Persistence Kinetics of Endosulfan, Fenvalerate, and Decamethrin in and on Eggplant (*Solanum melongena* L.)

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Persistence studies of endosulfan, decamethrin, and fenvalerate in and on fruits and leaves of eggplant along with cropped soil under field conditions of eastern India were undertaken after spraying at the recommended and twice the recommented rates. The initial deposits of applied insecticides on average were higher on leaves than on fruits and least on soil. Residues of endosulfan and fenvalerate in and on fruit were below the tolerance level of 2 ppm as specified by FAO/WHO immediately after application of the recommended rate, whereas decamethrin required 4.32 days to decrease below the tolerance level at the same application rate as endosulfan and fenvalerate. Waiting periods (defined as the time required to decrease the residue below the tolerance level) of 2.57, 6.50, and 0.14 days were calculated for endosulfan, decamethrin, and fenvalerate, respectively, when double the recommended rate was applied. Approximately 50–70% of remaining insecticide residues were dissipated during washing followed by cooking.

A wide range of insecticides including organochlorine, organophosphorus, and pyrethroids have been used on eggplant to control its insect pests. An important consideration in the choice of insecticides for crop protection is the length of time for which the toxic residues will persist on foliage or reproductive tissue, as well as on soils. Persistent insecticides might be preferable to use against a continuous, heavy infestation of pests, while those of short persistence might be preferable for the control of sporadic infestations to allow the survival or rapid reestablishment of natural enemies. The insecticides endosulfan, decamethrin, and fenvalerate are used intensively by cultivators in many parts of eastern India on eggplant. Studies on the persistence and degradation of these three insecticides in different soils and plants in different climatic conditions have been reported (Awasthi, 1985; Kole et al., 1989; Sukul and Handa, 1984; Agnihotri et al., 1980; Subbaratnum et al., 1984). However, data on the persistence and dissipation pattern in and on eggplant growing in new alluvial (Typic Udifluvent) soil of eastern India are inadequate, and hence this study was undertaken.

EXPERIMENTAL PROCEDURES

Reagents. Analytical standards of α-endosulfan (98%), β-endosulfan (98.3%), endosulfan sulfate (ES) (97.2%), decamethrin (99%), and fenvalerate (98.5%) were supplied by U.S. EPA Environmental Research Center, Research Triangle Park, NC 27711. Thiodan, containing 35% α- and β-endosulfans (ai), and Decis, containing 2.8% decamethrin (ai), were supplied by Hoechst India Ltd.; Agrofen, containing 20% fenvalerate (ai), was supplied by Gujrat Agro Industries Corp. The percent purity of the insecticides was checked by GC. Stock solutions of α- and β-endosulfans and cyclic sulfate (100 μg/mL), decamethrin (50 μg/mL), and fenvalerate (50 μg/mL) were prepared separately in *n*-hexane. Anhydrous Na_2SO_4 was heated at 140 °C overnight prior to use. Charcoal (Art. 17505, E. Merck India, Bombay) and neutral alumina were activated prior to use. All organic solvents used were of GR grade (E. Merck India Lmtd.) and distilled before use.

Location and Experimental Design. Eggplants (Pusa Kranti) were raised during the winter season (October–January) of 1987–1988 at the District Seed Farm, located in Kalyani (23° 30′ N, 89° E; 9.75-m altitude), about 60 km north of Calcutta. On-farm experiments were designed in the following ways: plot size, 3 m × 2.5 m; drainage, 1 m; plot to plot distance, 0.5 m; plant to plant distance, 75 cm; row to row distance, 60 cm; total plants, 252, variety, Pusa Kranti.

Table I. Physicochemical Properties of the Soil[a] under Study

pH (1:2.5)	7.50	% sand	51.16
conductivity, dsm^{-1}	0.70	water-holding capacity, %	57.85
CEC, mequiv/100 g	7.6	organic matter, %	0.96
AEC, mequiv/100 g	0.026	total nitrogen, %	0.056
% clay	27.58	C:N ratio	10.0
% silt	21.26	available phosphorus, %	10.0

[a] Typic Udifluvent, new alluvium soil, according to seventh approximation.

Site Preparation and Planting. Vegetation was removed manually as much as possible from the site, with minimal disturbance of the duff layer (5–10-cm depth). Land was plowed by a power tiller, and 60-day seedlings were planted in desired points previously marked during land preparation. Irrigation and fertilization were made according to the crop schedule.

Soil Characteristics. Prespray soil samples were collected at random from the experimental field and analyzed for pH, cation-exchange capacity, anion-exchange capacity, conductivity, water-holding capacity, organic matter, total nitrogen, available phosphorus, and particle size distribution (Jackson, 1961; Piper, 1966) (Table I). According to the seventh approximation, the soil is Typic Udifluvent.

Chemical Application. The three insecticides, endosulfan, decamethrin, and fenvalerate, were applied to different plants as aqueous solutions of Endocel (35% EC), Decis (2.8% EC), and Agrofen (20% EC) with a Ganesh sprayer (1-L capacity; boom length, 0.5 m; number of nozzle, 1; nozzle type, cone mist spray) using compressed air (200 kPa) as propellant at the recommended rates (0.05%, 0.0015%, and 0.015% respectively) and at double the recommended rates. The volume of water used was 500 L ha^{-1}. All three insecticides were applied twice, on October 27 and November 16, 1988. The second spraying was done at the time of 50% fruit formation.

Sampling. After the first spray, samples of soil and leaves were drawn randomly from each replicate at intervals of 0 (2 h after spray), 5, 10, 15, and 20 days for endosulfan and 0, 1, 3, 5, 7, 10, and 15 days for decamethrin and fenvalerate. Fruit samples were taken at intervals of 0, 1, 3, 5, 7, 10, and 15 days after a second spraying of all three insecticides.

In addition, fruits harvested at 0 and 5 days were subjected to different decontamination processes such as washing with water and cooking to observe the efficiency of these processes in reducing the residues. Fruit samples were washed by manual rubbing

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under tap water for 1 min. Cooked fruits were prepared by boiling for 5 min in borosilicate beakers using quantities of water sufficient to cover the samples. During boiling the container was kept uncovered.

Samples of fully expanded leaves were taken at a leaf node; 15 to 16 leaves were collected from each plot with average size of 14–15-cm length. Fruits of average size of 10–12 cm were collected randomly, coinciding with harvests, for evaluating the persistence of the insecticides. Soil samples were taken with a soil auger driven to a depth of 6–10 cm.

Weather. Field weather stations were used to monitor rainfall, humidity, and temperature. Weather data were obtained from the University Agrometeorological Station (UAMS) at Kalyani (approximately 2 km northeast from the study sites). It was felt that these data from UAMS were the second best source and would provide a reasonable approximation of the climatic conditions during the experimental period. These weather data were used to indicate that the year 1987–1988 was climatically normal compared to past years (Table II).

Sample Preparation. Leaf and fruit samples were collected in polyethylene bags and preserved in a deep freeze in the laboratory at −10 °C within half an hour of sampling for 20–24 h. Soil cores also were collected in polyethylene bags and then allowed to air-dry, homogenized in a heavy-duty stainless steel blender, and sieved through a 10 mm mesh brass sieve (Feng and Klassen, 1986).

Formulation Analysis. The formulation products of the three insecticides were dissolved in acetone and partitioned three times with *n*-hexane; cleanup was done following a similar procedure as in the case of residue analyses.

Extraction and Cleanup. Leaf samples (50 g) were chopped and fruit samples were cut into small pieces and then blended in a Remi-automix blender for 2 min with 100 mL of acetone for each of the insecticides and filtered through a Büchner funnel. The residue was transferred back to the blender and re-extracted with 50 mL of acetone and filtered. Soil samples were dipped into 200 mL of acetone in a 500-mL Erlenmeyer flask and kept overnight. It was then agitated for 45 min by a mechanical shaker, and the contents were filtered. The extracted material from each matrix, viz. leaves, fruit, and soil, was partitioned three times with *n*-hexane (100 mL + 75 mL + 50 mL). The total *n*-hexane fraction was concentrated to 100 mL for endosulfan and decamethrin in a Kuderna-Danish evaporator and dried over anhydrous Na_2SO_4; 2.5 g of activated charcoal was added to the concentrated hexane extract. The Erlenmeyer flask was shaken thoroughly for about half an hour and allowed to stand; then the contents were filtered through Whatman No. 42 filter paper, and the filtrate was collected in a 250-mL Erlenmeyer flask. The charcoal present on the filter paper was washed frequently with a solvent mixture of *n*-hexane/acetone (9:1) to bring the total volume to 250 mL. The combined filtrate was concentrated, taken up in 5- and 10-mL volumetric flasks, and brought to volume with hexane for analysis by GC.

For fenvalerate, the hexane layers collected from solvent partitioning were concentrated and dried over Na_2SO_4 (anhydrous). Samples were cleaned up on chromatographic columns (2 × 40 cm) packed with a small plug of glass wool and 10 g of activated alumina (acidic) overlaid with 2 g of Na_2SO_4 (anhydrous). Columns were prewashed with 100 mL of *n*-hexane, and the extract in *n*-hexane was transferred to the column. Fenvalerate was eluted with 100 mL of *n*-hexane/acetone (9:1). The eluates were evaporated to dryness (50–60 °C), and the residues were dissolved in *n*-hexane for analysis by GC.

Gas Chromatographic Analysis. Residues were analyzed by a Hewlett-Packard Model 5890A gas chromatograph equipped with ^{63}Ni electron capture detector coupled to a Model 3392 itegrator. A glass column (1.8 m × 2.2 mm i.d.) packed with 3% OV-101 on Chromosorb WHP (80–100) (Hewlett-Packard) was used. The operating parameters of the gas chromatograph were as follows: injector, column, and detector temperatures, 200, 200, and 300 °C, respectively, for endosulfan and 275, 255, and 275 °C, respectively, for decamethrin and fenvalerate; carrier gas flow rate, nitrogen 65 mL/min for endosulfan and 70 mL/min for decamethrin and fenvalerate. A detector fluctuation of ±10% was considered to be acceptable. A stock solution of 1 ppm of each insecticide (analytical grade, 98.5%) was prepared as an

Table II. Monthly Temperature, Humidity, and Rainfall Data for the Period 1979 (August–December) to 1988 (August–December)

	1988		1987		1986		1985		1984		1983		1982		1981		1980		1979	
month	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min
										Temperature, °C										
Aug	32.25	26.89	32.51	25.9	32.32	25.80	31.32	26.41	33.23	26.48	31.40	25.79	32.40	26.19	31.00	25.92	33.75	26.39	33.50	25.60
Sept	32.25	26.90	33.30	26.63	31.54	24.53	31.00	25.71	33.85	25.65	31.93	26.23	34.21	25.76	34.40	24.35	34.00	26.95	34.60	25.69
Oct	30.78	23.58	32.70	23.93	30.03	21.77	31.47	24.09	33.19	23.86	32.69	23.77	35.23	22.78	31.74	23.08	33.45	23.04	33.86	23.70
Nov	29.26	18.99	28.10	18.46	28.49	17.63	29.07	17.09	30.02	15.72	30.48	17.66	29.13	17.01	32.88	15.65	31.50	16.77	33.76	19.71
Dec	26.13	15.17	25.03	13.18	25.05	13.12	26.62	13.09	27.10	11.27	28.22	11.90	27.33	11.04	26.19	11.31	29.01	12.61	26.68	13.72
										Humidity, %										
Aug	87.78	71.70	86.75	77.00	80.01	66.22	72.90	58.70	90.80	70.58	89.43	57.62	90.14	71.77	88.74	69.71	88.82	71.57	88.03	68.90
Sept	92.91	66.40	84.39	72.03	83.83	71.23	80.73	62.30	83.92	59.44	90.70	64.30	89.50	71.93	89.90	66.43	87.71	69.80	88.72	64.11
Oct	90.06	52.83	87.46	55.87	81.79	61.00	83.90	59.00	82.00	51.73	86.03	55.00	86.82	61.19	89.29	53.71	90.17	62.23	87.32	57.96
Nov	90.83	49.10	82.66	68.00	82.28	42.00	87.00	41.00	82.47	36.80	82.87	48.43	90.13	61.33	87.33	54.13	91.63	49.50	88.23	57.00
Dec	91.93	45.41	81.04	58.22	76.70	46.00	80.00	40.00	83.16	36.00	86.84	48.84	77.58	40.42	79.61	52.77	88.12	44.90	86.12	52.09
										Average Rainfall, mm										
Aug	17.85		25.58		13.81		21.46		36.88		14.13		14.84		32.23		38.32		22.22	
Sept	21.77		9.23		42.97		14.17		18.82		13.46		5.78		26.79		9.29		8.78	
Oct	4.39		1.39		12.33		11.76		12.54		14.86		0.20		0.00		5.28		1.44	
Nov	0.18		0.20		17.44		0.00		0.00		0.00		0.43		0.00		0.00		1.72	
Dec	0.41		1.46		0.55		0.00		0.48		0.88		0.00		8.58		0.00		0.45	

Table III. Recovery Efficiencies for Endosulfan, Decamethrin, and Fenvalerate from Soil, Leaf, and Fruit of Eggplant

substrate	amt fortified, ppm	% recovery ± SD (n = 3) α-endosulfan	β-endosulfan	endosulfan sulfate	decamethrin	fenvalerate
soil	1.00	85.5 ± 2.33	84.3 ± 2.85	87.2 ± 5.4	83.5 ± 0.85	86.2 ± 1.39
	0.5	92.7 ± 4.14	97.1 ± 1.86	84.2 ± 0.79	97.1 ± 3.36	96.9 ± 3.41
	0.05	95.3 ± 2.33	87.7 ± 4.42	86.4 ± 5.06	83.3 ± 0.75	85.1 ± 3.47
	0.005	94.7 ± 4.13	81.7 ± 0.93	90.1 ± 4.89	83.2 ± 2.36	82.4 ± 3.18
leaf	1.00	92.3 ± 1.58	89.6 ± 0.72	90.4 ± 7.83	90.4 ± 1.2	97.3 ± 2.08
	0.5	94.5 ± 3.10	92.4 ± 4.18	89.5 ± 4.21	85.2 ± 4.95	84.1 ± 2.67
	0.05	97.8 ± 1.81	89.8 ± 3.51	85.6 ± 2.65	85.4 ± 5.25	91.5 ± 0.88
	0.005	82.6 ± 2.99	82.8 ± 2.03	81.3 ± 0.61	82.6 ± 2.30	83.4 ± 3.21
fruit	1.00	87.3 ± 1.65	86.1 ± 0.77	89.7 ± 4.49	95.3 ± 1.02	96.5 ± 2.37
	0.5	95.4 ± 0.63	89.6 ± 5.18	95.7 ± 2.45	91.1 ± 5.03	84.9 ± 0.66
	0.05	99.3 ± 1.31	91.4 ± 2.51	98.3 ± 2.57	84.4 ± 3.03	87.2 ± 2.70
	0.005	82.2 ± 1.51	84.0 ± 3.29	81.1 ± 1.84	81.8 ± 2.5	84.1 ± 3.73

Table IV. Residues of Endosulfan, Decamethrin, and Fenvalerate in Eggplant Cropped Soil

substrate	insecticide	residues,[a] ppm 0 DAS[b]	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	15 DAS	20 DAS	regression eq	$t_{1/2}$, days
soil (recommended dose)	endosulfan										
	α-isomer	0.036			0.006		0.002	ND	ND		
	β-isomer	0.005			0.005		0.003	ND	ND		
	ES	ND[d]			0.005	0.004	0.004	0.002	ND		
	total (T_1)	0.041			0.016		0.009	0.002		$Y = 1.62 - 0.08X$	3.76
		(–)			(60.99)[c]		(78.04)	(95.12)			
	decamethrin (T_3)	0.12	0.08	0.06	0.04	0.02	0.004	ND		$Y = 2.0 - 0.12X$	2.50
		(–)	(33.33)	(50.0)	(66.66)	(83.33)	(96.66)				
	fenvalerate (T_5)	0.20	0.18	0.12	0.05	0.02	0.006	ND		$Y = 2.43 - 0.16X$	1.88
		(–)	(10.0)	(40.0)	(75.0)	(90.0)	(97.0)				
soil (double the dose)	endosulfan										
	α-isomer	0.073			0.014		0.005	ND			
	β-isomer	0.027			0.029		0.006	ND			
	ES	ND			0.03		0.008	0.004	0.001		
	total (T_2)	0.10			0.073		0.019	0.006	0.001	$Y = 2.18 - 0.10X$	3.01
		(–)			(27.0)		(54.0)	(94.0)	(99.0)		
	decamethrin (T_4)	0.28	0.17	0.13	0.09	0.06	0.009	0.002		$Y = 2.5 - 0.14X$	2.15
		(–)	(39.28)	(53.57)	(67.86)	(78.57)	(96.78)	(99.23)			
	fenvalerate (T_6)	0.48	0.38	0.28	0.12	0.05	0.017	ND		$Y = 2.77 - 0.15X$	2.00
		(–)	(20.83)	(41.66)	(75.0)	(89.58)	(96.46)				

[a] Average of three replicates. [b] DAS, days after spraying. [c] Values in parentheses indicate the percent reductions relative to the initial deposit. [d] ND, not determined.

external standard. One microliter each of 1 ppm of analytical grade α- and β-endosulfans and ES, decamethrin, and fenvalerate was injected into the gas chromatograph using the above-mentioned parameters. The retention times (RT) of decamethrin and fenvalerate were observed as 7.03 and 7.16 min, respectively. For endosulfan, RTs of its three isomers, viz. α, β, and ES, were 4.20, 5.51, and 7.20 min, respectively. The RT of each of the insecticides in different substrates was compared with those of the external standards, and the data were recorded.

Fortification. Samples were fortified with α- and β-endosulfans and endosulfan sulfate, decamethrin, and fenvalerate at concentrations of 1, 0.5, 0.05, and 0.005 ppm. Chopped leaves, small sliced fruits, and sieved soil samples were placed in 250-mL standard joint borosilicate bottles and fortified by the addition of appropriate volumes of previously prepared stock solutions of the insecticides. The bottles were capped, manually shaken to ensure thorough mixing, and stored in a deep freeze at –10 °C for 24 h to simulate residue sample storage conditions.

Calculation of Regression Equation, Half-Life, and Waiting Period. The method described by Hoskins (1961) was followed for generation of regression equation, half-life, and waiting period.

RESULTS AND DISCUSSION

Active Ingredient in Formulation. The active ingredient (ai) contents of the Endocel 35 EC, Decis 2.8 EC, and Agrofen 20 EC were found to be 34.68%, 2.77%, and 19.79% (average of three replicates), respectively, and the spray solution for application was made on the basis of these values.

Recovery Efficiency. The recovery efficiency for the analytical method is shown in Table III. An average of 91.6% α-endosulfan was recovered from all fortified samples. For β-endosulfan, endosulfan sulfate, decamethrin, and fenvalerate average values were 88.0%, 88.2%, 86.9%, and 88.3%. The limits of detection were as follows: α- and β-endosulfan, 0.002 ppm; endosulfan sulfate, 0.001 ppm; decamethrin and fenvalerate, 0.002 ppm. The limit of quantification was 0.005 for all of the insecticides.

Persistence and Degradation. The results revealed that the average initial deposits of applied pesticides were higher on leaves than on fruits and least on soil (Tables IV–VI). The higher initial deposits on leaves could be due to horizontal disposition of the lamina, pubescent nature of the leaf surface, or greater surface area per unit weight of leaves compared to fruits. From the rate of dissipation of these insecticides, it was understood that decamethrin and fenvalerate dissipated more quickly than endosulfan. A common trend of dissipation of endosulfan,

Table V. Residues of Endosulfan, Decamethrin, and Fenvalerate in the Leaves of Eggplant

substrate	insecticide	residues,[a] ppm 0 DAS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	15 DAS	20 DAS	regression eq	$t_{1/2}$, days	T_{TOL}, days
leaves (recommended dose)	endosulfan											
	α-isomer	11.43			0.08		0.03	0.02	0.005			
	β-isomer	9.53			0.14		0.05	0.02	0.01			
	ES	ND[d]			1.94		0.54	0.37	0.03			
	total (T_1)	20.96			2.16		0.62	0.41	0.045	$Y = 4.14 - 0.12X$	2.51	7
		(-)			(89.69)[c]		(97.04)	(98.04)	(99.78)			
	decamethrin (T_3)	13.7	10.4	5.6	2.24	1.18	0.16	0.04		$Y = 4.21 - 0.18X$	1.67	13.94
		(-)	(24.08)	(59.12)	(83.65)	(91.83)	(98.83)	(99.70)				
	fenvalerate (T_5)	4.74	3.93	2.74	1.08	0.06	0.02	0.004		$Y = 3.78 - 0.22X$	1.37	3.55
		(-)	(17.08)	(42.19)	(77.22)	(98.73)	(99.57)	(99.92)				
leaves (double the recommended dose)	endosulfan											
	α-isomer	33.05			0.31		0.06	0.05	0.002			
	β-isomer	21.17			0.55		0.14	0.04	0.03			
	ES	ND			4.50		1.41	1.32	0.23			
	total (T_2)	54.22			5.36		1.61	1.41	0.28	$Y = 4.48 - 0.10X$	2.92	11.46
		(-)			(90.14)		(97.03)	(97.39)	(99.48)			
	decamethrin (T_4)	27.7	22.1	12.1	5.03	2.36	0.32	0.09		$Y = 4.53 - 0.18X$	1.67	15.72
		(-)	(24.66)	(56.32)	(81.84)	(91.48)	(98.84)	(99.68)				
	fenvalerate (T_6)	8.57	7.92	6.07	2.57	0.15	0.06	0.011		$Y = 4.15 - 0.22X$	1.37	5.23
		(-)	(7.58)	(29.17)	(70.01)	(98.23)	(99.30)	(99.87)				

[a] Average of three replicates. [b] DAS, days after spraying. [c] Values in parentheses indicate the percent reductions relative to the initial deposit. [d] ND, not determined.

Table VI. Residues of Endosulfan, Decamethrin, and Fenvalerate in the Fruits of Eggplant

substrate	insecticide	residues,[a] ppm 0 DAS	1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	15 DAS	regression eq	$t_{1/2}$, days	T_{TOL}, days
fruits (recommended dose)	endosulfan										
	α-isomer	0.85	0.60	0.50	0.21	0.15	0.08	0.04			
	β-isomer	0.71	0.55	0.48	0.11	0.09	0.04	0.013			
	ES	ND[d]	ND	ND	0.30	0.28	0.16	0.06			
	total (T_1)	1.56	1.15	0.98	0.62	0.52	0.28	0.113	$Y = 3.20 - 0.78X$	3.86	
		(-)	(26.28)[c]	(37.17)	(60.25)	(66.66)	(82.05)	(92.75)			
	decamethrin (T_3)	0.70	0.42	0.08	0.03	0.007	0.003	ND	$Y = 2.78 - 0.25X$	1.20	4.32
		(-)	(40.0)	(88.57)	(95.71)	(99.00)	(99.57)				
	fenvalerate (T_5)	0.66	0.30	0.06	0.05	0.02	0.002	ND	$Y = 2.73 - 0.23X$	1.30	
		(-)	(54.54)	(90.90)	(92.42)	(96.96)	(99.69)				
fruits (double the recommended dose)	endosulfan										
	α-isomer	1.92	1.23	0.90	0.45	0.27	0.21	0.09			
	β-isomer	1.35	1.20	0.81	0.24	0.21	0.12	0.03			
	ES	ND	ND	ND	0.90	0.72	0.45	0.15			
	total (T_2)	3.27	2.43	1.71	1.59	1.20	0.78	0.27	$Y = 3.48 - 0.07X$	4.30	2.57
		(-)	(25.48)	(47.70)	(51.37)	(63.30)	(76.14)	(91.74)			
	decamethrin (T_4)	1.51	0.92	0.26	0.10	0.015	0.008	0.002	$Y = 3.06 - 0.21X$	4.30	2.57
		(-)	(39.07)	(82.78)	(93.37)	(99.00)	(99.47)	(99.86)			
	fenvalerate (T_6)	1.19	0.66	0.15	0.08	0.06	0.005	ND	$Y = 3.03 - 0.22X$	1.37	0.14
		(-)	(44.53)	(87.39)	(93.27)	(94.95)	(99.57)				

[a] Average of three replicates. [b] DAS, days after spraying. [c] Values in parentheses indicate the percent reductions relative to initial deposit. [d] ND, not determined.

decamethrin, and fenvalerate residues with time was evident. In terms of their half-life values, endosulfan had the longest persistence followed by decamethrin and fenvalerate. Thus, endosulfan can be used against continuous heavy infestations of insects, while decamethrin and fenvalerate might be preferable for the control of sporadic infestations on eggplant. The results of the present investigation also revealed that the dissipation of the three insecticides investigated followed first-order kinetics irrespective of matrices (Figures 1–6), and residues of all three insecticides in eggplant fruits fell below the tolerance level of 2 ppm (for all three insecticides) as specified by FAO/WHO (1985) and the Central Insecticide Board of India (Parmar and Dureja, 1990) within 2.57 days for endosulfan, 4.3–6.50 days for decamethrin, and 0.14 day for fenvalerate.

As far as individual endosulfan isomers and their degradative product, endosulfan sulfate, were concerned, the α-isomer had the highest initial deposits on soil, leaves, and fruits followed by the β-isomer and endosulfan sulfate irrespective of the dosage. Moreover, endosulfan sulfate in eggplant and soil could be detected 5 days after application of endosulfan.

Decontamination Processes. The insecticidal residues of fruits were also determined after washing and cooking to determine the effect of these processes to reduce residue levels. It was observed from the results of these decontamination processes (Table VII) that washing of

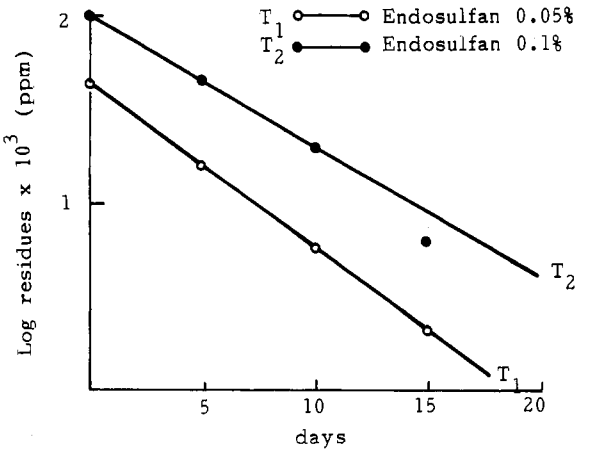

Figure 1. Linear plot of first-order reaction of endosulfan in soil cropped with eggplant.

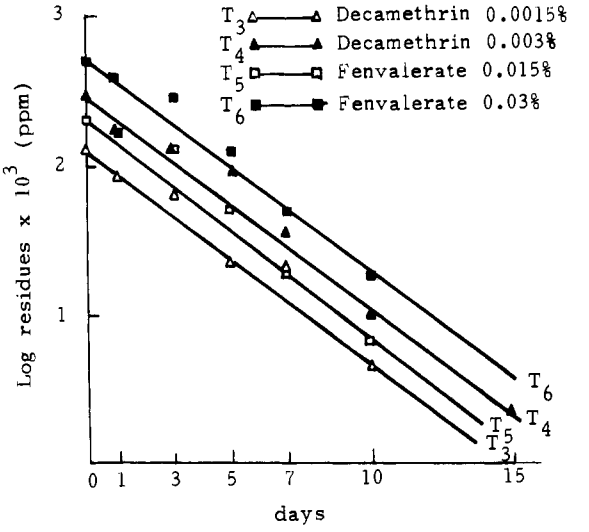

Figure 2. Linear plot of first-order reaction of decamethrin and fenvalerate in soil cropped with eggplant.

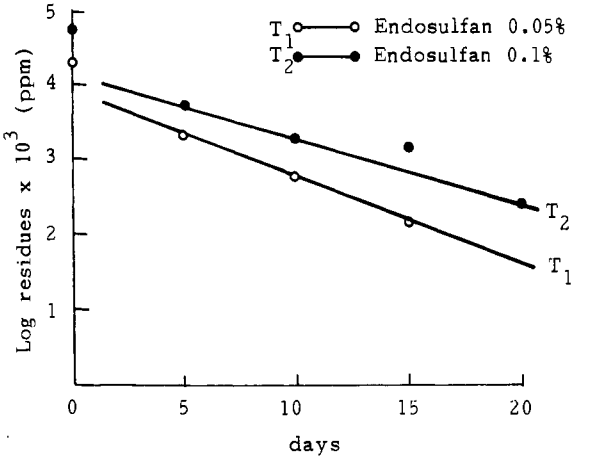

Figure 3. Linear plot of first-order reaction of endosulfan in leaves of eggplant.

the fruits alone reduced the initial deposits by 29–51%, while washing followed by cooking reduced deposits by 50–74%. This reduction depended on the insecticide application rates and time of sampling. From this it could be understood that the usual decontamination processes substantially reduced the amount of residues.

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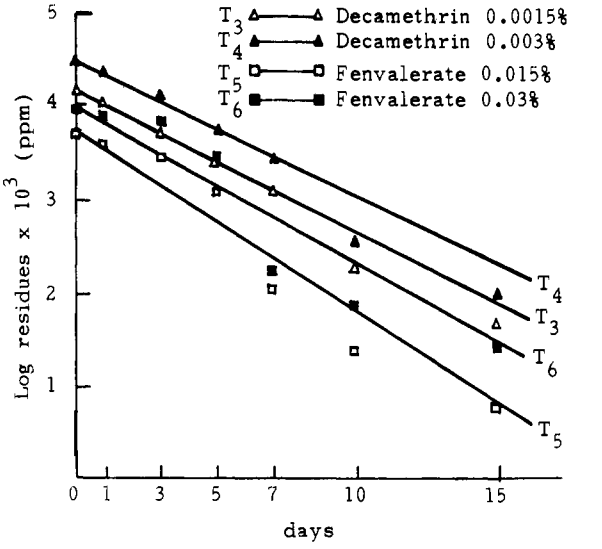

Figure 4. Linear plot of first-order reaction of decamethrin and fenvalerate in leaves of eggplant.

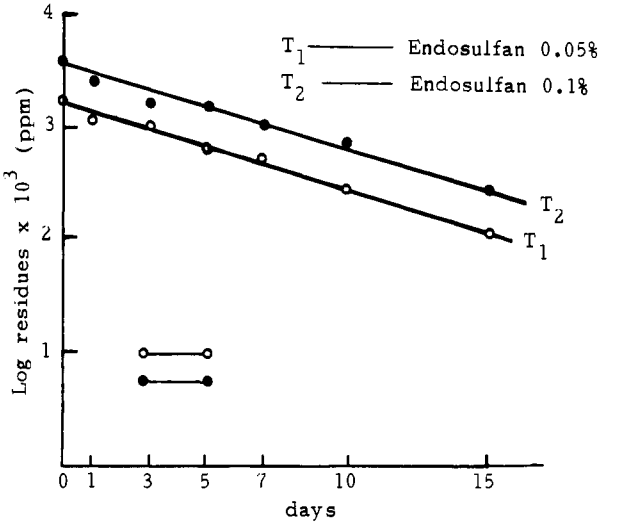

Figure 5. Linear plot of first-order reaction of endosulfan in fruits of eggplant.

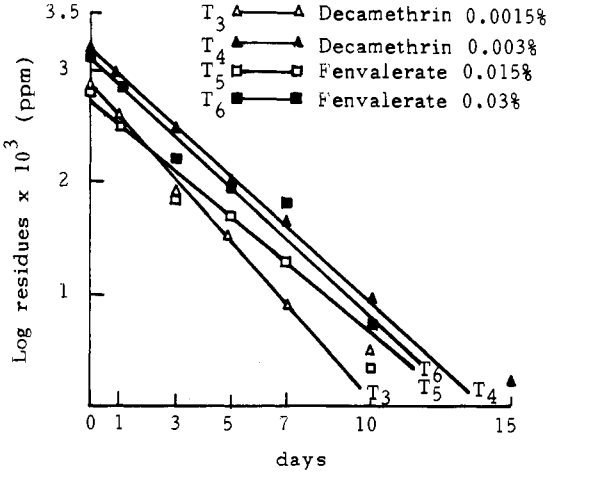

Figure 6. Linear plot of first-order reaction of decamethrin and fenvalerate in fruits of eggplant.

Table VII. Residues of Endosulfan, Decamethrin, and Fenvalerate in the Fruits of Eggplant after Washing and Cooking

insecticide	days after spraying	decontamination process	residues,[a] ppm		% loss	
			recommended dose	double the recommended dose	recommended dose	double the recommended dose
endosulfan[b]	0	initial	1.56	3.27		
		washing	0.76	1.17	51	48
		washing and cooking	0.40	0.84	74	74
	5	initial	0.62	1.59		
		washing	0.32	0.79	48	50
		washing and cooking	0.17	0.42	73	74
decamethrin	0	initial	0.70	1.51		
		washing	0.50	1.05	29	30
		washing and cooking	0.35	0.74	50	50
	5	initial	0.03	0.10		
		washing	0.02	0.07	33	30
		washing and cooking	0.013	0.045	57	55
fenvalerate	0	initial	0.66	1.19		
		washing	0.44	0.70	33	41
		washing and cooking	0.32	0.56	51	52
	5	initial	0.05	0.08		
		washing	0.03	0.048	40	40
		washing and cooking	0.02	0.03	60	63

[a] Average residues of three replicates. [b] Sum of α- and β-isomers and the sulfate.

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