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Sterility-inducing Effects of some Antibiotics and Sulphanilamides on the Legum Aphid *Aphis craccifora* K.

by

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Introduction: The hazards caused by large scale use of insecticides for the control of crop pests have focussed the attention of investigators to switch over to other alternative methods involving minimum risks. One of the recent developments in this direction is the use of antibiotics and sulphanilamides which are reported to induce sterility in insects either by contact or when ingested along with the plant, by interfering with the normal physiology of the insect. The first report on the possible use of these substances in the control of crop pests was made on recently by Harries (1961) in two spider mites viz., *Tetranychus telarias* (L) and *Panonychus ulmi* (Koch), Harries and Mattson (1963) extended the use of antibiotics against the aphids *Myzus persicae* (Sulz) *Aphis pomi* De Geer and *Macrosiphum pisi* (H). Later workers like Ehrhardt and Schmutterer (1966), Jayaraj and Schmutterer (1966), Ehrhardt *et al.*, (1966) and Jayaraj *et al.*, (1967) established that certain antibiotics and sulphanilamides have got irreversible effect in *Aphis fabae* Scop and that sterility can be induced to the progenies indicating the possibility of permanent control. These authors attributed the effect to the destruction of symbionts in the insect.

No work has been done in India so far in this method of pest control eventhough these chemicals are already available and used widely for the control of diseases of crops. When the usefulness of the method could be established for pest control the scope for the use of these chemicals would be widened for controlling both diseases and insects simultaneously. In view of these, work was initiated on the effects of certain antibiotics and sulphanilamides, including some crude forms, on the legume aphid *Aphis craccifora* Koch a common pest and vector of virus diseases, occurring on several crops (Kuppuswamy, 1969). In the present paper the results on the reproduction of the insect when treated with seven antibiotics and four sulphanilamide products in three methods of application are reported. The observations were continued upto the third generation of the pest.

Materials and Methods: The antibiotics and sulphanilamides mentioned in Table 1 were applied at 0.2% concentration, reported to be the best concentration by Jayaraj *et al*, (1967) in the case of *Aphis fabae* in the following three methods.

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i) *Direct effect or contact effect:* In this method the newly deposited first instar nymphs of *Aphis craccivora* were placed on a filter paper and sprayed with different antibiotics and sulphanilamides. After drying, ten nymphs were introduced to each caged plant in three replications,

ii) *Indirect effect via host plants or systemic effect:* One week to ten days old seedlings of cowpea were first sprayed with different chemicals and thereafter ten apterous adults of the aphid were introduced for larviposition, in three replications.

iii) *Combination of contact and systemic effects*: In this method ten young apterous adults from the culture were introduced to every caged plant for larviposition for five hours. The adults were then removed and the nymphs on the plants sprayed with an all-glass atomizer. The spraying of the antibiotics and suphanilamides was so regulated that each plant along with the insect was throughly wetted with 1 ml of the solution. Later on only ten nymphs were left at random on each plant. In the same way the control plants were sprayed with water alone and kept as the check.

In all the three methods mentioned above the fertility rate of the adults reared from treated first instars was assessed by counting the number of larvae deposited during their life period. The larvae of the second generation were then transferred to untreated normal plants for further observations. As in the case of the first generation the observations were taken for second and third generations also.

Results: *Comparison of chemicals:* In screening the various antibiotics and sulphanilamides the number of nymphs laid by the apterous aphid has been observed in three different methods of application and three generations. The results presented in Table 1 indicate that tetracycline and sulphanilamide at 0.2% concentration irrespective of the method of application and generation could reduce the fertility level greatly by 60.0 and 55.8 per cent respectively from the untreated insects. Penicillin both as potasium and sodium salts and sulfaguanidene at the same concentration were not able to reduce the fertility but on the other hand they enhanced the reproduction from 1.0 to 13.9 present. The other antibiotics and sulphanilamides were having reduced effect in diminishing the fecundity of the aphid.

Comparison of the methods of application: The chemicals applied in three methods had significantly different influence on the fecundity of the aphid. The application of the antibiotics and sulphanilamides on aphids, on plants *in situ* was found to have maximum effect irrespective of the generations, followed by the treatment of the plants alone without insects, which recorded respectively 21.2 and 12.8% greater efficacy when compared to the application on the aphids off the plants (Table 1).

TABLE 1. *Effect of antibiotics and sulphanilamides on the facundity of the aphid in three methods of application (Mean of 9 observations)*

Treatments	Contact		Systemic		Combined		Mean	
	Mean	% decrease (−) or increase (+) over control	Mean	% decrease (−) or increase (+) over control	Mean	% decrease (−) or increase (+) over control	Mean	% decrease (−) or increase (+) over control
1. Tetracycline 0.2%	78.72	−30.81	32.83	−70.22	20.32	−80.74	43.96	−61.01
2. Chlortetracycline 0.2%	102.56	− 9.86	95.79	−13.82	87.23	−22.10	95.20	−14.37
3. Chloramphenicol 0.2%	99.46	−12.59	90.67	−18.47	82.42	−21.91	90.85	−18.33
4. Erythromycin 0.2%	105.94	− 6.89	97.64	−12.14	91.32	−13.47	98.30	−11.54
5. Streptomycin 0.2%	103.94	− 8.78	95.67	−13.93	86.36	−17.33	95.94	−13.69
6. Penicillin K 0.2%	132.19	+16.18	125.68	+14.00	117.63	+11.45	125.16	+13.94
7. Penicillin G 0.2%	128.27	+12.74	119.46	+ 8.35	111.76	+ 5.90	119.83	+ 9.09
8. Sulfanilamide 0.2%	81.39	−28.46	39.61	−64.07	24.78	−76.51	48.59	−55.76
9. Sulfaguanidene 0.2%	120.60	+ 5.99	112.68	+ 2.21	99.51	− 5.71	110.93	+ 0.98
10. Sulfadimidene 0.2%	116.34	+ 2.25	107.15	− 2.80	96.21	− 8.83	106.57	− 2.99
11. Sulfacetamide 0.2%	107.36	− 5.32	98.32	−11.52	92.22	−12.20	99.30	−10.64
12. Control	113.77	—	110.24	—	105.53	—	109.85	—
% decrease (−) or increase (+) over control	107.53	—	93.81	−12.76	84.78	−21.55		

Difference between treatments is significant at the 1% probability level. C.D. (P=0.05) = 2.21.
Difference between methods of application is significant at the 1% probability level. C.D. (P=0.05) = 1.92.
Interaction between treatments and methods of application is significant at 1% probability level. C.D. (P=0.05) = 3.84.

The interaction between treatments and methods of application was also found to be highly significant. In all the cases of treatments, the trend of efficacy was maintained uniformly as indicated above, the combination of systemic and contact effects being more pronounced than their individual effects. In the comparison of treatments under each method of application it was again found that teracycline and sulphanilamide had the maximum effect, the former being significantly better than the latter in the systemic and combined effects eventhough they are on par for their contact effects (Table 1).

Comparison between generations: The sterility-inducing effect of these chemicals was studied in three successive generations and the results are presented in Table 2. A perusal of the data would reveal that fecundity of the aphid in the pooled analysis over all the methods and treatments varies significantly in the three generations. The rate of reproduction was at its minimum in the third generation which was 13 5% lower than that in the first generation. In other words the antibiotics and sulphanilamides showed in general progressively increased efficacy from the first to the third generation. However, the interaction between treatment and generation was not significant indicating that the efficacy of the chemicals was rather unaltered in the successive generations. Similarly the interaction between method of application and generation could not also yield significant results thereby showing that the efficacy was not changed by the method of application in the generations.

TABLE 2. *Effect of antibiotics and sulphanilamides on the fecundity of the aphid in three generations (Mean of 9 observations)*

Treatments	G I		G II		G III	
	Mean	% decrease (−) or increase (+) over control	Mean	% decrease (−) or increase (+) over control	Mean	% decrease (−) or increase (+) over control
1. Tetracycline 0.2%	50.13	−55.49	44.71	−59.23	37.03	−65.47
2. Chlortetra-cycline 0.2%	102.10	− 9.34	95.34	−14.24	88.14	−21.05
3. Chloramphenical 0.2%	98.64	−12.41	90.67	−18.51	83.23	−25.63
4. Erythromycin 0.2%	105.52	− 6.30	97.51	−12.27	91.87	−17.58
5. Streptomycin 0.2%	102.78	− 9.12	95.92	−13.72	89.10	−20.16
6. Penicillin 0.2%	133.93	+18.92	124.80	+11.38	116.77	− 8.86
7. Penicillin G Na 0.2%	127.94	+12.59	119.42	+ 8.90	112.11	− 4.53
8. Sulphanilamide 0.2%	55.86	− 9.20	48.23	−57.21	41.69	−61.13
9. Sulfaguanidene 0.2%	117.88	+ 4.66	112.60	+ 2.68	102.31	− 4.82
10. Sulfadimidene 0.2%	113.33	+ 0.66	106.58	− 2.81	99.80	−10.18
11. Sulfacetamide 0.2%	106.56	− 5.39	98.39	−11.47	92.97	−16.56
12. Control	112.62		109.67		107.26	
% of decrease (−) or increase (+) over I generation	102.28		95.32	− 6.80	88.52	−13.48

Difference between generations is significant at the 1% probability level. C.D. (P=0.05)=1.92. Interaction between generations and treatments is not significant at the 5% probability level.

Discussion: Consistent data have been gathered and presented for the first time that certain antibiotics and sulphanilamides can effectively be used in reducing the population of the legume aphid, *Aphis craccivora* Koch. This was true in all the three methods of application. When the aphid larvae were sprayed off the plant, the antibiotics and sulphanilamides have acted like contact poisons and when the host plant alone was treated without the insects, they were comparable to systemic insecticides. When these two methods were combined the treatment resulted in greater efficacy owing to the combination of contact and systemic effects (Table 1). In view of the well established bactericidal action of the antibiotics and sulphanilamides they may be attributed to destroy the symbiotes in the aphid mycetomes leading to a distinct reduction in the reproduction of the aphid as already reported by Ehrhardt and Schmutterer (1966) based on experimental evidences in the black bean aphid, *Aphid fabae* Scop. on *Vicia faba* L.

In screening the various antibiotics and sulphanilamides the above mentioned three different methods were employed and the effect was studied in three successive generations. Among the different antibiotics and sulphanilamides tested, tetracycline and sulphanilamide at 0 2% concentration were able to reduce the fertility of the aphid by 60.0 and 55.8 % respectively from the untreated insects (Table 1). The results are in accordance with the earlier findings of Jayaraj and Schmutterer (1966) on *Aphis fabae* Scop. in which likuden (Griseofulvin) both as spray on plants at 0.2% and as root application at 0 01% along with Knop's nutrient solution was able to reduce the fertility remarkably. In the same way terramycin at 0.2% (oxytetracycline) was found to be the most effective against *Aphis fabae* in reducing the fertility (Jayaraj, Ehrhardt and Schmutterer, 1967).

Among the different methods employed in the present study to screen the antibiotics and sulphanilamides, the combined method of application for the contact and systemic effects was found to have maximum influence irrespective of the generations followed by the treatment of the plants alone without insects, which recorded respectively 21.1 and 12.8% greater efficacy when compared to the application on the aphids off the plant (Table 1). Similar results were obtained in the treatment terramycin which reduced the fecundity of *A fabae* by 97% (Jayaraj *et al*, *loc. cit.*).

The antibiotics and sulphanilamides may penetrate the insect cuticle by dissolving the lipoid epicuticular layer stimulating the contact action of insecticides. The absorption of antibiotics and sulphanilamides through the stems and leaves have been well established. Anderson and Niewnow (1947) reported that wheat radish and soybean seedlings readily absorbed streptomycin. Crowdy *et al* (1955) have also shown that broad bean leaf absorbs chloramphenicol and griseofulvin. Bioassay studies by Goodman and Dowler

(1957) have demonstrated the absorption of streptomycin by foliage of bean plants. Harries and Mattson (1963) on the effect of different antibiotics on *Tetranychus telarius* and *Panonychus ulmi* concluded that these chemicals were systemic in their action. The effectiveness of root application of chemicals like griseofulvin in the control of *Aphis fabae* Scop. was reported by Jayaraj and Schmutterer (1966).

In the same way the effect of antibiotics and sulphanilamides was studied in successive generations and it was found to be more pronounced in the third generation. The rate of reproduction was at its minimum in the third generation which was 13.5% lower than that in the first generation (Table 2). In other words the antibiotics and sulphanilamides showed in general, progressively increased efficacy from the first to the third generation. However, a total sterility could not be observed in this case as reported by Jayaraj and Schmutterer (1966) and Jayaraj, Ehrhardt and Schmutterer (1967) in *Aphis fabae* treated with likuden and terramycin respectively in the second generation.

Penicillin at the same concentration of 0.2% both as pottassium and sodium salts was found to have no adverse effect on *A.craccivora*, but on the other hand enhanced the reproduction (Table 1). These results support the earlier findings of Ehrhardt and Schmutterer (1966) that penicillin and streptomycin are not effective in reducing the fertility rate of *Aphis fabae* Scop. Even at higher concentrations penicillin was not found to be effective and the greater fecundity rate was associated with increase in body weight and size of aphid (Kuppuswamy, 1969). Similar beneficial effect of penicillin was earlier reported by Murthy *et al.*, (1951) in the silk worm larvae, *Bombyx mori* L. where the growth and other metabolic activities were promoted. However, results contradicting these findings have earlier been obtained by Brues and Dunn (1945) who demonstrated that penicillin at higher concentrations causes metabolic disturbances by destroying the symbiotic micro-organisms leading to death of the insects in the case of the Florida cockroach *Blaberus cranifer*. Similarly, administration of penicillin at lower concentrations greatly reduced the number of bacteroids in this cockroach but apparently without any ill effects. In the same way penicillin administred at subtoxic level reduced the number of intracellular bacteroids in cockroaches and this reduction was accompanied by a deficiency of certain unidentified constituents essential for the normal functions of insect life (Glaser, 1946). In the aposymbiotic cockroaches caused by penicillin, there was almost no development of eggs.

Summary: Preliminary screening of eleven compounds of antibiotics and sulphanilamides for their sterility-inducing effects on the legume aphid *Aphis craccivora* Koch showed that tetracycline and sulphanilamide at 0.2% concentration could diminish the fertility rate by 60.0 and 55.8% respectively.

Penicillin both as sodium and pottassium salts and sulphaguanidene were not able to reduce the fertility but on the other hand enhanced it from 1.0 to 13.9%. The other substances viz. chlortetracycline, chloramphenicol, erythromycin, streptomycin, sulphadimidene and sulphacetamide were having reduced effect in diminishing the fecundity of the aphid. Among the methods of application tested, the treatment for the combination of systemic and contact effects had much pronounced efficacy than either of them individually. The effect was progressively increased from the first to the third generation of the insect, the reduction in the third generation being 13.5% from the first. However the difference between the chemicals was consistently maintained in the three generations and three methods of application.

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