piedmont Substation, Camp Hill.
11. Plant Breeding Unit, Tallassee.
12. Forestry Unit, Autauga County.
13. Prattville Experiment Field, Prattville.
14. Black Belt Substation, Marion Junction.
15. Tuskegee Experiment Field, Tuskegee.
16. Lower Coastal Plain Substation, Camden.
17. Forestry Unit, Barbour County.
18. Monroeville Experiment Field, Monroeville.
19. Wiregrass Substation, Headland.
20. Brewton Experiment Field, Brewton.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.