Resistant Pest Management Newsletter

A Biannual Newsletter of the **Center for Integrated Plant Systems (CIPS)** in Cooperation with the **Insecticide Resistance Action Committee (IRAC)** and the **Western Regional Coordinating Committee (WRCC-60)**

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Letter from the Editors

This issue is highlighted with several timely contributions concerning the USA Action Plan for controlling the sweetpotato whitefly, resistance reports from China, Madagascar, Michigan USA, Australia, Texas USA, and IRAC international's communications and minutes. In addition, the Gordon Research Conference and Latin American Workshop on pest resistance management are announced. Finally, we are presenting a backlog of citations that we have accumulated since the 1993 issues. We thank all of the contributors, and recognize that their efforts make this Newsletter possible. We would also like to express our appreciation to both the IRAC central committee's increased support for the Newsletter, and the emergency help from IRAC-US that enabled us to mail this edition out on time. Thank you for all the help.

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Resistance Management from around the Globe

The Preliminary Biochemical Analyses of Resistance of the Cotton Bollworm in China

The cotton bollworm, *Heliothis armigera* (Hubner), is an important pest during the squareboll period of the cotton growth cycle. Up to now, this insect has developed resistance to several groups of conventional insecticides such as pyrethroids, organophospates, and carbamates in Australia, Thailand, India, Indonesia, and Turkey. In 1989, the cotton bollworm developed resistance to the pyrethroids deltamethrin and fenvalerate in China. In this paper, the preliminary biochemical analysis of resistance was made.

The biochemical analysis and comparison of the MFO epoxidase activities of the sixth instar bollworm midgut for both the resistant colony collected Liaocheng County, Shandong Province and the susceptible colony collected Siyang County, Jiangsu Province, together with synergism studies with PBO (piperonyl butoxide) to fenvalerate revealed that the increase of the epoxidase activities was one of the factors that caused resistance. The MFO epoxidase activities in the midgut of resistant and susceptible colonies were 1.21 x 10-4 g/mg protein/min. and 2.21 x 10-5 g/mg protein/min., respectively. The former was 5.48 times as high as that of the latter. The toxicities of fenvalerate to resistant and susceptible larvae were synergized 4.3-fold and 1.3-fold respectively by PBO (1:10). The analysis of MFO activities both *in vivo* and *in vitro* were conduced. *In vivo*, the inhibitant ratio of PBO to MFO activity in bollworm midguts were 88.87% and 49.03% (5 hours), and *in vitro*, were 93.05% and 47.34%.

The biochemical analyses of the esterase activities of the sixth instar bollworm midguts in resistant and susceptible colonies showed that the esterase activities of midguts were 5.96 x 10-4 mM/mg protein/min. and 2.9 x 10-4 mM/mg protein/min. The former was two times as high as the latter. After examining effects of the esterase inhibitor TPP to toxicities of fenvalrate between resistant and susceptible colonies, we conclude that esterases were not significant. On the other hand, *in vivo* inhibition ratio of TPP in sixth instar bollworm midgut reduced esterase activities between resistant and susceptible colonies by 22.3% and 15.4%, respectively.

From the results obtained, it may be considered that the activities of carboxyl esterase between resistant and susceptible colonies were similar, and may have no association with pyrethroid resistance.

Tables 1, 2, 3, 4, and 5

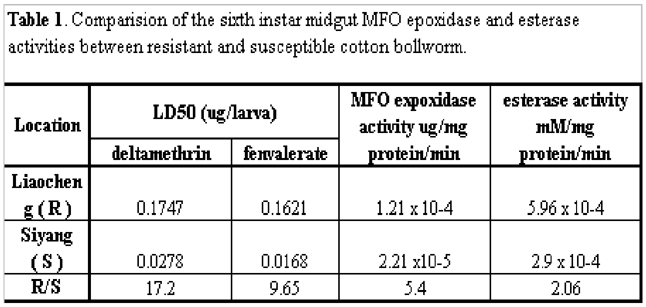

Table 1. Comparision of the sixth instar midgut MFO epoxidase and esterase activities between resistant and susceptible cotton bollworm.

Location	LD50 (ug/larva)		MFO expoxidase activity ug/mg protein/min	esterase activity mM/mg protein/min
	deltamethrin	fenvalerate		
Liaocheng (R)	0.1747	0.1621	1.21 x 10-4	5.96 x 10-4
Siyang (S)	0.0278	0.0168	2.21 x10-5	2.9 x 10-4
R/S	17.2	9.65	5.4	2.06

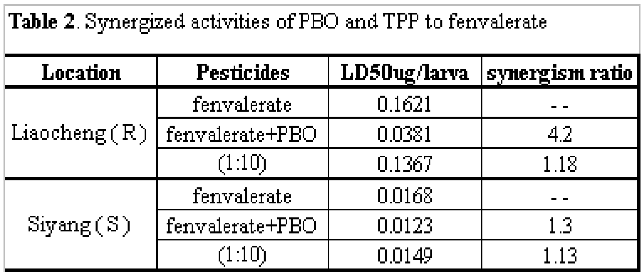

Table 2. Synergized activities of PBO and TPP to fenvalerate

Location	Pesticides	LD50ug/larva	synergism ratio
Liaocheng (R)	fenvalerate	0.1621	- -
	fenvalerate+PBO	0.0381	4.2
	(1:10)	0.1367	1.18
Siyang (S)	fenvalerate	0.0168	- -
	fenvalerate+PBO	0.0123	1.3
	(1:10)	0.0149	1.13

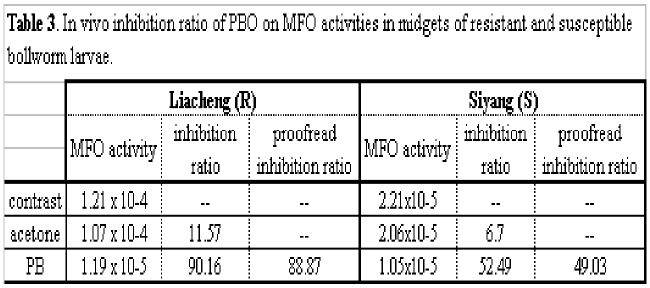

Table 3. In vivo inhibition ratio of PBO on MFO activities in midgets of resistant and susceptible bollworm larvae.

	Liacheng (R)			Siyang (S)		
	MFO activity	inhibition ratio	proofread inhibition ratio	MFO activity	inhibition ratio	proofread inhibition ratio
contrast	1.21 x 10-4	--	--	2.21x10-5	--	--
acetone	1.07 x 10-4	11.57	--	2.06x10-5	6.7	--
PB	1.19 x 10-5	90.16	88.87	1.05x10-5	52.49	49.03

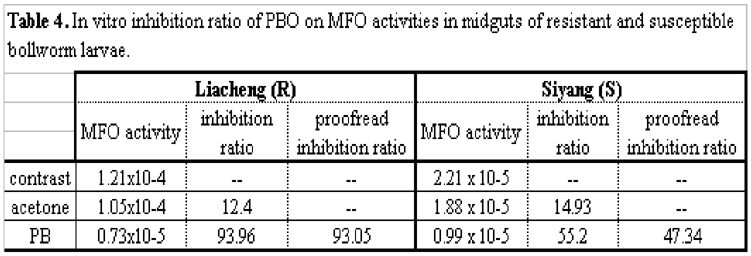

Table 4. In vitro inhibition ratio of PBO on MFO activities in midguts of resistant and susceptible bollworm larvae.

	Liacheng (R)			Siyang (S)		
	MFO activity	inhibition ratio	proofread inhibition ratio	MFO activity	inhibition ratio	proofread inhibition ratio
contrast	1.21x10-4	--	--	2.21 x 10-5	--	--
acetone	1.05x10-4	12.4	--	1.88 x 10-5	14.93	--
PB	0.73x10-5	93.96	93.05	0.99 x 10-5	55.2	47.34

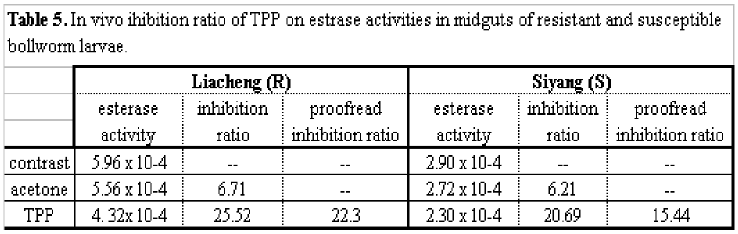

Table 5. In vivo ihibition ratio of TPP on estrase activities in midguts of resistant and susceptible bollworm larvae.

	Liacheng (R)			Siyang (S)		
	esterase activity	inhibition ratio	proofread inhibition ratio	esterase activity	inhibition ratio	proofread inhibition ratio
contrast	5.96 x 10-4	--	--	2.90 x 10-4	--	--
acetone	5.56 x 10-4	6.71	--	2.72 x 10-4	6.21	--
TPP	4. 32x 10-4	25.52	22.3	2.30 x 10-4	20.69	15.44

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Monitoring the Sensitivity to Pesticides of Some Cotton Pests in francophone Africa and Madagascar

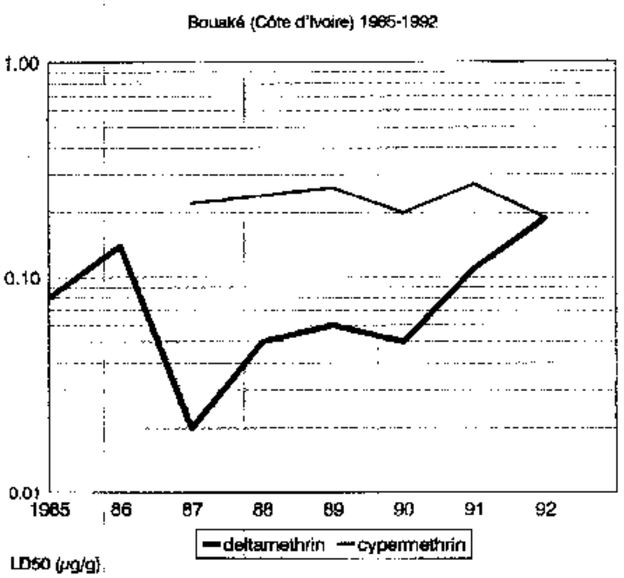
Starting in 1985, first IRCT and then the Annual Crop Department of CIRAD (CIRAD-CA), set up a network of laboratories in francophone Africa to monitor the sensitivity of the major cotton pests to insecticides. Such facilities have been set up with varying degrees of success in Côte d'Ivoire, Burkina Faso, Togo, Cameroon, Central African Republic and Chad (Pinchard & Cauquil, 1992).

These laboratories have generally been set up within the framework of national research institutions, and are in contact with the CIRAD-CA laboratory in Montpellier (France), where the following cotton insects are reared: *Helicoverpa armigera* (Hbn.), *Spodoptera littoralis* (Boisd.), *Earias* spp., *Pectinophora gossypiella* (Saund.) and *Cryptophlebia leucotreta* (Meyr.). This makes it possible not only to conserve reference strains (not exposed to pesticides), but also resistant strains.

The tests are performed by topical applications, using Arnold microapplicators, according to the method recommended by FAO (Anon. 1970). A computer program for statistical processing of the data and the determination of lethal doses (LD50 and LD90) has been developed by the Biometry-Data processing unit of CIRAD-CA.

A number of similar tests aimed at determining the sensitivity of several cotton insects to pesticides were performed before 1985 (Brader, 1970; Bournier & Peyrelongue, 1974; Vaissayre & Renou, 1978). In one case, Madagascar, it was concluded that there was loss of efficacy of organochloride compounds for the control of *Earias* spp. From 1985 to 1992, the results did not reveal decreased effectiveness of pyrethroids, used to control Lepidoptera, as can be seen in the example of *H. armigera* in Côte d'Ivoire (Fig. 1). Nevertheless there is an exception in Madagascar again, where *S. littoralis* appears to have rapidly developed a resistance to these compounds (Jacquemard, 1989).

Monitoring the sensitivity of Helicoverpa armigera to pyrethroids



Two main factors appear to limit a loss of sensitivity to pesticides among the cotton pests in Africa: first, the "dilution" of cotton fields among non sprayed areas, allowing the conservation of pesticide-free refuges for insect populations; and second, the moderate use of pesticides on the cotton crop (4 to 6 sprays per season), strictly controlled by the cotton development companies.

However, three signs indicate that the resistance problem is still relevant. There is the work carried out Bouchard et al. (1991) on vegetable crops in Burkina Faso, and the results obtained recently on cotton in Chad (Martin et al. 1993) and in Côte d'Ivoiry (Vassal, 1994). In all three situations, the sensitivity of *H. armigera* to pyrethroids seems to be decreasing.

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The Potential of Using *Barbarea vulgaris* in Insecticide-resistant Diamondback Moth Management

The diamondback moth (DBM), *Plutella xylostella* L., is a major pest of brassica crops worldwide. It can develop resistance to all pesticides that are commonly used in the field including *Bacillus thuringiensis* (Tabashnik et al. 1990). Wild hosts play an important role in maintaining DBM populations (Zhao et al. 1993). In southern Ontario and Michigan, DBM is commonly found on *Barbarea vulgaris* R. Br. in early spring in fields and pastures (Harcourt 1986, Idris (unpublished)).

The objectives of our studies were (1) to look at the influence of *B. vulgaris* on the DBM population abundance in early spring and (2) evaluate its potential in insecticide resistant management of DBM.

DBM larvae and pupae were collected from the Michigan State University Entomology Research Farm in July and August 1992. DBM were reared following ldris & Grafius (1993) with slight modification of the method of egg collection. We used aluminum foil soaked in the juice of broccoli leaves for DBM eggs oviposition. Between 190 to 210 eggs were used per treatment (50 +/- 5 eggs/replicate). Treatments were detached leaves or intact foliage of broccoli (*Brassica oleracea* L.), *B. vulgaris* R. Br., *Thalspi arvense* L. and *Capsella bursapastoris* (L.) Medic (2 x 4 factorial design). The eggs were put on intact leaves on plants or detached leaves of potted broccoli or brassica weeds raised in the greenhouse. The detached leaves were placed in 14.5 cm diameter petri dishes. Intact foliage was confined in 30 x 40 x 30 cm cages. Larvae were kept at room temperature (25 +/- 2oC) and a photo period of 16:8 (L:D). We measured percent eggs hatch, survival to second instar and to fourth instar, and total developmental time to pupation for 10 randomly selected second instars in each replicate. Each treatment had four replicates.

Mean percent egg hatch on the detached leaves of *B. vulgaris* was significantly lower than on the other treatments (Table 1). In contrast, percent egg hatch on intact leaves was somewhat higher than on detached leaves suggesting that chemical odors released by the detached leaves of *B. vulgaris* in the petri dish affected egg development. Detached or intact *B. vulgaris* leaves also showed reduced second and fourth instar DBM survival. Developmental time of surviving fourth instars was also significantly longer when fed on *B. vulgaris* than on the foods. Mustard glucosides are commonly found in the brassicaceae leaf tissues (Thorsteinson 1953). It is possible that the mustard glucoside contents of *B. vulgaris* was higher than in the other species tested and was toxic to DBM larvae especially the later instars. This effect may accumulate through feeding activity of early instars. We think that *B. vulgaris* could be used in DBM secticide-resistant in DBM management program. *B. vulgaris* seeds can be sown in the field before winter. They germinate in late April in the northern U.S. and the plants will be abundant throughout May and early June prior to planting of mid-to late-season cole crops. *B. vulgaris* is highly attractive to DBM females for oviposition (ldris, personal field observation). Any larvae surviving on *B. vulgaris* can be sprayed with a selective pesticide such as *Bacillus thuringiensis* without disrupting biological control by *Diadegma insulare* (ldris & Grafius 1993), the major parasitoid of DBM. Alternatively, B. vulgaris could be killed by cultivation or herbicides before DBM larvae mature. These tactics will reduce the number of insecticide-resistant DBM before the cropping season begins. Besides acting as trap crop for DBM, *B. vulgaris* also serve as excellent nectar source for *D. insulars* adults (Idris, unpublished).

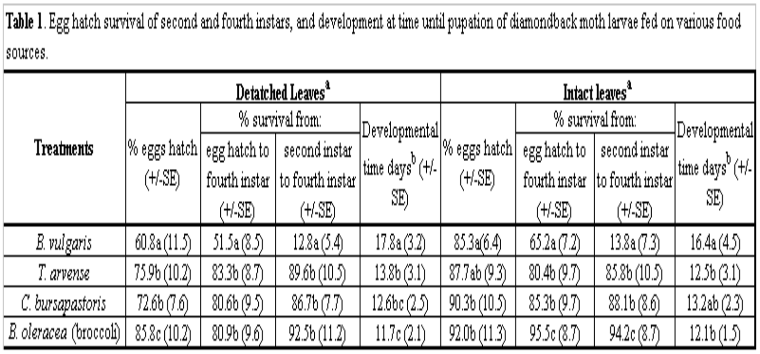

Table 1. Egg hatch survival of second and fourth instars, and development at time until pupation of diamondback moth larvae fed on various food sources.

Treatments	Detatched Leaves[a]: % eggs hatch (+/-SE)	Detatched Leaves[a]: % survival from: egg hatch to fourth instar (+/-SE)	Detatched Leaves[a]: % survival from: second instar to fourth instar (+/-SE)	Detatched Leaves[a]: Developmental time days[b] (+/-SE)	Intact leaves[a]: % eggs hatch (+/-SE)	Intact leaves[a]: % survival from: egg hatch to fourth instar (+/-SE)	Intact leaves[a]: % survival from: second instar to fourth instar (+/-SE)	Intact leaves[a]: Developmental time days[b] (+/-SE)
B. vulgaris	60.8a (11.5)	51.5a (8.5)	12.8a (5.4)	17.8a (3.2)	85.3a(6.4)	65.2a (7.2)	13.8a (7.3)	16.4a (4.5)
T. arvense	75.9b (10.2)	83.3b (8.7)	89.6b (10.5)	13.8b (3.1)	87.7ab (9.3)	80.4b (9.7)	85.8b (10.5)	12.5b (3.1)
C. bursapastoris	72.6b (7.6)	80.6b (9.5)	86.7b (7.7)	12.6bc (2.5)	90.3b (10.5)	85.3b (9.7)	88.1b (8.6)	13.2ab (2.3)
B. oleracea (broccoli)	85.8c (10.2)	80.9b (9.6)	92.5b (11.2)	11.7c (2.1)	92.0b (11.3)	95.5c (8.7)	94.2c (8.7)	12.1b (1.5)

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Glutathione Transferase Isozymes Involved in Insecticide Resistance of Diamondback Moth Larvae

In addition to the three glutathione transferase (GST) isozymes already identified in larvae of *Plutella xylostella* (L.) (Chiang and Sun 1993, Sun and Chiang 1993), a fourth one, GST-4, has been purified from a teflubenzuron (TFB)-resistant strain. This GST isozyme is similar to GST-3 in terms of biochemical and toxicological properties, GST-4, a homodimer with a subunit molecular mass of 26.6 kDa and a pI of ca.8.9, displays even stronger substrate preference than GST-3 for 1,2-dichloro-4-nitrobenzene and several organophosphorus insecticides, i.e., parathion, methyl parathion, and paraoxon. These two proteins are highly immuno-related and share at least the first 8 amino acids at N-terminus. Immunoblotting anaylsis indicate that polyclonal antiserum raised against GST-3 cross-reacts with GST-1 and GST-2 at least 40-fold less intensely than with the antigen. Using this antiserum as a probe, higher amounts and greater variations of GST-3/GST-4 have been observed in larvae of methyl parathion resistant and TFB resistant strains as compared with susceptible and fenvalerate resistant strains. Among the six lepidopterous insects examined, only *Spodoptera exigua* larvae have proteins clearly immuno-related to GST-3/GST-4 of the diamondback moth. No such cross-reactivity has been detected in *Musca domestica*, *Drosophila melanogaster* and *Aedes aegypti*.

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Esterases and Pyrethroid Resistance in Australian *Helicoverpa armigera*

Pyrethroid resistance in Australian *Helicoverpa armigera* is correlated to increased ability to hydrolyse napthyl esters. Resistant *H. armigera* have esterase enzymes which are absent from susceptible. These enzymes bind to and metabolize C14 fenvalerate. Extra esterases, detectable in all life stages, are clearly seen on polyacrylamide gels after electrophoresis. The most resistant *H. armigera* (fenvalerate ~ 300 fold) had approximately 50 times more enzyme than susceptible individuals. Such large quantities of esterase can detoxify and sequester significant amounts of pyrethroid in resistant *H. armigera*.

Individual *H. armigera* could be grouped in distinct populations according to total esterase levels. Low esterase level is correlated to pyrethroid susceptibility, medium level to intermediate resistance, and the greatest esterase levels of all to highly resistant individuals. Based on a total esterase assay, we produced a simple 10- minute 'spot test' for pyrethroid resistance in individual *H. armigera*. The assay results are easily read by eye. The results indicate "yes" or "no" to the presence of esterase resistance. If "yes" a quantitative measure of resistance is indicated. It can be performed under field conditions on any *H. armigera* life stage and only requires minimal amounts of tissue.

The accuracy of this biomedical assay for pyrethroid resistance was verified by comparison to conventional discriminating dose bioassays. Resistance frequencies, determined by biochemical or conventional assays, were not significantly different.

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The Changes of Insecticide Resistance of Rice Stem Borer, *Chilo suppressalis* (Walker)

The resistance to some organophosphorus and nereistoxin insecticides in rice stem borer (RSB), *Chilo suppressalis* (Walker), has been monitored since 1985. The insect is one of the important pests damaging rice in China. Control is heavily dependent upon chemical insecticides. Four field populations, Taihu Anhui (THAH), Anqing Anhui (AQAH), Xinghua Jiangsu (XHJS), Yangzhou Jiangsu (YZJS) and other populations were tested with the topical application method recommended by FAO (1980). The results indicated that the THAH population was the most susceptible population to all tested insecticides and showed little change from 1988 to 1993. The other field populations were obviously resistant to methamidophos, trichlorphon, Chachongdan (SCD) and dimehypo. But no obvious resistance was found to cartap in any tested populations.

The change in response of RSB to methamidophos and trichlorphon

Table 1 indicates that all field populations tested except the THAH population have developed moderate to high level resistance to methamidophos. Methamidophos is one of the most used conventional insecticide to control RSB. The highest level of resistance was 26.0 for the XHJS population, compared to the susceptible THAH population. The changes in response, from 1985 to 1992, in the four populations are shown in Fig. 1. The highest resistance was detected in 1989. After 1989 the resistance level gradually decreased. The response to methamidophos in the susceptible population remained similar throughout the study.

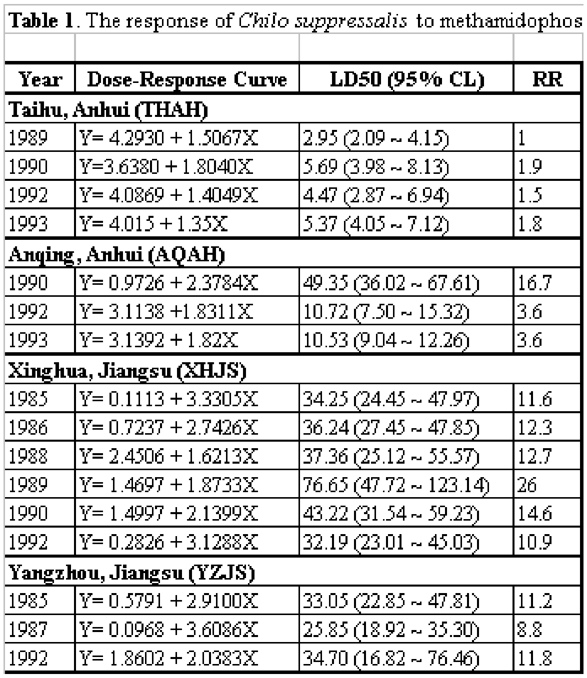

Table 1. The response of *Chilo suppressalis* to methamidophos

Year	Dose-Response Curve	LD50 (95% CL)	RR
Taihu, Anhui (THAH)			
1989	$Y= 4.2930 + 1.5067X$	2.95 (2.09 ~ 4.15)	1
1990	$Y=3.6380 + 1.8040X$	5.69 (3.98 ~ 8.13)	1.9
1992	$Y= 4.0869 + 1.4049X$	4.47 (2.87 ~ 6.94)	1.5
1993	$Y= 4.015 + 1.35X$	5.37 (4.05 ~ 7.12)	1.8
Anqing, Anhui (AQAH)			
1990	$Y= 0.9726 + 2.3784X$	49.35 (36.02 ~ 67.61)	16.7
1992	$Y= 3.1138 +1.8311X$	10.72 (7.50 ~ 15.32)	3.6
1993	$Y= 3.1392 + 1.82X$	10.53 (9.04 ~ 12.26)	3.6
Xinghua, Jiangsu (XHJS)			
1985	$Y= 0.1113 + 3.3305X$	34.25 (24.45 ~ 47.97)	11.6
1986	$Y= 0.7237 + 2.7426X$	36.24 (27.45 ~ 47.85)	12.3
1988	$Y= 2.4506 + 1.6213X$	37.36 (25.12 ~ 55.57)	12.7
1989	$Y= 1.4697 + 1.8733X$	76.65 (47.72 ~ 123.14)	26
1990	$Y= 1.4997 + 2.1399X$	43.22 (31.54 ~ 59.23)	14.6
1992	$Y= 0.2826 + 3.1288X$	32.19 (23.01 ~ 45.03)	10.9
Yangzhou, Jiangsu (YZJS)			
1985	$Y= 0.5791 + 2.9100X$	33.05 (22.85 ~ 47.81)	11.2
1987	$Y= 0.0968 + 3.6086X$	25.85 (18.92 ~ 35.30)	8.8
1992	$Y= 1.8602 + 2.0383X$	34.70 (16.82 ~ 76.46)	11.8

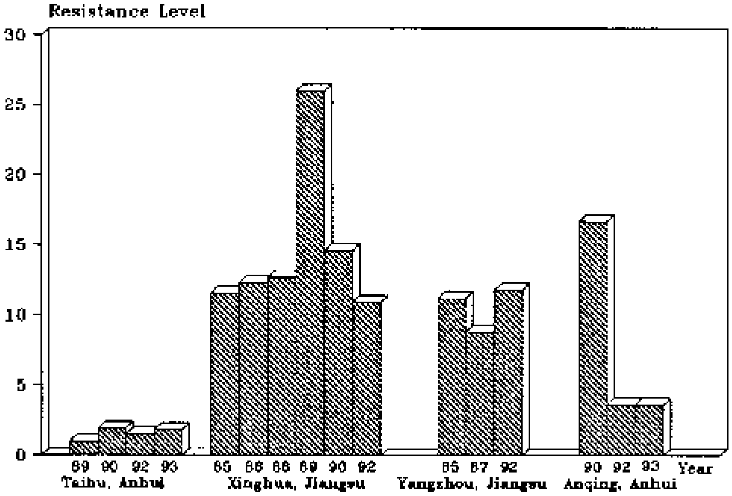

Fig. 1 The Change of Resistance Level to Methamidophos

The resistance to trichlorphon (Table 2) in all tested populations was much lower than that to methamidophos . The highest resistance (8.7 fold) was detected in the population of XHJS in 1989. This was the same year that the highest methamidophos resistance occurred. Fig. 2 shows that the changes in resistance to trichlorphon were similar to changes in resistance to methamidophos. The resistance level increased before 1989 and decreased after 1989.

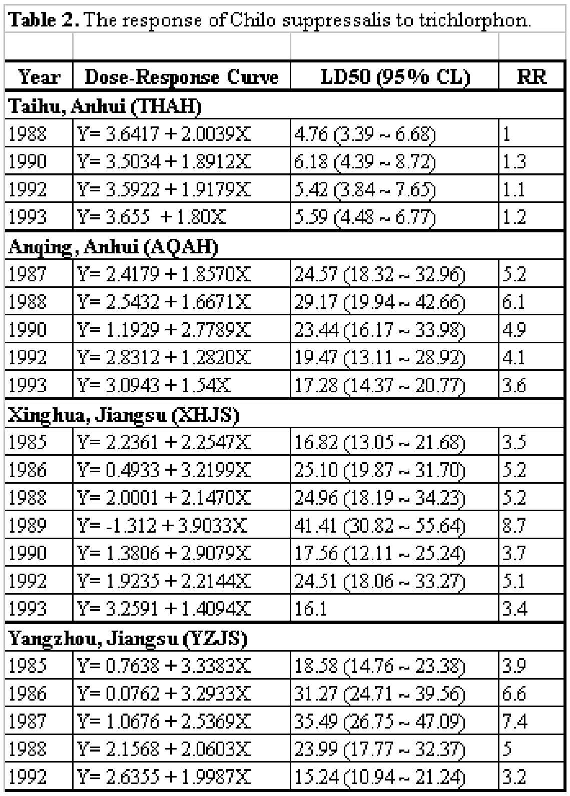

Table 2. The response of Chilo suppressalis to trichlorphon.

Year	Dose-Response Curve	LD50 (95% CL)	RR
Taihu, Anhui (THAH)			
1988	$Y= 3.6417 + 2.0039X$	4.76 (3.39 ~ 6.68)	1
1990	$Y= 3.5034 + 1.8912X$	6.18 (4.39 ~ 8.72)	1.3
1992	$Y= 3.5922 + 1.9179X$	5.42 (3.84 ~ 7.65)	1.1
1993	$Y= 3.655 + 1.80X$	5.59 (4.48 ~ 6.77)	1.2
Anqing, Anhui (AQAH)			
1987	$Y= 2.4179 + 1.8570X$	24.57 (18.32 ~ 32.96)	5.2
1988	$Y= 2.5432 + 1.6671X$	29.17 (19.94 ~ 42.66)	6.1
1990	$Y= 1.1929 + 2.7789X$	23.44 (16.17 ~ 33.98)	4.9
1992	$Y= 2.8312 + 1.2820X$	19.47 (13.11 ~ 28.92)	4.1
1993	$Y= 3.0943 + 1.54X$	17.28 (14.37 ~ 20.77)	3.6
Xinghua, Jiangsu (XHJS)			
1985	$Y= 2.2361 + 2.2547X$	16.82 (13.05 ~ 21.68)	3.5
1986	$Y= 0.4933 + 3.2199X$	25.10 (19.87 ~ 31.70)	5.2
1988	$Y= 2.0001 + 2.1470X$	24.96 (18.19 ~ 34.23)	5.2
1989	$Y= -1.312 + 3.9033X$	41.41 (30.82 ~ 55.64)	8.7
1990	$Y= 1.3806 + 2.9079X$	17.56 (12.11 ~ 25.24)	3.7
1992	$Y= 1.9235 + 2.2144X$	24.51 (18.06 ~ 33.27)	5.1
1993	$Y= 3.2591 + 1.4094X$	16.1	3.4
Yangzhou, Jiangsu (YZJS)			
1985	$Y= 0.7638 + 3.3383X$	18.58 (14.76 ~ 23.38)	3.9
1986	$Y= 0.0762 + 3.2933X$	31.27 (24.71 ~ 39.56)	6.6
1987	$Y= 1.0676 + 2.5369X$	35.49 (26.75 ~ 47.09)	7.4
1988	$Y= 2.1568 + 2.0603X$	23.99 (17.77 ~ 32.37)	5
1992	$Y= 2.6355 + 1.9987X$	15.24 (10.94 ~ 21.24)	3.2

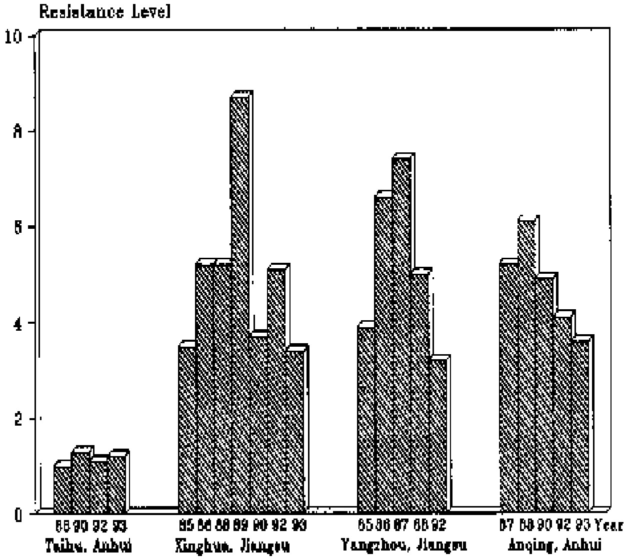

Fig. 2 The Change of Resistance Level to Trichlorphon

The change in response of RSB to nereistoxin insecticides

The response of RSB to three nereistoxin insecticides (SCD, dimehypo and cartap) was monitored from 1985 to 1993. SCD and dimehypo are frequently used in the field control of RSB because they are cheaper than any other chemicals. RSB resistance to SCD was detected in the AQAH, XHJS, and YZJS populations (Table 3). The highest level of resistance was 12.6 and 11.4, in the XHJS and YZJS populations, respectively. It is interesting that the pattern of SCD resistance is different from the pattern for methamidophos and trichlorphon resistance (Fig. 3). Overall the SCD resistance in all tested populations appears to be gradually increasing.

Table 3. The response of *Chilo suppressalis* to Shachongdan (SCD).

Year	Dose-Response Curve	LD50 (95% CL)	RR
Taihu, Anhui (THAH)			
1988	Y= 4.2907 + 1.9257X	2.33 (1.74 ~ 3.12)	1
1989	Y= 4.0330 + 1.7446X	3.58 (2.48 ~ 5.17)	1.5
1990	Y= 3.6112 + 2.0450X	4.78 (3.45 ~ 6.60)	2
1992	Y= 3.6324 + 2.0768X	4.55 (3.31 ~ 6.27)	1.9
1993	Y= 3.7067 + 1.72X	5.65 (4.49 ~ 7.11)	2.4
Anqing, Anhui (AQAH)			
1987	Y= 3.2391 + 2.1188X	6.78 (4.93 ~ 9.31)	2.9
1988	Y= 3.9430 + 1.0728X	9.67 (5.72 ~ 16.34)	4.1
1990	Y= 2.4953 + 2.0085X	17.67 (13.44 ~ 23.21)	7.6
1992	Y= 2.6361 + 2.2968X	10.70 (7.95 ~ 14.38)	4.6
1993	Y= 3.2477 + 1.66X	11.37 (8.97 ~ 14.39)	4.9
Xinghua, Jiangsu (XHJS)			
1985	Y= 2.4794 + 2.3807X	11.45 (8.46 ~ 15.49)	4.9
1988	Y= 1.5190 + 2.6522X	20.54 (13.98 ~ 30.16)	8.8
1990	Y= 2.0006 + 2.0416X	29.45 (21.29 ~ 40.74)	12.6
1992	Y= 2.5088 + 1.9017X	20.42 (14.12 ~ 29.53)	8.7
1993	Y= 2.3381 + 2.0004X	21.41	9.2
Yangzhou, Jiangsu (YZJS)			
1987	Y= 1.9743 + 2.1232X	26.61 (19.29 ~ 36.70)	11.4
1992	Y= 2.0751 + 21444X	23.12 (16.83 ~ 31.75)	9.9

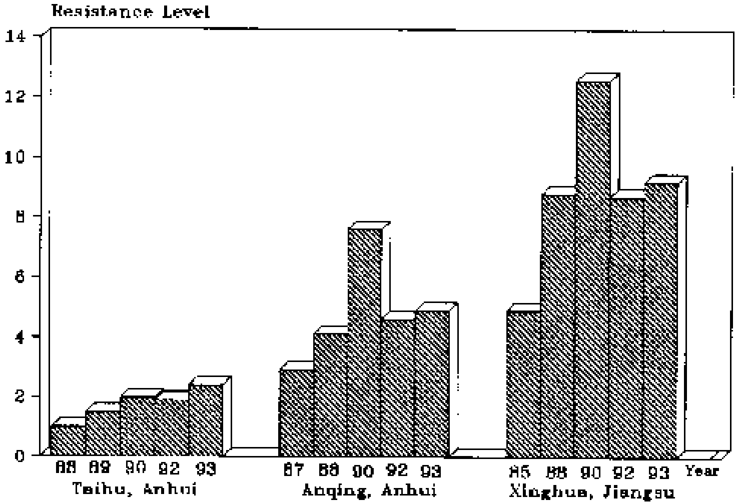

Fig. 3 The Change of Resistance Level to Shachongdac(SCD)

Table 4 shows that all tested populations have developed moderate resistance to dimehypo with resistance ratios ranging from 7.3 to 14.2. No obvious resistance to cartap was found any of the field populations tested (Table 5). This insecticide is not applied for field control of RSB. RSB with resistance to SCD and dimehypo do not show cross resistance to cartap. We suggest that cartap can be used as an alternative insecticide to replace SCD and dimehypo.

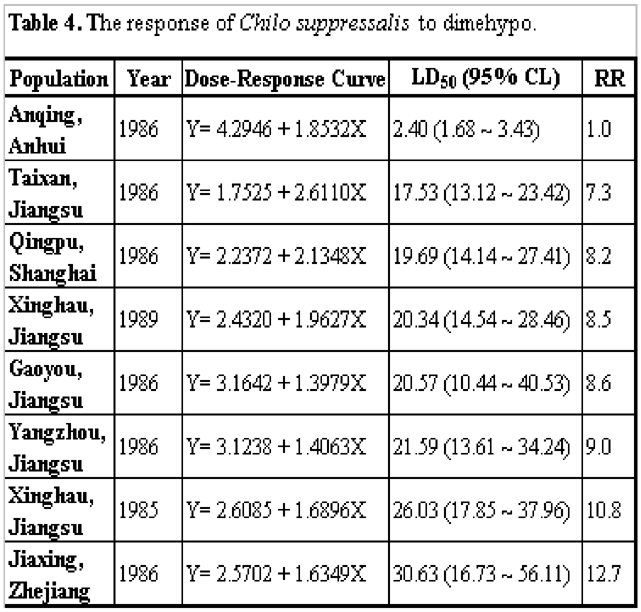

Table 4. The response of *Chilo suppressalis* to dimehypo.

Population	Year	Dose-Response Curve	LD_{50} (95% CL)	RR
Anqing, Anhui	1986	Y= 4.2946 + 1.8532X	2.40 (1.68 ~ 3.43)	1.0
Taixan, Jiangsu	1986	Y= 1.7525 + 2.6110X	17.53 (13.12 ~ 23.42)	7.3
Qingpu, Shanghai	1986	Y= 2.2372 + 2.1348X	19.69 (14.14 ~ 27.41)	8.2
Xinghau, Jiangsu	1989	Y= 2.4320 + 1.9627X	20.34 (14.54 ~ 28.46)	8.5
Gaoyou, Jiangsu	1986	Y= 3.1642 + 1.3979X	20.57 (10.44 ~ 40.53)	8.6
Yangzhou, Jiangsu	1986	Y= 3.1238 + 1.4063X	21.59 (13.61 ~ 34.24)	9.0
Xinghau, Jiangsu	1985	Y= 2.6085 + 1.6896X	26.03 (17.85 ~ 37.96)	10.8
Jiaxing, Zhejiang	1986	Y= 2.5702 + 1.6349X	30.63 (16.73 ~ 56.11)	12.7

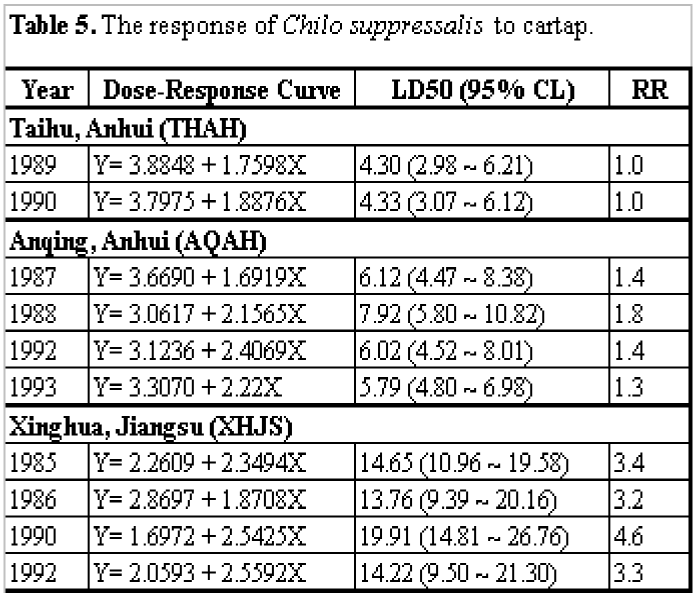

Table 5. The response of *Chilo suppressalis* to cartap.

Year	Dose-Response Curve	LD50 (95% CL)	RR
Taihu, Anhui (THAH)			
1989	Y= 3.8848 + 1.7598X	4.30 (2.98 ~ 6.21)	1.0
1990	Y= 3.7975 + 1.8876X	4.33 (3.07 ~ 6.12)	1.0
Anqing, Anhui (AQAH)			
1987	Y= 3.6690 + 1.6919X	6.12 (4.47 ~ 8.38)	1.4
1988	Y= 3.0617 + 2.1565X	7.92 (5.80 ~ 10.82)	1.8
1992	Y= 3.1236 + 2.4069X	6.02 (4.52 ~ 8.01)	1.4
1993	Y= 3.3070 + 2.22X	5.79 (4.80 ~ 6.98)	1.3
Xinghua, Jiangsu (XHJS)			
1985	Y= 2.2609 + 2.3494X	14.65 (10.96 ~ 19.58)	3.4
1986	Y= 2.8697 + 1.8708X	13.76 (9.39 ~ 20.16)	3.2
1990	Y= 1.6972 + 2.5425X	19.91 (14.81 ~ 26.76)	4.6
1992	Y= 2.0593 + 2.5592X	14.22 (9.50 ~ 21.30)	3.3

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Mechanisms of Resistance in the Tobacco Budworm to Organophosphorus, Carbamate, and Cyclodiene Insecticides

Resistance of tobacco budworm (TBW), *Heliothis virescens* (F.) to pyrethroid and nonpyrethroid insecticides is widely documented (Plapp & Campanhola 1986, Luttrell et al. 1987, Kanga et al. 1992, Elzen et al. 1992). Strategies have been developed and implemented in the Midsouth and Southwest to manage this resistance. The refinement of resistance management strategy and development of resistance countermeasures are dependent on an appreciation of the nature, frequency and evolution of resistance mechanisms in field populations of pest insects (Brent 1986). Here, we describe research to identify biochemical mechanisms involved in organophosphate, carbamate, and cyclodiene resistance in field-collected TBW.

Mechanisms of resistance in the TBW to organophosphates and carbamates:

Results of bioassays with the metabolic inhibitors PBO, DEF, fenoxcarb (Table1) indicated no significant increase of toxicity of profenofos to any strain of TBW. Therefore, enhanced metabolism does not appear to be the major mechanism of resistance to profenofos. In contrast, the results of AChE inhibition assays (Figures 1 & 2) shows that resistant TBW acetylcholinesterase was 7-9-fold less sensitive than susceptible TBW to inhibition by tetrachlorvinfos and methomyl, respectively. This finding suggested that target site insensitivity is more likely the major mechanism of resistance.

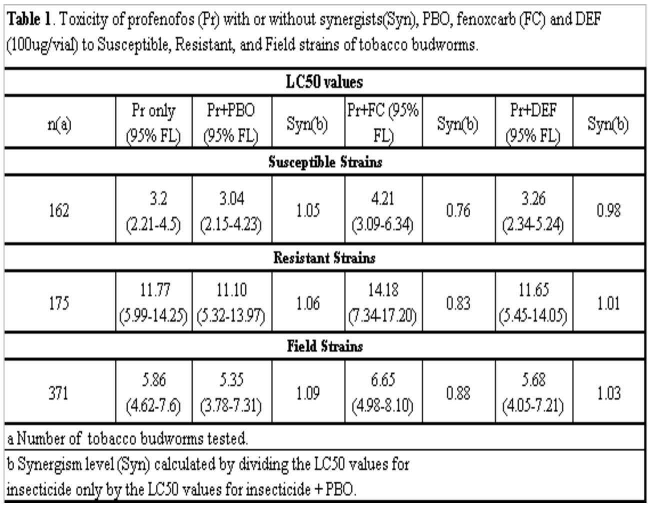

Table 1. Toxicity of profenofos (Pr) with or without synergists(Syn), PBO, fenoxcarb (FC) and DEF (100ug/vial) to Susceptible, Resistant, and Field strains of tobacco budworms.

LC50 values							
n(a)	Pr only (95% FL)	Pr+PBO (95% FL)	Syn(b)	Pr+FC (95% FL)	Syn(b)	Pr+DEF (95% FL)	Syn(b)
Susceptible Strains							
162	3.2 (2.21-4.5)	3.04 (2.15-4.23)	1.05	4.21 (3.09-6.34)	0.76	3.26 (2.34-5.24)	0.98
Resistant Strains							
175	11.77 (5.99-14.25)	11.10 (5.32-13.97)	1.06	14.18 (7.34-17.20)	0.83	11.65 (5.45-14.05)	1.01
Field Strains							
371	5.86 (4.62-7.6)	5.35 (3.78-7.31)	1.09	6.65 (4.98-8.10)	0.88	5.68 (4.05-7.21)	1.03

a Number of tobacco budworms tested.

b Synergism level (Syn) calculated by dividing the LC50 values for insecticide only by the LC50 values for insecticide + PBO.

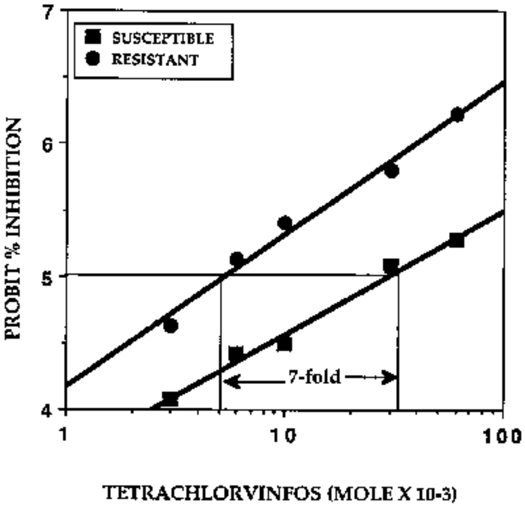

Figure 1. Inhibition of acetylcholinesterase activity in adult tobacco budworms by tetrachlorvinfos (Rabon). Values are in probit units, n= 6-10 replicates.

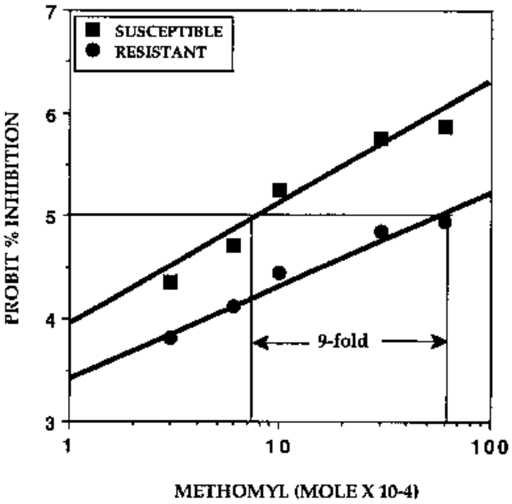

Figure 2. Inhibition of acetylcholinesterase activity in adult tobacco budworms by methomyl. Values are in probit units, n= 6-10 replicates.

Resistance patterns of endosulfan and dieldrin:

The proportion of TBW resistant to endosulfan and dieldrin were similar in field collected populations and the toxicities of dieldrin and endosulfan to TBW (Figure 3) were highly correlated (r > 0.98). Since dieldrin resistance has been attributed to target site insensitivity (ffrench - Constant & Rocheleau 1992), it follows that endosulfan resistance is also attributed to target site insensitivity.

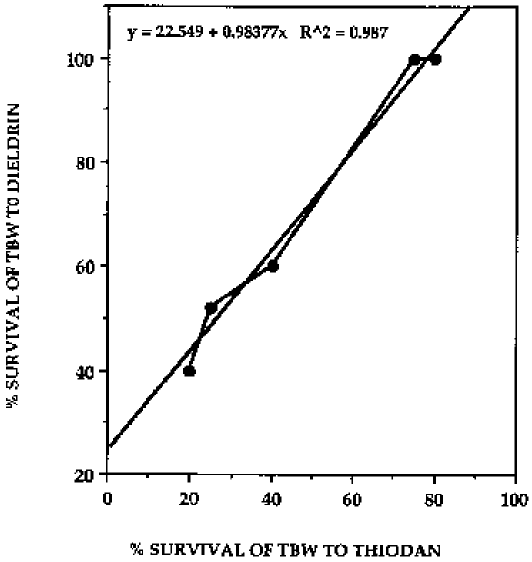

Figure 3. Relationships between the toxicity of endosulfan and dieldrin to adult tobacco budworms.

Insecticide uptake and metabolism in the TBW:

Results of cuticular penetration measurements with radio labelled profenofos in both resistant and susceptible TBW showed that the resistant strain sloughed off more radioactivity than a susceptible strain during the first hour after termination of a 30 min. exposure to a sub lethal residue of profenofos in a glass vial (Figure 4). At 24 hours, resistant TBW contained less radioactivity than susceptible TBW; further evidence for a decrease in rate of penetration. A change in cuticular permeability may supplement resistance provided by other mechanisms (Plapp & Hoyer 1968).

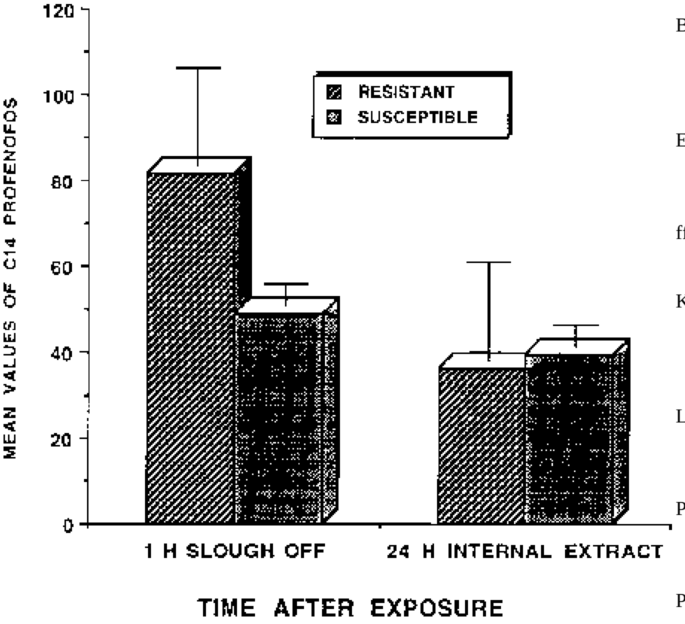

Figure 4. External extract (1 h) and internal extract (24 h) of radiolabelled profenofos obtained from susceptible and resistant tobacco budworms after 30 min exposure in glass vials.

The lack of synergism of profenofos by PBO and the difference in AChE inhibition by a phosphate (4-7 fold) and a carbamate (5-9 fold) between resistant and susceptible TBW indicated that target site insensitivity was the major mechanism of resistance to organophosphate (OP) and carbamate insecticides. High correlation of the toxicities of endosulfan and dieldrin to TBW, suggested similarity of the mechanisms of resistance to these insecticides. Measurement of penetration, excretion and total metabolism of radio labelled profenofos indicated that a change in cuticular permeability might be a complementary resistance factor in TBW.

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Monitoring for Resistance in the Tobacco Budworm to Organophosphorus, Carbamate, and Cyclodiene Insecticides

The tobacco budworm (TBW), *Heliothis virescens* (F.) has developed resistance to nearly every class of insecticides used in cotton (Plapp & Campanhola 1986, Allen et al. 1987). An adult vial test is used to monitor for resistance to pyrethroid insecticides. This technique is particularly useful when resistance is target site rather than metabolic, and expressed in all life stages (Plapp et al. 1987). Recently, resistance to organophosphorus (OP), carbamate, and cyclodiene insecticides was documented in adult TBW in several states (Kanga et al. 1992, Elzen et al. 1992).

The success of any insecticide resistance management plan depends upon the availability of an efficient technique to monitor for resistance to them (Kanga et al. 1993). Most OP, carbamate and cyclodiene residues are less stable than pyrethroid residues, and most residues on the glass vial surface do not last long enough to be useful under field conditions. In this study, we describe a solution to the residue problem which allows use of an adult vial test to monitor for resistance to non persistent insecticides in the tobacco budworm.

Stability of insecticide residues in glass vials:

In initial tests with profenofos, the toxicities of treated vials stored at room temperature or in a freezer were compared. Data indicated that the toxicity of profenofos disappeared in glass vials by 2 days at room temperature, but remained for more than 60 days in vials treated with profenofos plus benzoic acid and stored at room temperature or in the freezer (Fig 1). The addition of benzoic acid extended residue life in glass vials, and allowed entomologists to monitor for resistance to non persistent insecticides under field conditions (Fig. 1). Treating the vials with benzoic acid and storing them in the freezer is the preferred technique. Similar results were obtained with chlorpyrifos, methomyl, endosulfan, and azinphosmethyl (Kanga et al. 1993, 1994). Resistance monitoring vials were prepared with diagnostic doses of each insecticide in combination with benzoic acid (100 g) in the laboratory, and sent to cooperators and extension entomologists located in Texas, Arkansas, Mississippi and Louisiana for nonpyrethroid resistance monitoring.

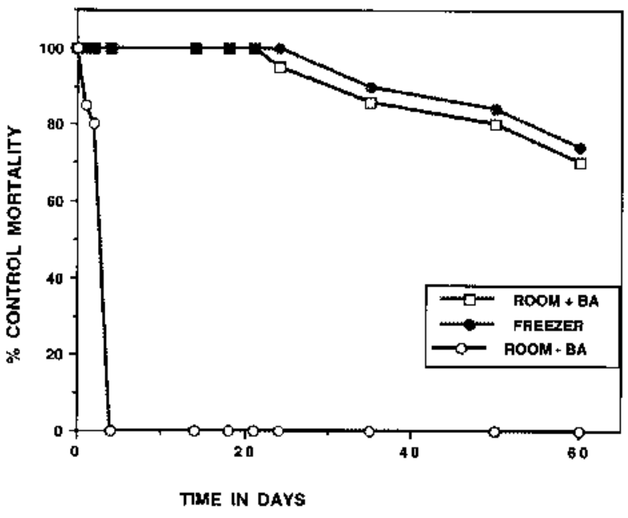

Figure 1. Toxicity to house flies of profenofos, profenofos ± benzoic acid (BA, 100 μg/vial) in vials held for different times at room temperature or in a freezer.

Field monitoring data:

The percentage survival of adult TBW males collected in Snook, TX and exposed to profenofos (25 g/vial) in 1992 is presented in Fig. 2. Analysis of results indicate that resistance was present in Texas for all test insecticides for most of the season. Resistance to profenofos and methomyl declined from June to July, increased in August, and declined again in September and October. The response patterns were similar for profenofos and methomyl. This suggests that the same mechanism conferred resistance to both insecticides. The frequency of endosulfan resistance was high early in the season with a peak in July, but dropped by the end of the season. In Arkansas, moth survival to endosulfan was relatively higher than to profenofos and methomyl (Fig. 3). This could have resulted from the use of this insecticide to control boll weevils. As in Texas, resistance frequency increased in July, peaked in August, and declined late in the season. The pattern of responses of TBW to profenofos and methomyl in Arkansas was similar. Again, this suggests a common mechanism of resistance to both insecticides.

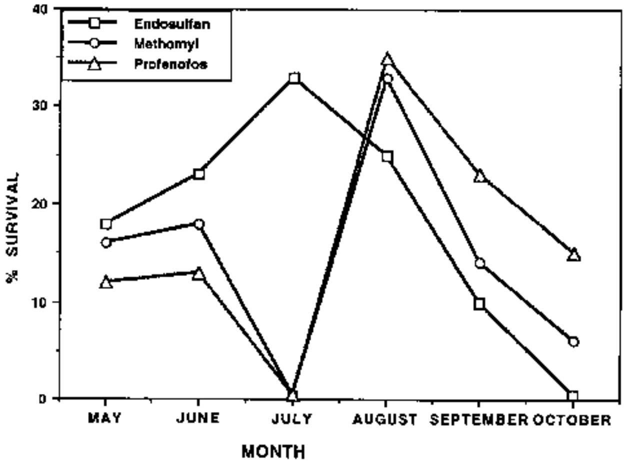

Figure 2. Percent survival of Snook, TX tobacco budworms exposed in to profenofos (25 μg), methomyl and endosulfan (5 μg) in glass vials in 1992.

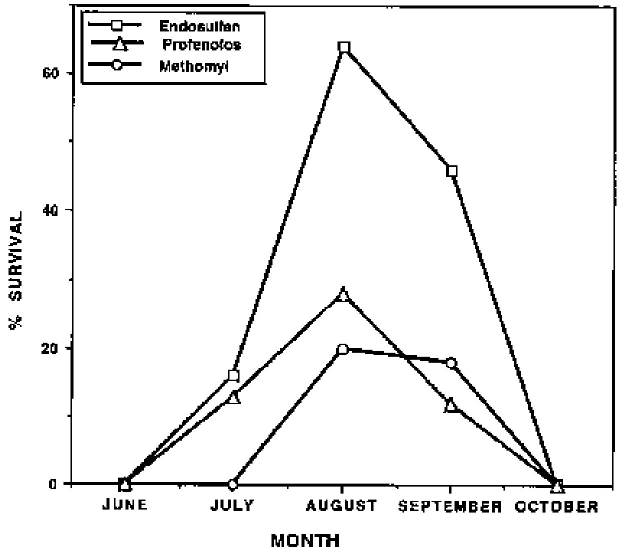

Figure 3. Percent survival of Arkansas tobacco budworms exposed in to profenofos (25 µg), methomyl and endosulfan (5 µg) in glass vials in 1992.

Data collected in Mississippi showed similar resistance patterns to profenofos and endosulfan as those collected in Texas and Arkansas. The overall frequency of resistance was higher with profenofos than with endosulfan (Fig. 4).

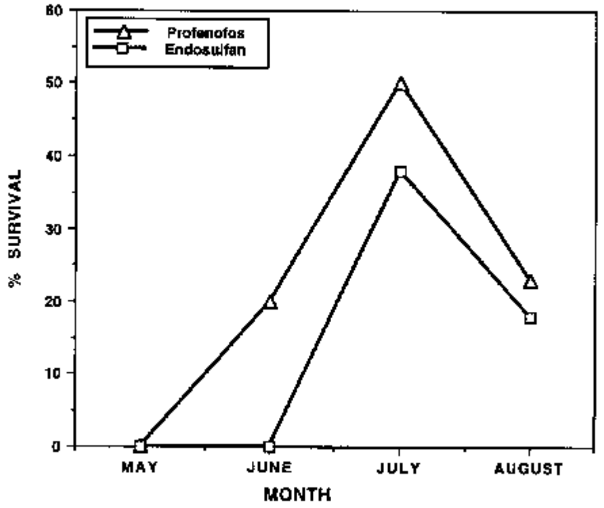

Figure 4. Percent survival of Mississippi tobacco budworms exposed to profenofos (25 µg), and endosulfan (5 µg) in glass vials in 1992.

Figure 5 shows the responses of TBW collected, in pheromone traps, during the 1993 growing season from Snook, TX and exposed to diagnostic doses. Doses used were 10g/vial for profenofos, 1 g/vial for methomyl, and 1 g/vial for endosulfan. Data indicated that moths collected in May were resistant to all insecticides. Resistance frequency dropped from May to June for methomyl, in June for endosulfan and, in July for profenofos. The rate of survival increased in August and declined again late in the September and October for all three insecticides.

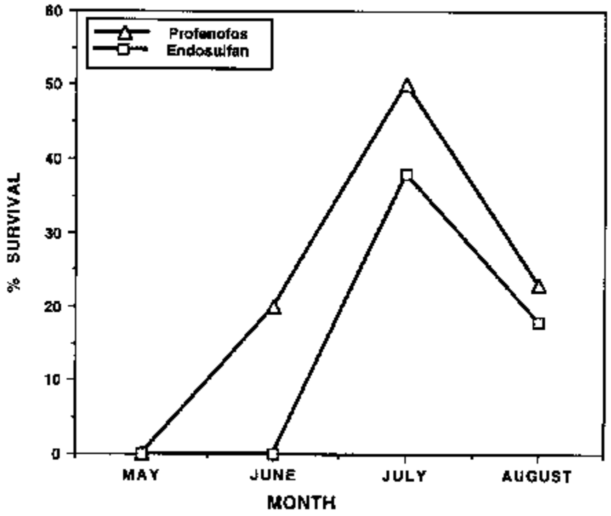

Figure 4. Percent survival of Mississippi tobacco budworms exposed to profenofos (25 µg), and endosulfan (5 µg) in glass vials in 1992.

Results of monitoring for resistance to nonpyrethroid insecticides in Arkansas and in Mississippi in 1993 were similar to those from Texas.

The technique described here allows entomologists to obtain fast, inexpensive, and reliable information on resistance to the major classes of insecticides used for tobacco budworm control. The data should be useful in the development of procedures to conserve susceptibility of TBW to all classes of insecticides.

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Resistance Management Reviews

Principles of Insecticide Resistance Management

Progress Review of the 5-Year National Research and Action Plan for Development of Management and Control Methodology for Sweetpotato Whitefly

I thank Nick Toscano and Tom Henneberry for the invitation to this meeting. I was asked to say something about resistance management in a few minutes. Of course, such a task is impossible. Instead, I would like to share some facts with you that, it seems to me, are important to remember when considering problems like the whitefly and resistance.

Agriculture and Capitalism
All segments of society that are involved in food and fiber production are driven by a profit motive. This is illustrated by what I call the greed chart (Table 1).

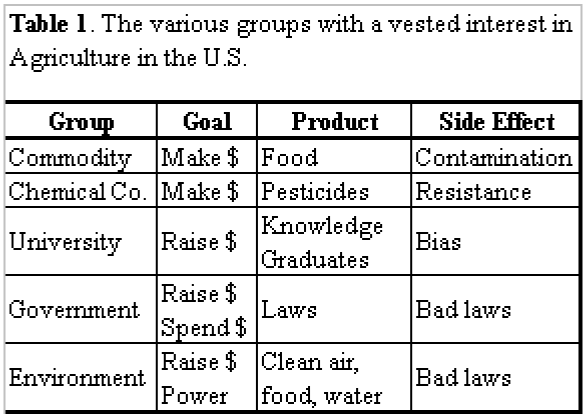

Table 1. The various groups with a vested interest in Agriculture in the U.S.

Group	Goal	Product	Side Effect
Commodity	Make $	Food	Contamination
Chemical Co.	Make $	Pesticides	Resistance
University	Raise $	Knowledge Graduates	Bias
Government	Raise $ Spend $	Laws	Bad laws
Environment	Raise $ Power	Clean air, food, water	Bad laws

Although it is clear that Agrochemical industry is in business to make money, growers are too. This fact should be kept in mind when considering resistance management.

Another fact not appreciated enough is that Universities, including Agricultural Experiment Stations are in the business of raising money. By slow attrition, State funds now account for about 1/4 of University budgets. The rest comes from the indirect costs of grants and other sources.

Resistance Management
Resistance management is relatively simple to do because there are few choices. Despite all the groups listed on the greed chart, there are two and only two players in the resistance game - growers and insects. All other entities play an indirect role at most.

Although there are some very important exceptions, we know intuitively that if a grower uses a given insecticide on a regular basis, resistance to that compound will eventually occur. We also know that if this hypothetical insecticide is used more frequently, we can expect the resistance to occur sooner rather than later. Guessing how soon is the part of the game that the growers get to play. Everyone else watches, therefore:

Resistance Management is a Guessing Game
We know the simple Mendelian explanation for how resistance is inherited; however despite this being the age of molecular genetics, we really don't know any details about how resistance occurs in the first place.

Genes are required to confer resistance. Where do these genes come from? Were they there all along? In most cases yes, but in a few cases probably not. Genes can be activated in insects to produce metabolic enzymes in response to dietary plant toxins, probably one of the original selection mechanisms in evolution, therefore:

Resistance Management is a Genetic Phenomenon
One thing is clear from a close look at the resistance game. The large populations and high turnover rate of insects give them a distinct advantage in overcoming insecticide treatments. In addition, the phenotype of resistance is difficult to measure especially in a single individual, therefore one usually resorts to measuring populations. The more insects we use to measure resistance, the better and more reliable are the measurements, therefore:

Resistance Management is a Numbers Game
The field of health is like the practice of farming in a way. Instead of keeping plants healthy, medical doctors keep people healthy. The analogy comes close to home when confronting the problems of resistance to antibiotics.

How does the health field handle resistance? An extensive resistance management program is an integral part of every good hospital. Pests (bacteria in this case) are collected from the patient, grown in lab culture and identified. In the same lab cultures, the antibiotics that discourage growth are also identified before the medicine is ever prescribed. This can all be done in a few hours.

Anyone struck with a chronic infection that shows resistance to all antibiotics would be faced with a potentially serious situation (not unlike the present inability to control certain whiteflies in agriculture) were it not for a uniformly strong effort put into finding new antibiotics.

Naturally, the newest and most potent antibiotics are not used unless absolutely necessary because hospitals practice resistance management (and incidentally because these newer products happen to be very expensive - the greed factor at work).

Resistance Management as Practiced in a Hospital
Medicines are discovered the same way pesticides are discovered. After all, pesticides are just another antibiotic. Indeed, many of the companies in the business of finding pesticides are also in the business of finding pharmaceuticals such as DuPont, Merck, Sandoz, etc.

Our colleagues in the medical profession have several advantages over us in agriculture. In addition to their salaries being higher, they have access to far more research funding. Indeed, we as a nation are spending a lot more money keeping people alive than we are on feeding them. The costs of modern medical technology continue to climb while food remains stagnant by design, therefore:

Insecticide Resistance Research is Underfunded
It may be presumptuous to compare the medical profession with entomology; however, leaving the medical profession and taking a pragmatic view, who really cares about insecticide resistance management?

Agrochemical industry shows concern through such groups as IRAC (Insecticide Resistance Action Committee), but they are not in the best position to do anything about it. Indeed, the development of resistance to insecticide products of one company spells a marked opportunity for all the other companies. The decline in efficacy of one product is actually a positive development in a capitalistic sense, therefore:

Resistance is a Market Opportunity
Do researchers care about resistance? Many of them do, but there is very little a researcher can do about it

when the main resistance management tactic has to do with changing insecticide use patterns.

Do environmentalists care? The answer to this, surprisingly, is yes. Environmentalists are very sensitive to the threat of insecticide resistance facing growers. In this they are joined by their colleagues in the government to a certain extent.

The current way EPA operates allows some leeway for registration of materials, even undesirable materials, if there are no alternatives. The regulators are a little like growers in this arena, however, because one gets far more response if resistance can actually be documented.

Resistance management is a concept that is easy to grasp, now widely understood, and everyone cares about it because:

Resistance Management is Popular

Then why don't we have more of it? This is worth thinking about. The simple answer is there are only a few cases of an imminent collapse of production of a commodity that would call for some kind of organized response. In my experience, grower's do not clamor for these sorts of things unless it is recognized that they have a genuine calamity on their hands.

Resistance management is a critical matter to the two players of the game, growers and insects. Growers are the only ones who ultimately make the decision to manage resistance. After all, they are the ones buying the insecticide and applying the selection pressure to the pests. No one else has a prayer, in fact, no one else has any business doing anything about it.

One key difference is liability. M.D.s can be blamed legally if they prescribe the wrong medicine and cause bodily harm. Growers, as a rule, don't sue entomologists if resistance occurs. Indeed, the best advice of entomologists is all too commonly ignored by growers.

Larry Pedigo recently suggested that agriculture consider prescriptions for pesticides much like the medical profession (American Entomologist, Fall 1992). While this is an interesting idea, I can't help thinking one of the many advantages the entomologist has over the physician is the lack of a need for malpractice insurance.

Indeed, the growers have few recourses for redress if they lose a crop. It is, after all, the growers who directly suffer if resistance occurs and that leads to our first conclusion:

Growers are Responsible for Resistance and Management

The second conclusion is that if resistance is a problem, it is a warning flag that insecticides are being used incorrectly, and the answer might be switching to another type of pest management strategy:

If Resistance Occurs at all then IPM has Failed

The third conclusion might take a little more explanation. Resistance management is not a legitimate research area. It is insecticide efficacy testing. In the end, research on resistance management doesn't really produce any new answers to pest problems. Perhaps even worse, because resistance can be measured, we tend to take time to do that instead of looking at the overall pest-crop complex, which is far more difficult, to find solutions, therefore:

Resistance Research is Flawed

This all comes back to a need to refocus on the main and often forgotten subject: Insects are difficult to control. Insecticide use is just one tool we have in this process of figuring out how to protect crops. The tremendous advantage offered by chemical control is that it is quick and certain. It buys time to study a given pest problem more closely and find more lasting solutions.

This was never more clearly demonstrated than in the present whitefly problem.

In my opinion insecticides are still the miracles they were when they were first discovered, and do not deserve to be vilified the way they are currently. We have come to take them for granted in the furor over the environment.

I mourn for the field of insect toxicology which doesn't exist anymore. It strikes me that agrochemical industry has been too busy collapsing and condensing to notice what has happened in Land Grant Universities which are in a bad way.

It strikes me as completely stupid that the nation answers the present crisis in pesticide resistance by pulling money out of the very field that is in the only position to understand the problem fundamentally and do something constructive about getting to answers.

What bothers me most about resistance management is that it is perceived as some kind of a solution to a problem when in fact it tends to preserve the status quo of chemical treatment of pests. By focusing on resistance, we tend to lose sight of the basic fact that insects are difficult to control. We also lose sight of the fact that sometimes using insecticides tends to hide bigger problems, or worse, to cover up simpler solutions.

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Abstracts in Resistance Management

Genetic Algorithms: A Tool for the Analysis of Genetic Backcross Data

ABSTRACT: A method is proposed that allows near optimal parameter values to be derived for three different hypotheses (one locus, two alleles; one locus, three alleles; and two loci, each with two alleles) fit to data from a backcross experiment. These hypotheses represent the basic and the two simplest alternatives to the monogenic model of resistance. All four dose-morality curves from a typical genetic backcross data set are used to estimate the parameters of genetic hypothesis. Data generated in these experiments have traditionally been analyzed by estimating parameters for the genetic hypothesis in question from only a portion of the data. Preliminary analysis suggested that many local minima exist in the search space when attempting to locate optimal parameter sets. The genetic algorithm, an optimization technique known for its ability to locate global minima in complex search spaces, was to maximize the probability of locating near-optimal parameter sets for backcross data. The genetic algorithm performed well compared to results obtained using another search technique based on the quasi-Newton method. A randomization bootstrap test was developed to estimate confidence limits for all estimated parameters. The bootstrap technique estimated parameters from the original data set, created a number of synthetic data sets using the estimated parameters and stochastic variability and then evaluated new parameter estimates based on the synthetic data sets. The range of values for each parameter was then used to estimate confidence limits for the parameter. When 200 synthetic data sets were used for each original data set, the procedure did not include the original parameter value in 11.6% of the trials, which exceeds the intended 5% error rate. The bootstrap method is promising, but further investigation with more efficient automated algorithms is necessary to determine if it can maintain its declared error rate when greater numbers of synthetic data sets are used. The technique is not limited to genetic algorithms and may be used with any parameter estimation technique.

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Internet Access

World Wide Web Access

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The Resistant Pest Management (RPM) Newsletter is now available over the internet as a world-wide-web hypertext document. This version of the RPM newsletter retains most formatting elements of the hard copy version, as well as figures and tables. Hypertext links ease movement between the table of contents and individual articles. This version of the newsletter is available from the Mississippi State University web server (URL http://www.msstate.edu).

To view the newsletter, a WWW browser, such as Mosaic, Cello, Lynx, MacWeb, or WinWeb is required. It is not feasible in a short space to explain the use and installation of such programs (there are books dedicated to this purpose). The most commonly used program, Mosaic, is available free from the NCSA for the X-windows, Macintosh and Windows operating environments, and may be obtained by anonymous ftp from ftp.ncsa.uiuc.edu or from sunsite.unc.edu (the directory at the latter site is: pub/packages/infosystems/www/clients/WinMosiac [or MacMosiac for Macintosh users] directory). Windows users will also need to get the win32s.zip file, which will update their windows system. For those willing to sort out the details, access to the internet over phone lines can be achieved with the trumpet winsock shareware package, available as the file winsock.zip from the previous ftp sites in the socket directory. OS/2 users should be aware that the latest versions of Mosaic are not compatible with winos2, and they should use alternatives such as WinWeb, Cello, or earlier versions of NCSA Mosaic. Several companies are producing all-in-one solutions for internet connections (NetManage's Internet Chameleon and O'Reilly and Spry's Internet in a Box are shipping), and the next releases of OS/2 and Windows are both rumored to include software to enable internet access.

The Resistant Pest Management Newsletter is now available via E-mail (as well as anonymous ftp and finger). Choose one of 3 different ways to download the Newsletter:

(1) via E-mail (aka ftpmail):

Address your E-mail to ftpmail@decwrl.dec.com. The body of the message should consist of only ftp commands - type:

"connect ftp.cicp.vt.edu chdir pub/cicp/rpmnews get rpmnews bye"

The ftpmail server decwrl.dec.com is very busy; allow up to 24 hours for delivery, or use a different ftpmail server if you know of one. You will receive the Newsletter just like regular E-mail.

(2) finger.

Type: "finger rpmnews@ftp.cicp.vt.edu / more" to view the document onscreen with page pauses or Type: "finger rpmnews@ftp.cicp.vt.edu filename" to write contents to a filename you make up in place of filename.

(3) anonymous ftp.

Type: "ftp ftp.cicp.vt.edu" Name: type "anonymous" Password: type your E-mail address then type "cd pub/cicp/rpmnews" to change to the news directory. type "get rpmnews" to transfer the RPM Newsletter to your host. type "bye" to exit.

Symposia

Global Pest Management Workshop

We are pleased to announce that the third annual Summer Institute on Global Pest Resistance Management will be held at Michigan State University from July 5 to July 14, 1995. The Summer Institute is a 2-week workshop designed to provide applied researchers and field personnel with the most current concepts and principles of pest resistance management through classroom instruction, field and laboratory demonstrations, and informal discussion. Over 30 instructors representing several disciplines (entomology, weed sciences, plant pathology, horticulture, sociology, etc.) contribute to the success of this program. Participants are provided with critical literature, networking capabilities and hands-on resistance management experience. To date, the Summer Institute has been attended by over 40 resistant managers from over 20 countries. Enrollment is limited, therefore, if you are interested apply early. The registration deadline is May 1, 1995. For more information about this resistance management workshop contact either Mark E. Whalon or Michael R. Bush.

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Insecticide Resistance Action Committee (IRAC)

If you would like further information on any of these topics, please contact the author:

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- The 23rd Central IRAC meeting was held on April 26-27, 1994 in Nambsheim (France) hosted by DuPont.
- IRAC's revised constitution was raffled in principle.
- IRAC central endorsed an inter IRAC meeting to be held in Brighton in November 1994.
- An international survey of insecticide resistance in the field will be updated and following analysis of the data by Working Groups will be published (possibly in the new issue of the Pesticide Manual along with current IRAC's guidelines).
- IRAC's Central Committee recognized the need for a better awareness of its mission (policies and guidelines) and activities among member companies and outside. An information package including publication list, organization chart, membership list, current guidelines, fact sheet, etc. is being prepared. Following an invitation by the Organizing Committee, a paper summarizing IRAC's achievements to date and strategy for the future will be presented at the Brighton Crop Protection Conference, Pests and Diseases, in November 1994.

IRAC Working Groups

Rice Working Group

As Japanese companies see no need to continue the Rice Working Group, it will be discontinued. However, the resistance situation will be closely followed up and, if needed, this Working Group will be resurrected.

Public Health Working Group

The proposed Anopheles resistance management project in Mexico should start in November 1994 upon termination of the rainy season. The protocol is under discussion and should be finalized during the next group meeting. The GIFAP project agreement has not yet been signed. The Group has instigated a method of preparing and distributing WHO insecticide susceptibility test kits. They are now available at Universiti Sains Malaysia and training is scheduled on how to use the test kits.

Fruit Crops Working Group (FCWG)

The New Acaricide Sub Group has established that the four new acaricides (fenazaquin, pyridaben, tebufenpyrad, and fenpyroximate) share a common mode of action. There is also some evidence that cross-resistance has occurred which affects all four compounds. It was agreed that the four companies involved would strive to include a label statement based on the updated FCWG spider mite resistance management guidelines.

The group is sponsoring a research project at Rothamsted (U.K.) to evaluate a novel "glass cell" monitoring technique for the new acaricides and to develop independent baseline data.

Guidelines for the following species/groups are currently being devised or updated: spider mites including citrus and Eriophyid mites, Myzus persicae, scales, Lepidoptera, Psylla, Phorodon humuli and other fruit tree aphids. Posters on spider mite and Myzus persicae resistance management guidelines will be presented at Brighton in November 1994.

Vegetable and Field Crops Group

Following completion of the IRAC-funded study on cross-resistance patterns of IGR's by Dr. Cheng in Taiwan, IRAC's attendance at the Plutella workshop in November 1994 is being planned (poster/stand/paper).

The resistance status of the Colorado potato beetle (Leptinotarsa decemlineata) is being investigated in Eastern Europe and strong speculation exists about resistance in countries including Poland and Hungary. Local resistance monitoring programs are already in place in Poland. The group will discuss the opportunity to provide some support (methodology and/or financial input).

Bt Management Working Group Update

The group is involved in significantly improving public awareness of its activity highlighting the research funding, and maintaining a balanced view of managing resistance with Bacillus thuringiensis (Bt) based products.

The group reviewed many research proposals. Three were ultimately funded. Priority was given to projects which will provide field data to support practical resistance strategy choices.

A symposium on managing Bt. resistance is being planned for the next ESA meeting.

Cotton Working Group

Central IRAC funded the attendance of Dr. Denholm (Rothamsted) and Dr. McCaffery (University of Reading) at the Beltwide Cotton Conference in San Diego (January 1994). Dr. Denholm, IRAC's advisor for Pakistan, reported the current resistance situation for the two major pests of cotton in this country. He had set up a 2 year monitoring program for Helicoverpa armigera and Bemisia tabaci (vector of the leaf curl virus) in cotton at six sites. Resistance against pyrethroids and organophosphates was detected. Overuse of low priced products is causing this problem. Without concerted action between researchers, growers, and manufactures, it is probable that the new products with novel modes of action will also be overused to the extent that resistance will rapidly diminish their effectiveness.

IRAC-Cotton's Pakistan Subgroup is funding a monitoring program in Falsalabad on bollworm and whitefly.

IRAC central funded a training session (two IRAC representatives) on the use of IRAC's Method No. 7 in Nanjing (China). It is hoped that, as a result of this initiative, IRAC's Method No. 7 will be used as the basis for monitoring Helicoverpa resistance in China.

A poster on IRAC's Method No. 7 was presented at the Beltwide Cotton Conference. Publication in the Journal of Economic Entomology is planned.

IRAC US Cotton Meeting Minutes

The second meeting of the year was held on the 19th of April in Memphis, TN at the headquarters.

1. IRAC and IRAC-US Cotton Constitutions - There was considerable discussion about proposing the change of IRAC-US Cotton to IRAC-US. The reason would be to broaden the organization to include crops other than cotton, especially since other IRAC commodity groups are not formally organized in the U.S. Also, discussion was held about Ad Hoc memberships for the USDA and Cotton Inc. A decision could not be made until IRAC-Central is first contacted.

Assignment: Gary Thompson/DowElanco and Walt Mullins/Miles, to contact Chuck Staetz/FMC, and Paul Leonard/IRAC Central, regarding the above. They will modify the wording in the constitution, pending the outcome of the discussion with IRAC-Central, and present a draft at the next meeting. Gary Thompson will also solicit input from non-member companies to join.

2. Long Term Goals - Gary Thompson/DowElanco, provided an outline of long term goals and had considerable input during the discussion. The following were established as long term goals for 1994 - 1999:

To improve the awareness and importance of

- Resistance Management
- Annual Beltwide Grower Workshops
- Periodic Researcher Workshops
- Popular press articles
- Publish minutes of activities with WRCC-60
- Develop "Principles for Resistance Management* publication

To support the Development of Significant Resistance

- Management Data
- Funding crucial research
- Identify critical research needs
- Seek/provide funding
- Improve administrative procedure for funding

To have improved the recognition of IRAC as a leader and authority on Resistance Management

- Develop a mailing list of contacts
- To have established a continuing dialogue with EPA, National Coalition for IPM, USDA and University Extension
- Develop better understanding/ knowledge throughout the ranks within industry

3. Educational Opportunities - Frank Carter/National Cotton Council, provided an outline of educational opportunities for IRAC.

Assignment: The whole committee is challenged to work on educational opportunities for this next year. Several activities are planned and programs will be developed at the next meeting.

4. Advertisement Report - Ian Watkinson/Gowan, provided a report on a public relations proposal prepared by Great Lines, Inc. The proposal outlines an excellent communication strategy which is very ambitious. Even though a cost was not provided, the committee feels that a certain component, such as the preparation of a pamphlet/brochure communicating "Principles of Resistance" or "Resistance Management Guidelines" would be very worthwhile.

Joe Hope/Rhone-Poulenc, also reported that Fiber Magazine, Cotton Grower and Cotton Farming are interested in IRAC activities and would be very cooperative in writing articles.

Frank Carter/National Cotton Council, indicated that they have a Communications Department which could be used to develop a news release. Other resources, such as mailing lists, are available in cooperation with the Cotton Council.

Action: Ian Watkinson will follow up with Great Lines, Inc. and determine the associated costs for the development of a pamphlet/brochure. He will report on this at the next meeting.

5. Resistance Statements in Advertising - A copy of GIFAP Guidelines with regards to resistance statements was handed out. There was a unanimous decision that the group adopt these guidelines.

6. Research Proposals - The following is a list of research proposals approved for funding: Table 1.

We also received a proposal from James Ottea/ Louisiana State University, entitled "Assessment of Techniques For Diagnosing Mechanisms of Pyrethroid Resistance in Field Populations of Heliothis virescens". This has been submitted to IRAC-Central for funding. The group voted unanimously to support this proposal in principle.

7. University of California Whitefly Report - In 1993, IRAC-US Cotton funded a study entitled "Strategies to Extend the Effectiveness of Chemicals Needed For Sweet Potato Whitefly Control", by Prabhaker, Toscano and Henneberry. A final report was received.

8. Research Proposal Guidelines - Ben Rogers/Zeneca, presented draft guidelines for 1) researchers, 2) IRAC and 3) research proposals. The intention is to have a more organized and focused system for handling research proposals and evaluation, thereof. Ben Rogers will formalize these guidelines and present them at the next meeting. Also, he will draft a procedure for evaluating proposals to be discussed at the next meeting.

9. EPA Response and Invitation - Walt Mullins/Miles, and Gary Thompson/DowElanco, drafted a letter to the EPA to 1) make EPA aware of the existence of IRAC, and 2) invite an EPA representative to attend our meeting. They were not able to attend this meeting because of travel limitations, but were very receptive to meeting with us if we meet in the Washington area. It was agreed that we would hold our next meeting in Washington during the end of September/early October and that we would meet for one and one half days. EPA would join us for the applicable section of the program only.

Assignment: Ian Watkinson/Gowan, has a company contact and will help establish a meeting location. Gary Thompson/DowElanco, will contact the EPA Pesticide Resistance Management Workgroup and ask for their participation during the section with issues dealing with the EPA. He will determine the meeting date, depending on their response.

10. Australian Conference - Ian Watkinson/Gowan, attended the First International Cotton Research Conference held in Australia and provided the group with a brief verbal summary. He handed out a copy of the paper he presented, entitled "Novel, Biological and Conventional Insecticides: What's New."

11. Proposal to EPA on Section 18 Requests - Walt Mullins/Miles, has prepared a "Proposal On Prevention of Resistance/Resistance Management For Evaluating Section 18 Requests." We did not have time to discuss this, but asked the group to review this and provide comments at the next meeting. This would be a subject to discuss with the EPA representatives at our next meeting.

12. Resistance Management Symposium - Ben Rogers/Zeneca, prepared a draft of program ideas that he obtained from five committee members for the subject symposium. The group felt that this type of symposium would be more discussion oriented and would not be suited to be part of the Beltwide Cotton Conference. Instead of holding a single symposium, it was suggested that we could collaborate with other groups holding meetings. Possibilities will be explored and discussed at the next meeting.

Assignment: Joe Hope/Rhone Poulenc, will contact the American Chemical Society regarding a "tie in" with their special conference entitled "Molecular Genetics and Ecology of Pesticide Resistance", scheduled to be held in Big Sky, Montana from June 18-24, 1995. Gary Thompson/DowElanco, will contact WRCC-60 regarding a "tie in" with a future conference similar to the one they jointly held with the National Coalition for IPM, held in Las Vegas on April 18-21, 1994 entitled "Second National IPM Symposium/Workshop."

13. Tank Mix vs. Rotations Symposium - We did not discuss program contents, but it was suggested that this type of symposium could be part of the ESA meeting in 1995, the American Chemical Society Special Conference or the next National IPM Symposium Workshop.

Assignment: Walt Mullins/Miles, Ian Watkinson/Gowan, and Chuck Staetz/FMC, to prepare a symposium topic with a list of speakers by next meeting. They will explore opportunities to "tie in" with other conferences.

14. IRAC Poster - The group agreed with the idea of having a promotional poster at the ESA and/or

Beltwide Cotton Conference communicating its functions.

Assignment: Gary Thompson/DowElanco, will explore the possibilities of preparing a poster.

15. Honorariums For Officers - Walt Mullins/Miles, indicated that other committees provide honorariums to officers and that we should consider this. It was agreed that this should be set aside for further discussion at the next meeting.

16. Beltwide Conference 1995 - It was suggested that a workshop be held similar to those in the past where regional updates are presented.

Assignment: Gary Thompson/DowElanco, and Frank Carter/National Cotton Council, will work on a title and submission.

17. Future Meeting - The next meeting will be held late September/early October in the Washington, DC area, to allow participation with EPA representatives. A date has not yet been established.

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Gordon research Conference in Agricultural Sciences

"Chemical/Biological Synergies to Reduce Inputs for Pest Control" February 5-10, 1995 Oxnard, California

The meeting will focus on rationally designed mixtures and strategies using biological and chemical mechanisms to synergistically lower inputs in weed, disease, and insect pest management. We will also discuss the constraints in applying these new approaches to agriculture.

For registration information contact either co-chairman below (preferably by e-mail) or see the October issue of "Science" for registration information and forms.

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Latin American Workshop on Pest Resistance Management

A Latin American workshop on Pest Resistance Management will be held on March 27 to April 1, 1995, at INIA Las Brujas (Uruguay). This workshop is organized by the Instituto Nacional de Investigacion Agropecuaria (INIA) from Uruguay and Michigan State University (MSU) from the United States.

Goals of the Workshop:

-- Provide training and literature to Latin American scientists on resistance detection and resistance management for insects, plant pathogens and weeds.

-- Assess the current status of the resistance problem in Latin America.

-- Development of regional strategies to cope with the problem, within an IPM framework.

Instructors and Participants:

Lectures and laboratory demonstrations will be instructed by scientists from the United States, Uruguay, Argentina, Brazil, and Chile. This workshop is based on the Summer Institute on Global Pest

Resistance Management (see page 1) but designed to meet the needs and challenges facing pest management in Latin America.

The participants to the workshop should be researchers working in the field of resistance. Participants should also must have a good knowledge of the English language as most of the lectures will be in English.

For further information about this workshop please contact:

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