TOMATO FRUITWORM CONTROL

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TOMATOES ARE GROWN by most home gardeners and approximately 4600 acres of field tomatoes were grown commercially in Alabama in 1966 for fresh market. There are several important insect pests of field tomatoes including tomato fruitworm, aphids, leafminers, hornworms, and loopers. The tomato fruitworm *Heliothis zea* (Boddie), is usually the most economically important insect attacking tomatoes, and control programs are generally directed specifically at this pest.

THREE-YEAR EXPERIMENTS

Some states have reported that *H. zea* attacking cotton had become resistant to certain insecticides. Hence, it was important to determine the effectiveness of currently recommended as well as some new materials against the fruitworm on tomatoes. At the same time, plant response to repeated insecticidal applications was measured in some experiments.

Experiments were conducted at the North Alabama Horticulture Substation, Cullman, and the Chilton Area Horticulture Substation, Clanton, Alabama, from 1964 through 1966. Recommended and experimental insecticides were evaluated for effectiveness against the fruitworm on ground and trellis tomatoes. Insecticides were applied with a fungicide, maneb, and compared with maneb used alone and an untreated check. In 1964, plant response to sprayable and dust formulations of carbaryl and TDE was measured.

1964 Experiments. Three small-plot field experiments were conducted in 1964, two at Cullman and one at Clanton. One experiment at each location was designed primarily to evaluate plant response to repeated applications of insecticides. Plots were 3 rows wide and 25 feet long and treatments were replicated 4 times in a randomized complete block design (repeated 4 times in plots to obtain averages for more reliable comparisons). Homestead 24 tomato variety was transplanted May 22 at Cullman and Marion variety was field seeded approximately the same date at Clanton. Prior to bloom three to eight plants per plot were selected for size uniformity and tagged for subsequent study.

Carbaryl at recommended and increased rates was compared with TDE, a fungicide alone, and untreated check. Materials were applied as sprays at Cullman and dust formulations were used in the Clanton test. Treatments were begun at early bloom and applied five times at weekly intervals. Sprays were applied with a knapsack sprayer at the

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rate of 30 gallons of spray material per acre and dusts were applied with a rotary-type hand duster.

Bloom counts were made weekly at Cullman. When tomatoes began to ripen, entire sacrificed plants were removed from the field. All tomatoes on each plant were counted, examined for insect damage, and weighed. Also, the wet weight of each vine was recorded.

In a second experiment at Cullman, nine insecticidal treatments were compared with an untreated check for fruitworm control. Seven applications were made at weekly intervals from early bloom until production terminated. All materials were applied as sprays following the procedure previously described. Tomatoes were harvested periodically as they ripened and examined for fruitworm damage. When final harvest was made, all tomatoes half-grown and larger were included in the sample. Unless otherwise indicated, these same procedures were followed in subsequent experiments.

1965 Experiments. Certain insecticides were evaluated for fruitworm control on trellis-grown Marion variety tomatoes at Cullman and Homestead 24 variety produced as ground tomatoes at Clanton. Basic experimental design, treatment, and harvest procedures were essentially the same as previously described. Treatments were begun at early fruit set in the Clanton experiment. At Cullman, a fruitworm infestation was allowed to develop before treatment was begun. Plots were sprayed nine times at Cullman and five times at Clanton. The Cullman planting was irrigated periodically to maintain optimum soil moisture. Tomatoes were harvested nine times at Cullman and four times at Clanton for yield data.

1966 Experiments. Two experiments were conducted on the Cullman station and one at Clanton in 1966. Several insecticides were evaluated for fruitworm control. Roma 884, a mechanical harvest variety, was planted in May at Cullman and a fall planting of Homestead 24 variety was made at Clanton. Plot size and design at Cullman were similar to those used in earlier tests. At Clanton, each treatment area was approximately one-fourth acre and materials were applied with a tractor-mounted sprayer calibrated to deliver 60 gallons of spray material per acre. Treatments were begun at early fruit set and applied at weekly intervals. Yield data were obtained by harvesting tomatoes at frequent intervals.

Evaluation of insecticidal effectiveness was based on percentage of damage tomatoes or yield of marketable tomatoes or both in all experiments.

RESULTS AND DISCUSSION

1964 Experiments. Results of experiments conducted at Cullman and Clanton are summarized in Tables 1, 2, and 3. Carbaryl and TDE applied as sprays gave excellent fruitworm control at Cullman based on percentage of damaged fruit. All insecticidal treatments were about equal in effectiveness and significantly superior to maneb and the untreated check (Table 1). However, total tomato yields from plots receiving effective fruitworm protection were not superior to those of the maneb treatment. There were no significant differences in number of blooms per plant among the treatments, but vine weights tended to be greater in all treated plots as compared with the untreated check. The latter was primarily because of effective disease control in all treated plots.

As given in Table 2, results at Clanton were quite similar to those from the Cullman experiment when the same insecticides were applied in dust formulations. The percentage of tomatoes damaged by the fruitworm was reduced by all insecticidal treatments. Tomato yield tended to be lower from the plots receiving no insecticides; however, the yield, total and undamaged, from plants

TABLE 1. RESPONSE OF TOMATO PLANTS TO INSECTICIDAL-FUNGICIDAL TREATMENTS APPLIED AS SPRAYS FOR FRUITWORM CONTROL, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1964

Treatment[1]	Active per acre	Fruitworm damage	Mean no.[2] blooms per plant	Av. no. fruit and wt./plant[3]				Av. plant weight (wet)
				Total		Undamaged		
	Lb.	*Pct.*		*No.*	*Lb.*	*No.*	*Lb.*	*Lb.*
Carbaryl+Maneb	1+2	1.7[a]	15	23[b]	3.8[b]	22[ab]	3.7	1.92[ab]
Carbaryl+Maneb	2+2	2.0[a]	14	23[b]	4.3[b]	22[ab]	4.2	2.05[ab]
Carbaryl+Maneb	4+2	1.5[a]	15	29[ab]	5.2[ab]	28[a]	5.1	2.64[a]
TDE+Maneb	1+2	2.4[a]	14	28[b]	4.8[ab]	27[a]	4.7	2.58[a]
Maneb	2	15.0[b]	15	35[a]	6.6[a]	30[a]	5.6	2.33[ab]
Untreated	0	17.0[b]	12	24[b]	4.5[b]	19[b]	3.6	1.69[b]

[1] Materials applied July 8, 14, 21, 28, and Aug. 3.
[2] Bloom counts made on treatment dates.
[3] Whole plants sacrificed Aug. 10 for yield data. Means followed by the same letter do not differ at the 0.05 level of protection (95 times out of 100).

TABLE 2. RESPONSE OF TOMATO PLANTS TO INSECTICIDAL-FUNGICIDAL TREATMENTS APPLIED AS DUSTS FOR FRUITWORM CONTROL, CHILTON AREA HORTICULTURE SUBSTATION, CLANTON, ALABAMA, 1964

Treatment[1]	Active per acre	Fruitworm damage	Av. no. fruit and wt./plant[2]				Av. plant wt. (wet)
			Total		Undamaged		
	Lb.	*Pct.*	*No.*	*Lb.*	*No.*	*Lb.*	*Lb.*
Carbaryl 5%+Zineb 6%	1+2	8.4[ab]	12.0	1.38	11.0[ab]	1.26	1.73
Carbaryl 5%+Zineb 6%	2+2	7.6[ab]	14.0	1.58	13.1[a]	1.46	2.03
Carbaryl 10%+Zineb 6%	4+2	2.6[a]	13.3	1.62	13.0[a]	1.58	1.92
TDE 5%+Zineb 6%	1+2	4.8[a]	11.5	1.36	11.0[ab]	1.30	1.76
Zineb 6%	2	16.2[bc]	13.8	1.60	11.5[ab]	1.34	1.85
Untreated	0	27.4[c]	10.9	1.55	7.9[b]	1.13	1.41

[1] Materials applied Aug. 14, 20, 27, Sept. 9 and 16.
[2] Whole plants sacrificed Sept. 14 and 21 for yield data. Percentage of fruitworm damage tested at 0.01 level for significance (99 times out of 100) and undamaged at 0.05 level (95 times out of 100); means followed by same letter are not significant statistically.

receiving insecticides was not significantly superior to the zineb-treated plants.

Carbaryl and TDE applied as sprays or dusts effectively controlled the tomato fruitworm in these experiments. However, at the fruitworm population density encountered, these materials applied in combination with a fungicide did not significantly increase fruit set when compared with that from a fungicide treatment alone.

Results from a second experiment conducted at Cullman where nine insecticidal treatments were evaluated for tomato fruitworm control are given in Table 3. Fruitworm damage was not heavy in this experiment as shown by the low level of injury to untreated plants. However, plots treated weekly with the following materials at indicated per acre rates yielded significantly fewer damaged tomatoes than plots receiving no treatment: Toxaphene+DDT, 2+1; carbaryl, 2; Naled, 2; toxaphene, 3; Thuricide, 90T; or endosulfan, 0.5. All of these materials were found to be equal in effectiveness when tested at the 0.05 level of protection. Weekly applications of toxaphene+DDT or TDE were more effective than carbaryl or Naled at 1 pound per acre applied every 2 weeks.

TABLE 3. EFFECTIVENESS OF VARIOUS INSECTICIDES FOR FRUITWORM CONTROL ON GROUND TOMATOES, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1964

Treatment	Active per acre	Tomatoes examined[1]	Fruitworm damage[2]
	Lb.	*No.*	*Pct.*
Toxaphene+DDT	2+1	866	3.2[a]
TDE	1	946	3.9[a]
Carbaryl	2	957	4.0[ab]
Naled	2	1120	4.4[ab]
Toxaphene	3	955	4.8[a-c]
Thuricide 90T	1 qt.	917	5.4[a-c]
Endosulfan	0.5	1251	5.7[a-c]
Carbaryl[3]	2	624	8.3[b-d]
Naled	1	723	9.6[cd]
Untreated	0	870	12.2[d]

[1] Tomatoes harvested July 28, Aug. 3, 10, and 17.

[2] Means followed by the same letter do not differ significantly at the 0.05 level (95 times out of 100).

[3] This material applied every 2 weeks, others applied 7 times at weekly intervals beginning June 30.

1965 Experiments. Results from the 1965 Cullman experiment where 18 insecticidal treatments were evaluated for effectiveness against the tomato fruitworm on trellis tomatoes are summarized in Table 4. As previously indicated, treatments were purposely delayed until a fruitworm infestation developed and the worms were never brought under control (Table 4). Azodrin, GS-13005, toxaphene+TDE, GC-6506, and carbaryl were the only materials affording a degree of control that was significantly better than that of the untreated check, based on percentage of damaged tomatoes. Furthermore, only Azodrin-treated plots yielded significantly fewer damaged tomatoes than those treated only with maneb. Fruitworms destroyed market value of about 75 per cent of tomatoes where no treatment was applied. Damage was approximately 50 per cent in plots treated with the more effective insecticides. Yield of marketable tomatoes ranged from 30.5 pounds in the untreated check to 80.1 pounds in plots treated with toxaphene+TDE. However, these differences were not statistically significant at the 0.05 level of probability (95 times out of 100).

Trellis tomatoes were grown on soil of high fertility and irrigated weekly. The plants were quite large with heavy vegetative growth; consequently, it was difficult to obtain good spray coverage although rates were increased to 60 gallons of spray material per acre. Apparently poor coverage contributed, at least in part, to inadequate fruitworm control obtained in this experiment. Furthermore, an insect infestation once established is difficult to control. These results show the necessity of beginning a control program before damaging fruitworm populations develop.

TABLE 4. FRUITWORM CONTROL ON TRELLIS TOMATOES, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1965

Treatment[1]	Active per acre	Fruitworm damage	Undamaged tomatoes per plot[2]
	Lb.	*Pct.*	*Lb.*
Azodrin	1.0	48.9	61.23
GS-13005	2.0	50.7	53.85
GS-13005	1.0	51.8	55.19
Toxaphene+TDE	2.0+1.0	52.2	80.06
GC-6506	0.5	54.9	56.19
Carbaryl	2.0	55.3	49.38
Carbaryl	1.0	57.7	37.90
Virus	1000LE	59.6	68.84
Guthion	0.5	61.7	50.15
Toxaphene	4.0	64.4	43.17
Maneb	2.0	64.9	54.06
Toxaphene	2.0	66.3	33.63
ACy-EIC	1.0	67.0	42.03
N-10,242	1.0	67.3	47.44
TDE	1.0	68.2	34.68
Endosulfan	1.0	69.2	37.67
Naled	2.0	69.6	27.91
Virus	100LE	73.4	35.58
Virus	10LE	73.4	34.25
Untreated Check	0	74.7	30.51
	LSD 0.05	15.7	NS

[1] Insecticides applied with 2 pounds maneb per acre on Sept. 2, 8, 15, 20, 27, Oct. 1, 4, 11, and 18. N-10,242 was not applied after Sept. 20 and GS-6506 after Oct. 4.

[2] Tomatoes harvested nine times from Sept. 7 to Oct. 18.

TABLE 5. FRUITWORM CONTROL ON GROUND TOMATOES, CHILTON AREA HORTICULTURE SUBSTATION, CLANTON, ALABAMA, 1965

Treatment[1]	Active per acre	Fruitworm damage[2]	Undamaged tomatoes per plot
	Lb.	*Pct.*	*Lb.*
Carbaryl	2.0	3.1[a]	50.5
Toxaphene	4.0	3.5[a]	48.0
TDE	1.0	4.1[a]	46.8
Carbaryl	1.0	4.5[a]	44.9
Endosulfan	1.0	4.8[a]	48.2
Toxaphene+ DDT	2.0+1.0	6.0[a]	53.8
Naled	2.0	6.2[a]	47.1
Virus	100LE	13.9[b]	41.2
Maneb	2.0	17.4[b]	50.3
Untreated	0	18.6[b]	32.0

[1] All materials applied with 2 pounds maneb per acre June 9, 17, 23, July 1 and 8.

[2] Tomatoes harvested for infestation determinations and yield data June 22, July 1, 8, and 15; means followed by the same letter do not differ significantly at the 0.05 level (95 times out of 100).

Summarized results of insecticidal performance on ground tomatoes at Clanton are presented in Table 5. All materials evaluated, except the fruitworm virus, afforded a significant degree of fruitworm control based on percentage of damaged tomatoes when compared with the maneb and untreated checks. However, there were no significant differences among treatments in yield of marketable tomatoes. Plots treated with maneb alone yielded as many marketable tomatoes as plots treated with an effective insecticide plus maneb.

1966 Experiments. Results from two experiments conducted at Cullman are presented in Tables 6 and 7. Fruitworm infestations were quite low on Roma 884 variety tomatoes. As given in Table 6, only 6.5 and 9.6 per cent of the tomatoes were damaged in the untreated and maneb checks, respectively. All insecticides evaluated in No. 1 experiment significantly reduced the percentage of damaged tomatoes (Table 6). Differences in yield of marketable tomatoes were not significant at the 0.05 level.

Results from the No. 2 experiment at Cullman in which five experimental insecticides were evaluated for fruitworm control are given in Table 7. Insect damage was very light in this experiment. Only 4 per cent of the tomatoes were damaged in the untreated plots;

TABLE 6. FRUITWORM CONTROL ON GROUND TOMATOES, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1966 (EXPERIMENT NO. 1)

Treatment[1]	Active per acre	Fruitworm damage[2]	Undamaged tomatoes per plot
	Lb.	*Pct.*	*Lb.*
TDE	1.0	1.9[a]	65.89
Toxaphene+ TDE	2.0+1.0	2.1[a]	72.72
Toxaphene+ TDE	1.0+0.5	2.6[a]	76.20
Toxaphene	2.0	3.0[a]	59.10
Carbaryl	1.0	3.5[a]	71.35
Untreated	0	6.5[b]	55.43
Maneb	2.0	9.6[b]	64.27

[1] All insecticides applied with 2 pounds maneb per acre July 7, 13, 18, 28, and Aug. 8.

[2] Tomatoes harvested July 20, 26, Aug. 3, 9, and 16 for infestation determinations and yield data; means followed by the same letter are not significantly different at the 0.05 level (95 times out of 100).

TABLE 7. FRUITWORM CONTROL ON GROUND TOMATOES, NORTH ALABAMA HORTICULTURE SUBSTATION, CULLMAN, ALABAMA, 1966 (EXPERIMENT NO. 2)

Treatment[1]	Active per acre	Fruitworm damage[2]	Undamaged tomatoes per plot
	Lb.	*Pct.*	*Lb.*
Her. 9007+ Toxaphene	2.0+2.0	3.0	82.60
Endosulfan	1.0	3.3	84.13
Azodrin	1.0	3.7	65.62
N-10,242	1.0	3.8	78.51
SD 8447	1.0	3.9	95.68
GS-13005	1.0	4.2	73.34
Untreated	0	4.0	75.27
P=0.05		NS	NS

[1] Insecticides applied with 2 pounds maneb per acre July 18, 28, and Aug. 8.

[2] Tomatoes harvested July 26, Aug. 5, 10, and 16 for infestation and yield data.

TABLE 8. FRUITWORM CONTROL ON GROUND TOMATOES, CHILTON AREA HORTICULTURE SUBSTATION, CLANTON, ALABAMA, 1966

Treatment[1]	Active per acre	Undamaged tomatoes per acre[2]
	Lb.	*Lb.*
TDE+Maneb	1+2	9472[a]
Toxaphene+Maneb	4+2	9200[a]
Toxaphene+TDE+Maneb	2+0.5+2	7767[ab]
Carbaryl+Maneb	2+2	6150[b]
Maneb check	2	2387[c]

[1] Materials applied Sept. 14, 20, 26, and Oct. 3.

[2] Tomatoes harvested Oct. 10 and 17; means followed by the same letter do not differ significantly at the 0.05 level (95 times out of 100).

consequently, no significant differences were detected in percentage of fruitworm damage or yield of marketable tomatoes among the treatments. Treatment with Hercules 9007+toxaphene was highly toxic to the plants. This was not reflected in total yield since treatment was not begun until most of the fruit was set.

Fruitworm damage was quite severe on a fall crop of ground tomatoes at Clanton and yields were low on plots receiving only a fungicide (Table 8). All insecticidal treatments resulted in significant increases in yield of undamaged tomatoes. A four-fold increase in yield was obtained with effective fruitworm control. Plots treated with TDE or toxaphene at 1 and 4 pounds per acre, respectively, yielded more than 9,000 pounds of undamaged tomatoes per acre, whereas plots receiving no insecticides yielded only 2,387 pounds of undamaged tomatoes. Yield of undamaged tomatoes from plots treated with TDE or toxaphene at indicated rates were significantly greater than from plots treated with carbaryl. A moderate to heavy aphid infestation developed in the carbaryl-treated plots and this may have accounted for some of the differences in yield. All plots in the experiment received the same treatment, maneb, for disease control, and this could not be considered as a variable.

SUMMARY

The tomato fruitworm was the most important insect pest of tomatoes during a 3-year study at Cullman and Clanton. Results from eight field experiments revealed that the fruitworm could be effectively controlled with weekly applications of recommended insecticides, carbaryl, toxaphene or TDE, applied as dusts or sprays. Other insecticides that showed some promise in controlling the insect included Azodrin, Endosulfan, GC-6506, GS-13005, and Thuricide 90T. Control was more effective when treatment was begun at bloom or early fruit set. No acceptable degree of fruitworm control was obtained with any of 18 insecticides on trellis tomatoes when treatments were delayed until an infestation developed.

Weekly applications of an effective insecticide and fungicide did not significantly increase tomato fruit set as compared with applications of a fungicide alone under low fruitworm damage. Tomato yield was generally lower in plots receiving no treatment and yield reduction appeared to result from a lack of disease control in several tests when insect damage was light.

Fruitworm damage was heavier in late summer and fall tomatoes, and effective control of this insect resulted in a four-fold increase in yield when damage was heavy.