REVERSION OF SUSCEPTIBILITY TO METHAMIDOPHOS IN THE PAKISTANI POPULATIONS OF COTTON WHITEFLY, *BEMISIA TABACI*

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Abstract

Resistance to methamidophos in the Pakistani populations of cotton whitefly, *Bemisia tabaci* was monitored continually from 1992 through 2000 using a leaf-dip method. A very high methamidophos resistance was encountered from 1992 to 1996. This resistance then fell sharply during 1997 to 1999 until the whitefly populations almost reverted to susceptibility in the year 2000. This reversion was mainly attributed to a major replacement of methamidophos by novel chemistries for whitefly control and adoption of better insecticide resistance management practices by the farmers. A rotation of effective chemistries, with different modes of action, along with the exploitation of non-chemical control methods for whitefly is recommended to prevent the development of resistance to methamidophos and other compounds.

Introduction

The cotton whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), has been a key pest of cotton, vegetables and summer legumes in Pakistan and threatening their production under favorable conditions. Methamidophos was the first choice of farmers for whitefly control during 1980s. It provided an excellent control of whiteflies and other sucking pests attacking cotton and other crops. It further gained popularity among farmers due to reduction in its prices after the introduction of generic scheme of pesticides in Pakistan. About 40 companies were selling it at very competitive rates. Methamidophos was an insecticide to be mixed in nearly every spray to keep the crop clean from all the sucking pests. By its such an extensive and intensive use a high level of whitefly resistance developed to methamidophos in *B. tabaci* in early nineties (Cahill et al., 1994; Ahmad et al., 1999). The present paper reports the chronological sequence of this resistance from 1992 to 2000.

Materials and Methods

Adult whiteflies were collected from different crops in the southern Punjab within a radius of 50km from Multan. Whiteflies were sampled randomly across a 2-ha block of a particular crop. Adults were collected with a battery-operated aspirator in the early hours of morning. Samples were pooled in wide mouth jars (11x11x19cm) and transferred to the laboratory in a cool-box to prevent damage. The whiteflies were used for bioassays within a couple of hours after receiving in the laboratory. Before treatment the jars were inverted (mouth down on a table) so that healthy individuals would climb to the top due to positive phototaxis. Disabled and dead individuals at the bottom were discarded.

The formulated methamidophos, Sundaphos 50% SCW (soluble concentrate in water) was obtained from Pakistan Agrochemicals (Private), Limited. The testing technique corresponded to that described by Dittrich et al. (1985). It is based on exposure of whitefly adults of both sexes to treated leaf disks (4cm diameter) that are laid flat on about 1mm thick layer of agar in plastic petri dishes. Disks of cotton leaves were dipped into an ascending sequence of test concentrations of methamidophos for 10s. Whiteflies were briefly immobilized with carbon dioxide, and transferred about 25-30 adults per dish. Deep petri dishes of the same size were used as lids with mesh-covered holes on either side for ventilation. Treatment with each concentration was replicated four times along with a similar untreated check. Serial dilutions of methamidophos were used at 0.4-fold intervals. After the treatment the laboratory temperature was maintained at 25±2°C with a photoperiod of 14:10 (L: D) hour.

Mortality was assessed after 24h. Results were expressed as percentage mortalities, correcting for untreated (check) mortalities using Abbott's formula. Data were analyzed on the computer by probit analysis according to Finney (1971). To determine resistance factors (RFs), lethal concentration (LC) values for each population were divided by the corresponding LC values for the Multan-5 population.

Results and Discussion

Multan-5 population showed the lowest LC values of methamidophos and a steeper slope of the regression line. It was therefore used as a reference strain for baseline. Its LC_{50} (6.8ppm) was quite close to the baseline of 5.9ppm reported by Dittrich et al. (1990a) on a susceptible laboratory strain of *B. tabaci* from Sudan. However, the slope of Multan-5 population is lower than that of Sudanese strain, which is typical of field populations. The LC values of Shershah-5 and Lar-3 populations tested in 2000 were near the Multan-5 population and did not differ significantly.

When the monitoring of *B. tabaci* resistance was initiated in 1992, resistance was already very high to methamidophos. It remained very high from 1992 to 1996 (83- to 576-fold at LC_{50} and 114- to 3824-fold at LC_{90}) (Table 1). The resistance was usually much higher at LC_{90}s than at LC_{50}s because of low slopes of regression lines. Very high levels of resistance to methamidophos were also recorded in the whitefly populations from Sudan, Turkey and Guatemala (Dittrich et al., 1990a).

From 1997 to 1999, methamidophos resistance declined progressively and then, by 2000, all the four populations tested became almost susceptible. It may be attributed to reduction in the use of methamidophos due to its poor performance against whiteflies owing to resistance development, shift towards new chemistries with novel modes of action and having no cross resistance to methamidophos or conventional chemistries, and adoption of better insecticide resistance management practices. A similar declining trend was also reported with respect to cypermethrin resistance in Pakistani whiteflies (Ahmad et al., 2000).

The occurrence of a very high methamidophos resistance in Pakistani whiteflies during 1992 to 1996 probably owed to the presence of multiple resistance due to more than one mechanism. However, synergism studies on resistant whiteflies from Pakistan did not indicate that metabolic detoxification was involved in imparting resistance to methamidophos (Ahmad et al., 1999). Mechanisms of resistance to other organophosphates in *B. tabaci* have been found to be due to insensitive acetylcholinesterases (Dittrich et al., 1985, 1990b; Byrne and Devonshire, 1993; Byrne et al., 1994), esterases (Disttrich et al., 1985, 1990b; Horowitz et al., 1988; Prabhaker et al., 1988; Cahill et al., 1995) and monooxygenases (Prabhaker et al., 1988; Dittrich et al., 1990b).

The development of a high methamidophos resistance in the cotton whitefly from Pakistan represents a typical case of resistance development in a pest due to excessive use of a toxicant over a long period. When the selection pressure by methamidophos was relaxed due to its reduced use and replacement by new chemistries, which were not cross resistant to the selecting agent, resistance in Pakistani *B. tabaci* reverted back to susceptibility within four years. This is in concurrence with the popular resistance management strategy of the rotational use of insecticides with different modes of action. A judicious rotation of effective chemistries coupled with the use of non-chemical control methods should thus be an integral part of any integrated pest management strategy for whitefly control.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:874-876 (2001)
National Cotton Council, Memphis TN

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Table 1. Toxicity of methamidophos to field populations of adult *Bemisia tabaci* using leaf-dip method.

Location	Host plant	Date collected	No. tested	Slope ± S.E	LC_{50}, ppm (95% FL)	RF at LC_{50}	LC_{90}, ppm (95% FL)	RF at LC_{90}
Multan-1	Cotton	Oct. 92	2219	1.10 ± 0.04	1158 (1019-1317)	171	16927 (13135-21815)	474
Bosan-1	Squash	Dec. 92	934	1.33 ± 0.07	1560 (1311-1857)	230	14241 (10728-18903)	399
Shershah-1	Brinjal	May 93	871	1.66 ± 0.09	691 (599-796)	102	4075 (3228-5144)	114
Jehanian-1	Cotton	Aug. 93	1402	1.38 ± 0.11	2210 (1332-3665)	326	18756 (7975-44112)	525
Khanewal-1	Brinjal	Mar. 94	858	1.25 ± 0.07	704 (582-853)	104	7433 (5482-10079)	208
Shershah-2	Brinjal	June 94	1837	0.77 ± 0.06	2904 (1574-5356)	429	136526 (40372-461685)	3824
Multan-2	Cotton	Oct. 94	1255	1.12 ± 0.05	2180 (1834-2592)	322	30363 (22634-40733)	851
Multan-3	Brinjal	July 95	795	1.62 ± 0.17	3430 (2173-5414)	507	21291 (10274-44124)	596
Shershah-3	Cotton	Sep. 95	984	1.28 ± 0.07	666 (559-794)	98	6676 (5016-8885)	187
Khokhran-1	Brinjal	Nov. 95	796	1.26 ± 0.07	3902 (3197-4763)	576	40622 (29615-55720)	1138
Shujabad-1	Squash	Jan. 96	807	1.32 ± 0.08	1663 (1375-2011)	246	15513 (11511-20907)	435
Bosan-2	Cotton	Aug. 96	814	1.46 ± 0.13	560 (367-854)	83	4241 (2156-8339)	119
Lar-1	Brinjal	June 97	2523	0.90 ± 0.09	234 (73.7-740)	35	6301 (1228-32317)	176
Jehanian-2	Cotton	Sep. 97	867	1.36 ± 0.07	290 (242-347)	43	2531 (1885-3399)	71
Shershah-4	Cotton	Oct. 97	906	1.19 ± 0.07	268 (222-324)	40	3190 (2313-4399)	89
Khanewal-2	Cotton	July 98	1000	1.53 ± 0.13	225 (151-335)	33	1543 (805-2958)	43
Lar-2	Cotton	Sep. 98	979	1.60 ± 0.12	215 (155-298)	32	1363 (804-2308)	38
Bosan-3	Brinjal	Mar. 99	1113	1.33 ± 0.07	194 (165-227)	29	1792 (1387-2315)	50
Khokhran-2	Cotton	Sep. 99	630	1.56 ± 0.10	104 (86.1-125)	15	686 (511-921)	19
Shujabad-2	Brinjal	Oct. 99	609	1.51 ± 0.10	189 (157-226)	28	1335 (980-1819)	37
Multan-4	Squash	Dec. 99	778	1.52 ± 0.15	133 (81.8-217)	20	927 (416-2064)	26
Bosan-4	Brinjal	June 00	717	1.32 ± 0.09	30.9 (25.4-37.6)	4.6	290 (211-399)	8.1
Shershah-5	Cotton	Sep. 00	625	1.90 ± 0.12	14.1 (12.2-16.4)	2.1	66.9 (53.0-84.5)	1.9
Lar-3	Brinjal	Oct. 00	798	1.31 ± 0.14	9.61 (5.40-17.1)	1.4	90.9 (32.8-252)	2.5
Multan-5	Squash	Dec. 00	628	1.77 ± 0.19	6.77 (4.38-10.5)	1.0	35.7 (17.4-73.5)	1.0