Varying Susceptibility to Methomyl and Permethrin in Widely Separated Cabbage Looper (Lepidoptera: Noctuidae) Populations within Eastern North America[1]

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ABSTRACT Cultures of *Trichoplusia ni* (Hübner), collected during 1980 from 11 eastern states and California, were assessed for susceptibility to methomyl and permethrin. *T. ni* were more susceptible to permethrin than methomyl, and the ratio of LD_{50} values (methomyl to permethrin) within each location ranged from 28:1 to 691:1. LD_{50} values for permethrin varied by a factor of 15 between locations, compared with 8.2 for methomyl. LD_{50} values for the California culture were similar to those of its eastern counterparts. There was no significant trend indicating that susceptibility to methomyl influenced susceptibility to permethrin. Although susceptibility to methomyl varied between geographic strains, there was no consistent pattern of increased tolerance in northern populations due to migration during a single growing season.

The cabbage looper, *Trichoplusia ni* (Hübner), has been reported to feed on at least 119 species and cultivars of plants encompassing 29 families (Sutherland 1965). Throughout most of the United States it is a primary pest of crucifers. *T. ni* is subtropical and, within the eastern United States, has been reported to overwinter only in Florida, the coastal plain of Georgia, and eastern South Carolina (Chalfant et al. 1974). In peninsular Florida, *T. ni* adults are present on late-winter crucifers; with warming temperatures and southerly winds, however, they migrate northward in early spring. Thus, *T. ni* does not generally arrive in the mid-Atlantic states until early summer and into the New England area until late summer or early fall.

Infestations of *T. ni* tend to be more severe in southeastern than in northeastern states, as evidenced by the higher action thresholds in the latter (Shelton et al. 1982, Shelton et al. 1983). However, in New York, field and laboratory evaluations have shown that methomyl, an insecticide widely used against *T. ni* on crucifers throughout the United States, has lost much of its effectiveness (Davis and Kuhr 1974). Because of this, as well as shortcomings of other registered insecticides (Eckenrode et al. 1981), New York was granted section 18 permits for permethrin (1979, 1981) and fenvalerate (1980) to control *T. ni* on cabbage.

Because of the migratory nature of *T. ni* and the higher number of sprays applied for its control on southern crucifers, we hypothesized that the decreasing susceptibility of *T. ni* populations to methomyl in the northern latitudes reflected the migration of tolerant survivors from the south. To test this hypothesis, as well as to document base-line information on *T. ni* susceptibility to permethrin and any possible cross-resistance from methomyl to permethrin, we investigated the relationship of susceptibility to permethrin and methomyl for several geographic populations.

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Materials and Methods

Late-instar larvae and pupae of *T. ni* were collected during 1980 by cooperators from 14 sites encompassing 11 eastern states and 1 western state. *T. ni* were collected from research and commercial fields of *Brassica oleracea* during peak population periods in the respective crucifer-growing regions, then transferred to Geneva, N.Y., where all bioassays were performed. All cultures were reared similarly at 26°C under a photoperiod of LD 16:8 on a high-wheat germ diet (Bell et al. 1979). Larvae were reared to the 4th instar (ca. 30 mg) and treated by topical application with technical grades of methomyl (Du Pont Co., Wilmington, Del.) and permethrin (FMC, Middleport, N.Y.; 52% *trans-*: 48% *cis-*) in 1 μl of acetone. Control insects were treated with acetone only. Five and six concentrations, plus controls, of methomyl and permethrin, respectively, were tested on insects in generations 2 to 7 of each culture. More emphasis was placed on determining LD_{50} values for methomyl since it was commercially registered and more widely used than permethrin during the test year. The criterion for mortality was the insect's inability to translocate when prodded. Data from mortality counts made 72 h after treatments were analyzed by probit analysis (Russell et al. 1977). LD_{50} values from each culture for both insecticides were paired and used in regression analysis to determine the degree of mutual susceptibility.

Results and Discussion

The 14 locations within eastern North America are listed in order of increasing latitude (Table 1). LD_{50} values for methomyl between these 15 locations varied from 1.10 to 8.98 μg/g, but there was no indication that susceptibility was related to latitude. Although migration patterns for *T. ni* have not been thoroughly investigated, we presume that migration occurs at least along the Atlantic coast; however, no relationship between location and LD_{50} was apparent along this possible migration path.

T. ni were more susceptible to permethrin than methomyl (Table 1). The LD_{50} values obtained in this study

Table 1. Toxicity of topically applied methomyl and permethrin to populations of cabbage looper larvae[a]

Source	Methomyl				Permethrin			
	n	LD_{50}	95% CL	Slope (SE)	n	LD_{50}	95% CL	Slope (SE)
Hastings, Fla.	300	6.20	4.58– 8.50	1.23 (0.13)	100	0.15	0.12–0.18	3.60 (0.61)
Tifton, Ga.	350	1.97	0.91– 3.66	1.50 (0.14)	299	0.07	0.05–0.09	2.96 (0.30)
Crystal Springs, Miss.	300	1.85	1.44– 2.34	1.82 (0.19)	259	0.05	0.04–0.06	3.27 (0.38)
Auburn, Ala.	310	3.34	2.50– 4.39	1.37 (0.14)	240	0.07	0.03–0.13	2.54 (0.30)
Salisbury, Md.	435	4.46	2.61– 7.58	1.33 (0.11)	360	0.09	0.01–0.08	3.65 (0.34)
Columbia, Mo.	250	8.98	5.91–14.61	0.93 (0.13)			—[c]	
Newark, Del.	300	2.97	1.58– 5.28	1.50 (0.15)	240	0.08	0.05–0.13	2.83 (0.32)
Lafayette, Ind.	300	3.90	2.73– 5.47	1.07 (0.12)	120	0.04	—[b]	4.43 (0.88)
Long Island, N.Y.	325	1.10	—[b]	0.93 (0.12)			—[c]	
Sunderland, Mass.	400	2.24	1.64– 2.95	1.18 (0.11)	360	0.06	0.05–0.07	3.17 (0.31)
Geneva, N.Y.	365	7.02	4.57–11.28	0.73 (0.10)	120	0.05	—[b]	2.03 (0.38)
Albion, N.Y.	320	2.25	0.77– 4.88	1.11 (0.12)	120	0.05	0.04–0.06	5.49 (1.09)
Rosemont, Minn.	300	6.91	3.22–17.45	0.90 (0.12)	120	0.01	0.05–0.22	2.60 (0.39)
Santa Maria, Calif.	250	2.69	1.05– 5.64	1.12 (0.14)	318	0.07	0.06–0.08	4.30 (0.47)

[a] n, Number of insects treated with insecticide; 95% CL, 95% confidence limits for LD_{50}.
[b] Confidence limits not computed, since the g statistic > 0.5.
[c] Culture not tested.

were similar to those reported in other studies for methomyl (Davis and Kuhr 1974, Palazzo 1978, Livingston et al. 1978) and permethrin (Palazzo 1978, Sparks et al. 1982). The ratio of LD_{50} values (methomyl to permethrin) within each location varied from 28:1 to 691:1. LD_{50} values for permethrin ranged by a factor of 15 between locations, compared with 8.2 for methomyl. No relationship between permethrin LD_{50} and latitude was evident. LD_{50} values for both toxicants on the California culture were similar to those of its eastern counterparts. When LD_{50} values of each toxicant within a culture were paired and tested by regression analysis, there was no significant trend indicating susceptibility to methomyl influenced susceptibility to permethrin ($r^2 = 0.02$, 10 df).

These data demonstrate that, although the susceptibility of *T. ni* to methomyl varies between geographic strains, there is no consistent pattern of increased tolerance in northern populations through a single growing season. Differences in susceptibility may be due to differences in host crops of previous generations, a complex history of exposure to insecticides in specific areas, variations in migration patterns, or the interaction of these or other factors. Regardless of causes, the ca. ninefold variation in methomyl's LD_{50} values between some geographic populations will cause a corresponding variation in control achieved in the field.

Davis and Kuhr (1974) reported a steady decline from 1968 to 1973 in the effectiveness of methomyl against *T. ni* in New York, but our report does not indicate any further decline. They attributed this decreasing susceptibility to selection pressure by methomyl, DDT, parathion, and other insecticides. In the absence of evidence of northward migration of resistant individuals, it is unclear how resistance develops in regions such as New York, which are reported to lack a stable breeding population (Sutherland 1965). It is possible that Davis and Kuhr (1974) witnessed a decline in methomyl's toxicity and this same phenomenon occurred concurrently, but was undocumented, in other areas. Also, this area-wide resistance may have occurred mainly as a result of the selection pressure in Gulf States, where *T. ni* populations are higher and present almost year round. If this hypothesis is correct, the aspect of *T. ni* migration may add little to its development of resistance. However, a possible alternative hypothesis is that isolated groups of tolerant *T. ni* may overwinter in and around the many cabbage cold storage areas and greenhouses in New York. Such surviving populations may provide foci for the establishment of tolerant or resistant infestations in the subsequent season. Early infestations by local survivors may also explain why the date of infestation of individual cabbage fields in upstate New York may vary by as much as 1.5 months (Andaloro et al 1982).

The permethrin data collected during this study emphasize the high degree of efficacy and uniformity of response for this compound in widely separated cabbage looper populations. These data will serve to establish a base line for the effectiveness of permethrin before this insecticide is widely used. Future comparisons with these data can be used to monitor resistance to permethrin within eastern North America.

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