THE INCREASE OF EGG PRODUCTION OF THE FRUIT TREE RED SPIDER MITE (*METATETRANYCHUS ULMI* KOCH) UNDER INFLUENCE OF DDT

by

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INTRODUCTION.

It is a well established fact that frequently the application of DDT is followed by severe outbreaks of spider mites. This has been noticed on many species of plants with different mites. For this reason the application of DDT in fruit orchards has been much opposed (cf. GROVES 1951). Usually these outbreaks are explained by reasoning that DDT, while harmless to the mite itself, eradicates the predators. This has been tested qualitatively (COLLYER, 1949), but the quantitative aspect of the hypothesis has not been sufficiently studied. DEBACH et al. (1950) studied the quantitative relations between DDT, predators and the Citrus red mite, a pest related to the Fruit Tree Red Spider. Though they believe that the effect of DDT can be explained by its influence on predators, there are some inconsistencies in their results which cannot be accounted for on this assumption only.

HUFFAKER & SPITZER (1950) have shown that qualitatively there exists no correlation between eradication of predators by DDT and the build-up of populations of the spider mite. Other factors must be involved. They write that: "Some of the results were consistent with the idea of a physiological stimulus to reproduction under DDT influence, although this tendency was erratic in occurrence and of only secondary importance as an explanation of the problem." (p. 830).

We think their results allow a firmer conclusion and that the data show definitely that DDT may stimulate Red Spider development, apart from predator influence.

For a number of years the ecology of *M. ulmi* has been studied by some of us and we found evidence of a build-up of the mite Population after the application of DDT independent of the destruction of predators. The results obtained up to the present moment are presented in this paper.

THE INCREASE OF *Metatetranychus ulmi* AFTER DDT APPLICATION IN THE ABSENCE OF PREDATORS.

The phenomenon itself can be shown in experiments such as the following: A number of plum-trees were sprayed with parathion and subsequently half the number was treated with DDT. The mites and predators were counted each week for a period of several months from samples of 100 leaves per treatment (3 fair-sized bush-trees). Earlier investigations had shown that this number gives a sufficiently reliable result (KUENEN 1946). No predators were found for many weeks on the trees after the treatment with parathion, which confirms similar observations by MASSEE (personal communication).

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Table 1. *Population of mites and eggs in complete absence of predators (Plums, 1949) (mean number of mites per leaf).*

date	control Trees		DDT treated Trees (date of treatment: July 13)	
	mites	eggs	mites	eggs
July 19	3.8	11.3	2.3	6.4
— 25	8.9	2.3	6.6	2.0
Aug 1	6.9	33.9	8.4	45.1
— 5	4.4	56.0	5.4	82.0
— 12	17.7	35.6	30.5	54.8
— 22	80.9	32.8	104.1	48.8

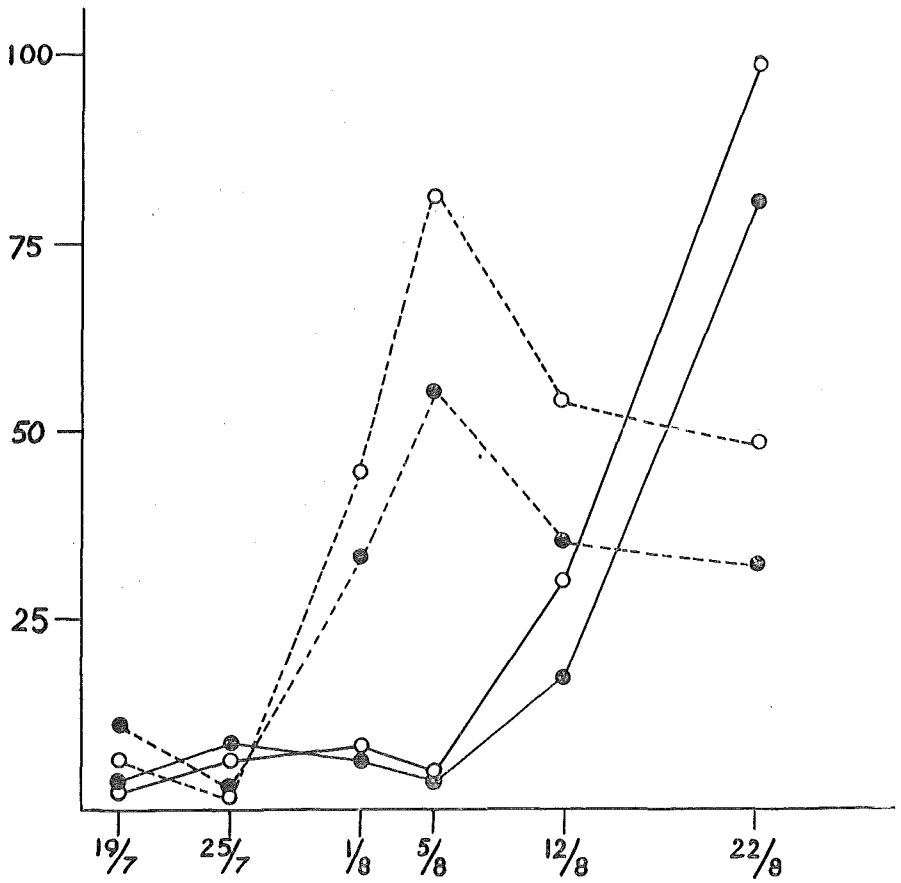

Fig. 1. Numbers of mites (full line) and eggs (broken line) of Red Spider on plum; mean numbers per leaf, calculated from 100 leaves. Untreated = black points; DDT = open circles.

The results, so far as they are of interest for this discussion, are tabulated above (Table I). As has been explained on previous occasions (KUENEN 1949) the number of mites and eggs fluctuate because the different generations remain more or less distinguishable

throughout the year, maxima in mites coïnciding with minima of eggs and alternating with maxima in eggs and minima in mites (fig. 1).

In this case July 19 marks the beginning of an increase of mites with a maximum on July 25 in one group of trees and Aug 1 in the other, followed by an egg increase with a maximum on Aug 5, coïnciding with a mite minimum on the same date.

These numbers already show a marked effect of the DDT. For a good comparison of the two populations it is best to compare the numbers present in a certain period, which can be expressed by comparing the area enclosed above by the graph, at the sides by the two verticals marking the beginning and end of the period of comparison, and below by the abscissa of the graph [1]).

For the mite areas for the period July 19—Aug 5, the period between the first and second mite minimum after DDT application, the ratio for control: DDT is 116 : 106; the mite populations are therefore nearly equal.

For comparing the egg data we should take the areas from July 25—Aug 12, the period between the first and second egg minima, after DDT application, this increase in eggs arising from the two nearly equal mite populations. The ratio control: DDT then is 636 : 911. The mite: egg ratio on the control trees therefore is 5.5 and on the DDT trees 8.6.

It is quite obvious that in spite of the fact that neither group of trees had any number of predators of importance, the DDT treated trees show a very much greater increase of the Red Spider than the control.

These data do not show what stage in the mite development is influenced. As we thought that the number of eggs produced by each female might be increased, we planned a field experiment which would show us whether the ratio females: eggs was changed by DDT.

POPULATION-GROWTH OF *Metatetranychus ulmi* UNDER INFLUENCE OF DDT IN THE FIELD.

The aim of the experiment to be described was to get more detailed information on population-growth. For this purpose 4 apple-trees with a fair infestation of spider-mites were sprayed with parathion (Aug. 1949). This spray kills all mites which are not in the egg-stage. Though some eggs are killed too, enough are left to provide a reasonable number of mites to be investigated. Furthermore all predators (and most other insects on the tree) are killed. As in the experiment described above (p. 371) we found no predators on the trees for many subsequent weeks. Consequently the experiment involved only *Metatetranychus ulmi*.

After the parathion had been applied, two of the trees were sprayed with DDT-suspension (0.1 % DDT). The number of mites was estimated every other day by counting all stages of the mites separately on 50 leaves of each tree. As both parallels gave fundamentally the same results, only totals of each treatment will be given.

The best way for comparison of these populations is again to use the sum of "mite-days", which is the same as comparing the areas included between the abscissa (time-axis), the graphs and the ordinates (number-of-mites-axis) of the days of comparison. It was possible to calculate the total number of mite-days separately for each of the two generations involved in the experiment, and for each stage of development. The data (see table 2) were reduced to equal numbers of eggs (10.000) as a starting-point in the first generation, since the two sets of trees had a different number of eggs on the leaves ($\pm$ 10.000 and $\pm$ 15.000 per 100 leaves on the data of beginning of the experiment [2]).

[1]) For an exact mathematical treatment see HUECK 1952.

[2]) The actual counts began on the 5th day of the experiment, and showed the presence of 7934 eggs + 293 mites and 11265 eggs + 546 mites, which by extrapolation led to the above mentioned number of eggs on the first day.

Table 2. *Development of population of Metatetranychus ulmi under influence of DDT, starting from* 10.000 *eggs on* 100 *leaves expressed as total mite-days per developmental stage.*

Generation	Stage	mite-days		Ratio DDT/control
		control	DDT	
1st	larva	2790	3183	1.1
	protochrysalis	5326	4128	0.8
	protonympha	1758	1392	0.8
	deutochrysalis	4614	3403	0.7
	deutonympha	1978	1390	0.7
	teleiochrysalis	4732	2811	0.6
	♂	3082	2505	0.8
	♀	7565	7832	1.0
2nd	eggs	195444	283017	1.5
	larva	6777	11668	1.7
	protochrysalis	16053	23704	1.5
	protonympha	8350	13799	1.7
	deutrochrysalis	17652	27683	1.6
	deutonympha	12591	19617	1.6
	teleiochrysalis	16969	26155	1.5
	♂	20943	32678	1.6
	♀	32874	52003	1.6

The most important points in table 2 are the following.

On all trees the resting stages counted are more numerous than the mobile stages of the mites. We are not yet sure of the reason for this difference, and must await further observations. One of the main reasons may be that dead resting stages cannot be distinguished for some time after they have died, and therefore are counted, although they do not give rise to mobile mites of the next stage. For females the larger number found is certainly due to the fact that they have a much longer life than the other stages (except eggs).

The ratio DDT/control falls in the first generation from 1.1 to 0.6 and then increases as the adults appear. This means that the mortality on the DDT trees is greater than on control trees, until the adult stage is reached. Then the reverse happens which could be due to a different reaction of the adults to the same amount of DDT or a gradual reduction of the DDT. This change continues in the next generation which makes it probable that it is due to the reduction of the residue of DDT. The lower concentration therefore appears to have a stimulating effect on the mites and especially on the egg-production. The remainder of this generation shows a fairly constant ratio, indicating that the DDT no longer has any effect.

It is perfectly clear that at the end of the first generation the amount of females on the DDT-trees was, at its best, equal to the amount of females on the control-trees. More probably it was even less. There can, therefore, hardly be any doubt that the sudden increase of the ratio DDT/control with the beginning of the second generation must be accounted for by a higher egg-production of the females on the DDT-trees.

LABORATORY-EXPERIMENTS ON THE EFFECT OF DDT ON THE EGG-PRODUCTION OF *Metatetranychus ulmi.*

For the laboratory-experiments leaf discs of 22 mm diam. were cut out of fresh apple-leaves. The discs were floated on tap-water in Petri dishes. Some of the discs were treated with a 5 % dust of DDT in talcum. Females from trees not treated previously with DDT were isolated on these discs. The females could be observed over a period of 8—10 days before the discs had to be discarded. As the reaction of the mites proved to be dependent on the dosage of DDT, different dosages were applied. The results were sometimes rather erratic, probably reflecting the influences of humidity and temperature which we are not yet able to define clearly. If the lid of the Petri-dish was closed egg-production both in control and DDT-dishes was depressed, probably owing to the high humidity in the dish.

Table 3. *Effect of DDT on egg-production of Metatetranychus ulmi.* 4—8—1950

Treatment	Total number of eggs produced by 10 females	Mean length of life (days)	Egg-production per mite per day
Control a	26	4.0	0.65
b	50	5.1	0.98
c	38	4.3	0.88
d	32	4.4	0.73
mean	37	4.5	0.81 ± 0.08
DDT conc. 1/8	78	4.6	1.70
1/4	24	3.2	0.75
1/2	31	4.6	0.67
1	23	3.1	0.74

Table 4. *Effect of DDT on egg-production of Metatetranychus ulmi.* 16—8—1950

Treatment	Total number of eggs produced by 10 females	Mean length of life (days)	Egg-production per mite per day
Control a	47	5.0	0.94
b	47	5.5	0.85
c	55	6.2	0.89
d	50	5.0	1.00
e	48	5.3	0.91
mean	49	5.4	0.91 ± 0.03
DDT conc. 1/8 a	83	5.2	1.60
b	83	6.6	1.26
c	75	5.8	1.29
d	83	5.7	1.46
e	72	4.7	1.53
mean	79	5.7	1.41 ± 0.07

The same occurred when the lid was removed, because of rapid drying of the leaf-discs. The best results were obtained with partly closed Petri dishes. As a standard deposit in

these experiments 2,5 g/m² (= 25 kg/ha) of a DDT-dust containing 5 % DDT was used. This concentration is called 1 in table 3. The experiments were carried out with series of 10 females. The results tabulated in tables 3 and 4 give averages for 10 females. Table 3 gives the result of a series of experiments with different deposits of DDT, table 4 gives a more elaborate comparison of the results at 1/8th of the standard deposit and a control series.

The difference between the means of the DDT and control series in the last experiment is statistically significant, $p \ll 0.01$ according to Student's t-test. According to the test of Wilcoxon the difference is significant with $p = 0.008$. In other experiments of the same kind we could not always produce a statistically significant increase in egg-production as a result of DDT application, though several gave positive results and no negative results were obtained. Apparently some unknown factor is involved. We have indications that past treatments of the trees from which the mites are derived exert a certain influence, apart from humidity and seasonal variations.

These experiments also suggest that higher deposits of DDT (viz. 1) are somewhat noxious to the mite.

We are aware of the fact that these experiments are of a preliminary kind. As the problem of Red Spider increase is of considerable importance we thought it advisable to publish these results now and not wait for further results which could prove the increased egg-production beyond doubt.

SUMMARY.

Application of DDT is often followed by an outbreak of Red Spider Mites. This is to a certain extent due to the eradication of predators, but some other factor must be involved as the same phenomenon may be observed in the total absence of predators. In a series of experiments we have shown that with the Fruit Tree Red Spider (*Metatetranychus ulmi* Koch) the increase in numbers is at least partly due to an increase in egg-production caused by low DDT-concentrations.

For the effect to be seen a certain DDT-concentration must coincide with the susceptible period (about the egg-laying period) of a sufficient number of females. This may explain some of the erratic results obtained by other authors and ourselves. The experiments are of a preliminary kind and will be supplemented by further observations.

RÉSUMÉ.

Les traitements antiparasitiques avec DDT sont souvent suivis d'une pullulation de l'Araignée Rouge. En partie cela s'explique par la destruction des prédateurs par l'insecticide, mais il est nécessaire qu'encore un autre facteur entre en ligne de compte parceque le même phénomène se présente en cas d'absence totale des prédateurs.

Par quelques expériments nous avons démontré que la pullulation de l'Araignée Rouge du Pommier (*Metatetranychus ulmi* Koch) en partie au moins est causée par une augmentation de la production des œufs sous l'influence des concentrations basses de DDT. Pour obtenir un résultat perceptible il faut qu'une certaine concentration de DDT coincide avec une periode susceptible d'un assez grand nombre de femelles de l'acarien.

Ceci peut expliquer probablement les résultats variables obtenus par différents auteurs.

Les experiments sont d'une caractère provisoire et seront continués.

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