The Effects of Some of the Newer Insecticides on Tomatoes and Tomato Insects[1]

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The development of new insecticides has proceeded at a rapid rate since World War II. Although these new toxicants may become of tremendous value in the field of economic entomology, their possibilities have not always been fully investigated prior to their release for general use.

An evaluation of some new materials on the tomato plant was undertaken because certain insects are a serious problem on this major Indiana vegetable crop. In addition, the tomato plant is recognized as being sensitive to many materials. From this investigation, it was hoped to establish the value of these new materials in the control of the insect pests on tomatoes.

Six new materials were tested as dusts and as sprays. These were DDT, TDE, chlordane, parathion, toxaphene and methoxychlor. With the exception of parathion these materials were used in sprays as wettable powder suspensions and as emulsions. In the spraying experiments lead arsenate was used as a standard control for comparison, while in dusting a 3/4 per cent rotenone mixture was the standard. Two additional materials, ditolyl trichloroethane (Gytol from Geigy) and purified or aerosol grade DDT (DuPont), were included with the dusts formulations.

Methods and Equipment

The experiments reported herein were carried out on the Murtaugh farm near Lafayette, Indiana, in the summer of 1948. Three plantings of tomatoes used in the experiments were made on May 3, May 18 and June 9. The seeds were drilled with a single row Planet Junior garden seed drill. The rows were spaced 42" apart to permit tractor cultivation. The plots were laid out in a randomized block design and replicated. The rows were interspaced with rows of beans to help prevent the drift of sprays and dusts from one plot to another. The insecticides were applied as dusts to the first two plantings and as sprays to the third planting. Records of injury, fresh weight, and heights of plants were made and the number and weight of ripe fruit harvested and the weight and number of green fruits left at the first killing frost recorded. Records of the effects of the insecticides on the potato aphid were made on the third planting.

The dust concentrations for the first two plantings, except for parathion, were mixed in a Day Sifter and Mixer, using pyrophyllite

[1] This paper is based on a Master's Thesis submitted at Purdue University, in June, 1949.

(Pyrax ABB) as a diluent. The parathion dusts, .25 per cent and 1.0 per cent, were the commercial products of the American Cyanamid Company. The dusts were applied with a Hudson Hand Duster No. 766 such as is commonly used by home gardeners. The sprays were mixed in the field and applied with a Hudson knapsack sprayer, Dumore, which has an agitator.

Records of the injury to the plants from spraying or dusting the tomato seedlings were made as soon as sufficient visible injury had developed, usually in 48 hours. The injury was given a numerical rating from 0 to 10, 0 indicating no visible injury and 10 indicating a dead plant.

The fresh weight samples on all plantings were made by selecting ten plants at random from each plot. The ten plants selected were cut off at ground level and placed in a one quart waxed ice cream carton for transportation to the laboratory. Although the weighings were made as soon as possible, it was thought that this technique of temporary storage and transportation would prevent severe moisture loss. A rapid estimate of the height of the ten plants on the second and third plantings was made by laying the ten plants on a lined chart and striking a visual average.

The aphid counts taken on the third planting were made by choosing ten leaves at random from each plot. The leaves selected were the fourth or fifth from the top of the growing tip. The leaves were carefully turned over and the aphids, nymphs and adults counted.

The ripe tomatoes were picked every other day and weighed on a spring scale suspended from a tripod. The weight and the number picked from each plot were recorded for each picking. After the first killing frost the green fruits remaining on the vines were picked, counted, weighed, and recorded.

Experiments

First Planting. On May 29 the first application of dusts was made when the tomatoes were just forming their third true leaf. Readings of the injury caused by this dust application were made on June 1. A second application of dusts was applied on June 8, and three days later the resultant injury was recorded. On June 14 the first fresh weight samples were taken. This sample was followed the next day by a second sample of fresh weights.

On the basis of total weight of the two samples (Table I) rotenone 3/4 per cent was the only treatment statistically heavier than the untreated check. All other insecticide treatments were significantly lighter than the untreated check. The chlordane treatments were significantly lighter and more stunted than all other treatments and the check. Chlordane 5 per cent was significantly lighter than the 1 per cent chlordane. All other treatments were significantly better than chlordane, and significantly worse than parathion .25 per cent, DDT 1 per cent, TDE 5 per cent, rotenone 3/4 per cent, and the untreated check. There was no significant difference in the weights of the parathion 1 per cent and the DDT 5 per cent plots.

TABLE I. Results Obtained from Two Applications of Dusts to the First Planting of Indiana Baltimore Tomatoes, planted May 3.

Chemical	Per cent Concentration	Fresh Weights in Grams			Numerical Rating of Injury*		Visible Injury
		6/14	6/15	Grand Total			
Rotenone	3/4	572.5	759.5	1332.0	0	0	Non-visible
Check	untreated	598.5	617.5	1216.0	0	0	Non-visible
Parathion	1/4	464.1	595.0	1059.1	0	0	Non-visible
DDT	1	457.0	558.5	1015.5	9	1	Chlorosis
TDE	5	475.6	526.5	1002.1	11	10	Chlorosis
Parathion	1	474.5	495.5	970.0	0	0	Non-visible
DDT	5	413.5	550.5	964.0	9	12	Chlorosis
TDE	1	442.1	491.5	933.6	3	1	Chlorosis
Chlordane	1	415.0	439.0	854.0	12	19	Chlorosis
Chlordane	5	293.0	416.5	709.5	26	34	Chlorosis
L.R.D. 0.05	Significance	17.86	20.24	8.70	15.06	.471	
L.R.D. 0.01		——	——	——	17.41	.544	

*Maximum number of points possible—60.

DDT, TDE, and chlordane, at the strengths tested, caused chlorosis of the leaflets. The chlorosis took place at nearly any spot on the surface of the leaf, and was especially noticeable in areas where the dust became concentrated a little too heavily. Parathion dusts, .25 and 1.0 per cent, caused no visible injury such as burning or chlorosis but the data revealed stunting.

A few scattered insects were observed on the first planting, but none became abundant enough to be noticeable.

Second Planting. The second planting was dusted with two dilutions of aerosol grade DDT, two dilutions of ditolyl analogue of DDT and 5 per cent concentrations of technical grade DDT and TDE. On June 16 the first series of dusts was applied to the second planting. Seventy-two hours later, on June 19, the first injury reading was made. As shown in Table II, DDT and TDE caused light injury which took the characteristic form of chlorosis as noted on the first planting.

Eight days after the first dusting, a second application was made. A total of 1.06 inches of rain fell in two heavy showers before the injury readings could be made seventy-two hours later. The results of this reading, as shown in Table II, was light injury caused by the 5 per cent DDT, and moderate injury caused by TDE. The injury was in the form of yellowing of the younger leaves with a slight amount of actual burning in a few cases.

On July 1, fifteen days after the first application of dusts and nine days after the second dusting, the first fresh weight samples of the second planting were taken. A total of 3.04 inches of rain fell between the first dusting and this fresh weight sample. Both height measurements in inches and weight in grams were taken.

Statistical treatment of the data showed neither height nor weight measurements to be significant, although the height measurements approached significance. The check plants, untreated, were taller than any

TABLE II. Results of Dusting the Second Planting of Tomatoes

Chemical	Total Fresh Weights	Total Height	Numerical Rating of Injury*		Visible Injury
DDT Aerosol Grade 5%	1147.0	64.0	0	0	Non-visible
GyTol DDT 5%	1122.0	63.5	0	0	Non-visible
DDT Aerosol Grade 1%	1017.5	63.5	0	0	Non-visible
Check—untreated	997.5	65.5	0	0	None
DDT Technical Grade 5%	843.5	57.0	6	12	Chlorosis
GyTol DDT 1%	839.0	58.0	0	0	Non-visible
TDE Technical Grade 5%	782.5	55.5	7	28	Chlorosis
L.R.D. 0.01	——	——	——		.378
L.R.D. 0.05	——	——	——		.438

*Maximum number of points possible—50.

of the dust treated plants, although not significantly so. GyTol 1 per cent, DDT technical and TDE technical apparently caused dwarfing. On the basis of weight, the 5 per cent dusts of GyTol and Aerosol grades of DDT appeared to stimulate seedling growth. The other treatments and concentrations caused injury reflected as stunting, although the differences were not significant and merely indicated a trend. The results of this experiment are presented in Table II.

Several species of insects were noted on the second planting but none became abundant enough to be noticeable.

Third Planting. The plots of the third planting of tomatoes were sprayed with wettable powder suspensions and emulsions for the first time on July 3 at the dilutions shown in Table III. The plants were sprayed a total of five times and in the fourth application (August 12) a fungicide, Dithane Z-78, was combined with each of the insecticides as a disease preventative. The check plots were treated with the fungicide only. It was noted that methoxychlor and Dithane Z-78 were incompatible and formed a gummy precipitate.

TABLE III. Dilutions of Sprays for the Third Planting of Indiana Baltimore Tomatoes

Chemical	Formulation	Dilutions per 100 gallons of water	Dilutions per 2 gallons of water
DDT	50% Wettable	2.0 pounds	18.1 gm.
DDT	25% Emulsion	1.0 quart	19.0 cc
TDE	50% Wettable	2.0 pounds	18.1 gm.
TDE	25% Emulsion	1.0 quart	19.0 cc
Methoxychlor	50% Wettable	2.0 pounds	18.1 gm.
Methoxychlor	25% Emulsion	1.0 quart	19.0 cc
Arsenate of Lead		4.0 pounds	36.2 gm.
Chlordane	40% Wettable	2.5 pounds	22.6 gm.
Chlordane	25% Emulsion	1.0 quart	19.0 cc
Toxaphene	40% Wettable	2.5 pounds	22.6 gm.
Toxaphene	40% Emulsion	0.5 quart	9.5 cc
Parathion	25% Wettable	2.0 pounds	18.1 gm.
Check—untreated			

Readings of the injury was made as soon as the injury developed enough to be readily visible. This was usually in about three days. Two weight samples and height measurements were taken in the manner described under Methods and Equipment. Then the plants were thinned to eight per plot on July 26 and their height measured.

At the time of the first injury reading the plants were just forming their first true leaves and varied in height from approximately one to three inches. Light injury was noted on DDT wettable and DDT emulsion, TDE wettable, and methoxychlor emulsion plots. These in-

TABLE IV. Height, Weight, and Injury Data for the Third Planting.

Chemical	Fresh Weight (10 plants)		Height Total (10 plants)			(Max. 50) Numerical Rating of Injury			Visible Injury
	7/19	7/26	7/19	7/26	7/28				
Chlordane W	758.5	1360.5	29.0	45.5	62.0	0	1	0	Chlorosis
Toxaphene E	702.5	1525.0	27.0	45.5	66.0	0	0	0	None
TDE W	683.0	1182.5	25.0	40.5	57.0	2	6	5	Chlorosis
TDE E	659.5	1304.5	24.5	45.0	60.5	0	5	0	Chlorosis
Toxaphene W	642.5	1392.5	26.0	45.0	62.5	0	0	0	None
Methoxychlor E	589.0	1092.5	25.0	40.5	63.5	4	7	0	Chlorosis
Methoxychlor W	561.5	1448.5	25.0	42.0	64.5	0	1	5	Chlorosis
Chlordane E	546.5	1455.0	24.5	41.5	60.0	0	0	0	None
Parathion W	546.5	878.5	25.5	37.5	56.0	9	14	21	Burning
Arsenate of Lead	520.5	1205.0	26.0	40.0	60.5	0	0	0	None
DDT E	512.5	1089.5	23.5	40.5	56.0	5	0	0	Chlorosis
Check	471.0	1121.5	25.5	39.0	54.0	0	0	0	None
DDT W	394.0	1006.0	24.0	37.5	53.5	3	8	5	Chlorosis
L.R.D. 0.05	28.30	—	—	—	—	.434	1.19	.202	
L.R.D. 0.01	32.68	—	—	—	—	.501	1.38	.283	

juries were in the form of yellow chlorosis of the new leaves. Parathion sprayed plots showed injury in the form of browning and actual burning of the leaves, particularly along the margins.

The injury from the second spray application was recorded five days after the application, since it was noted that the symptoms developed more slowly than with dust applications. There was .24 inch of rain between the date of application and the injury reading. Light chlorosis was noted on the DDT, TDE and methoxychlor plots. Rather heavy chlorosis was noted on the TDE wettable treated plants. As in the case of the previous spraying, parathion caused moderate injury of the leaves by actual burning.

Three days after the third spraying a third injury reading was made. DDT, TDE, and methoxychlor wettable powder applications all caused injury in the form of light chlorosis and parathion caused moderate injury by burning.

No chlorotic injury was noted as a result of the fourth and fifth sprays. The DDT plots, however, showed symptoms of injury reflected as small, linear leaves, which showed a tendency to spiral and twist like the hormone-growth effect of 2,4-D.

On July 19 the first fresh weight sample was taken. On the basis of the weight of the plants as shown in Table IV, the DDT wettable plots were significantly lighter than the untreated check and all other treatments. Both wettable and emulsion forms of TDE, methoxychlor, and toxaphene were statistically superior to the standard control, lead arsenate. Of the chlordane formulations, only the wettable powder was superior to the standard control. Both DDT formulations were statistically inferior to the lead arsenate treatment.

One week after the first weight sample was taken, a second sample was taken. Statistical examination revealed that differences in height and weight were not significant. The parathion plots, however, were lighter and both the parathion and DDT wettable plots were shorter.

The first ripe fruits picked were from the chlordane formulation plots. This was on September 13, and four days later all treatments yielded a few fruits. All yield data are presented in Table V. There was no correlation between the weights of green and ripe fruits.

On the basis of the yield of ripe fruits, methoxychlor wettable, chlordane emulsion, and toxaphene emulsion showed no significant differences. These three treatments yielded a significantly larger number of ripe fruits than all other treatments and the untreated check. There was no significant difference in the number of tomatoes yielded by lead arsenate and chlordane wettable, but both of these treatments significantly outyielded both TDE formulations, methoxychlor emulsion, both DDT formulations, the untreated check, toxaphene wettable, and parathion wettable treated tomatoes. There was no significant difference in the yields of the TDE formulations, but this material was significantly superior to methoxychlor emulsion, DDT formulations, the untreated check, toxaphene wettable, and parathion wettable plots. The yield of ripe tomatoes from the DDT emulsion plots was significantly

TABLE V. Yield Data of Third Planting, Ripe and Green Tomatoes.

Chemical	Ripe			Green				
	Number	Total Weight Lbs.	Average Weight per Fruit Lbs.	Number	Total Weight Lbs.	Average Weight per Fruit Lbs.	Grand Total Weight	Grand Total Weight
DMDT W	389	158.2	.407	1765	433.5	.244	591.7	2154
Chlordane E	389	155.4	.399	1555	337.9	.217	493.3	1944
Toxaphene E	381	145.4	.379	1747	371.9	.212	517.3	2128
Chlordane W	367	142.4	.388	1234	298.2	.241	440.6	1601
Arsenate of Lead	356	145.6	.408	1750	417.6	.238	563.2	2106
TDE W	341	145.2	.425	1573	383.1	.243	528.3	1914
TDE E	329	130.4	.396	1490	325.2	.245	455.6	1819
DMDT E	305	119.0	.389	1682	399.0	.237	518.0	1987
DDT E	301	123.6	.410	1797	436.3	.245	559.9	2098
Check	297	118.4	.398	1341	334.3	.249	452.7	1638
Toxaphene W.	280	110.8	.395	1390	315.9	.227	426.7	1670
DDT W	259	93.5	.361	1741	382.6	.219	476.1	2000
Parathion W	251	104.1	.414	1725	414.9	.240	519.0	1976
L.R.D. 0.05	13.76	——	——	76.10	10.94	----	13.55	----
L.R.D. 0.01	——	——	——	——	12.64	----	----	----

better than that from the DDT wettable plots. Toxaphene wettable, DDT wettable, and parathion wettable plots were all inferior in their yields to that of the untreated check.

Statistical examinations of the data on the basis of the weight per fruit showed that the data were not significant. TDE wettable plots showed the largest average weight per fruit, closely followed by parathion wettable, DDT emulsion, arsenate of lead, methoxychlor wettable, chlordane emulsion and the untreated check. The average weights of TDE emulsion, toxaphene wettable, methoxychlor emulsion, chlordane wettable, toxaphene emulsion, and DDT wettable were all smaller than the untreated check. DDT ripe fruits averaged less per fruit than any other treatment.

On the basis of the number of green fruits left on the vine at the killing frost, October 18, it was found that there was no statistical difference in the plots treated with DDT emulsion, methoxychlor wettable, arsenate of lead, toxaphene emulsion, DDT wettable, or parathion wettable, but all of the above treatments left significantly higher numbers of fruits on the vines than methoxychlor emulsion, the TDE formulations, the chlordane formulations, toxaphene wettable, and the untreated check. Chlordane wettable had significantly less fruit left on the vine at frost than did the untreated check. On the basis of this result, it would appear that chlordane wettable did not delay maturity.

DDT emulsion and methoxychlor wettable showed no significant difference in the weight of the green fruits left on the vine at frost, but their weights were highly significantly heavier than all remaining treatments. The differences between the weights of the fruits left on the vines of the untreated check and the TDE emulsion plots were not significant, but the weight of the green fruits left on the toxaphene wettable and chlordane wettable plots were significantly smaller than that of the untreated check and all other treatments but TDE emulsion. It would appear that DDT emulsion, methoxychlor wettable, arsenate of lead, parathion wettable, methoxychlor emulsion, TDE wettable, DDT wettable and toxaphene emulsion all delayed the maturity of Indiana Baltimore tomatoes under the conditions of this test.

There was no statistically significant difference in the average weight per fruit of the green fruits left on the vine at frost, but the fruits from all treatments were smaller than those from the untreated check.

On the basis of total weight yielded, including ripe and green fruits, the yield from methoxychlor treated plants was significantly higher than that from all other treatments. Toxaphene wettable treated plants were the only ones significantly lighter in yield than the untreated check, although chlordane wettable treated plots were lighter and nearly significantly so. On the basis of these results, it would appear that chlordane wettable and toxaphene wettable reduced the crop yield.

The plants treated with chlordane formulations had the highest percentage of their crop ripe by frost. The chlordane treated plants were closely followed by the TDE formulations, toxaphene emulsion, methoxychlor wettable treated plants, and the untreated check. Evidently these treatments stimulated maturity. Lead arsenate, toxaphene wettable, methoxychlor emulsion, DDT formulations and parathion wettable, apparently delayed maturity of fruits as they had a smaller percentage of ripe fruit than did the untreated check.

By August 12 colonies of aphids were building up in sufficient numbers to give reliable data. Four aphid counts were made as shown in Table VI. The data obtained by the first three aphid counts showed significant differences while those from the fourth count were not significant.

TABLE VI. Results of Four Samples of the Potato Aphid Population on the Third Planting of Indiana Baltimore Tomatoes.

Chemical	Aphid Population			
	Sample 1 August 21	Sample 2 September 7	Sample 3 September 13	Sample 4 September 21
Toxaphene W	593	998	1172	1877
Chlordane W	576	2040	2283	2730
Methoxychlor W	569	1082	1001	1579
Chlordane E	517	763	1519	2403
TDE W	490	820	1138	1918
DDT W	465	874	950	1873
TDE E	415	833	888	1468
Check—untreated	410	1619	2115	2266
Toxaphene E	406	242	309	1015
DDT E	346	111	338	882
Methoxychlor E	329	692	1348	2125
Arsenate of Lead	280	1452	1943	2691
Parathion W	65	4	51	59
L.R.D. 0.05	34.85	26.16	103.28	....
L.R.D. 0.01	....	30.20	119.26	...

A comparison of the two types of formulations, wettable powder and emulsion showed that the differences in aphid abundance after treatment was not due to materials, but to the formulation. The emulsions were significantly better as aphicides than the wettable powders, except for methoxychlor where the reverse was true. The aphid populations on the chlordane wettable plots were much higher than the untreated check and in the first three samples was significantly so. Apparently chlordane stimulated the aphid populations. Parathion was the outstanding material, for it not only greatly reduced the initial population, but also kept it at a low level for several weeks.

Conclusions

All of the new insecticides tested as dusts injured tomato seedlings more than ¾ per cent rotenone dust. Rotenone and parathion were the only dusts which did not produce chlorosis of the seedlings. The five percent concentrations of the insecticides produced more chlorosis than the 1 per cent dusts. Both aerosol and technical grade DDT caused stunting of the seedlings, but the aerosol grade did not produce a visible chlorosis.

Applications of the new insecticides as sprays indicated that methoxychlor wettable powder was the best material when the four factors, visible injury, stunting, aphid control, and total yield of fruits were considered. Parathion was an outstanding aphicide, but as a spray caused serious burning and stunting of tomato plants.