THE FATE OF ^{14}C-FENITROTHION IN RICE-FISH MODEL ECOSYSTEM*

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ABSTRACT

The fate of fenitrothion in rice- fish ecosystem was studied using ^{14}C- fenitrothion (^{14}C- F) labelled at methoxyl and two application rates. The fenitrothion in water disappeared quickly, only 8 and 11 ppb in two treatments at harvest were detected respectively. Most of ^{14}C- F in soil existed in upper layer and that in plants appeared in shoots. The extractable residues in cargo rice were 0.36 and 0.58 ppm in two treatments respectively. ^{14}C- residues (^{14}C- R) were concentrated in bones, next viscera, meat and scales. Total ^{14}C- R in meat were 0.92 and 1.77 ppm at harvest. Comparing two treatments, the residue dynamics of fenitrothion in water, soil, plants and fish were similar. ^{14}C- R in water and soil after harvest affected the rice- fish ecosystem in the next season. However, the extractable ^{14}C- R in cargo rice, soil and water were very low.

Keywords: Fenitrothion ^{14}C- fenitrothion Rice- fish Model ecosystem

Fenitrothion, 0,0- dimethyl- 0- (3- methyl- 4- nitrophenyl) phosphorothioate, is an organophosphorus insecticide, which has been widely used for the control of insects in paddy field. The mixed cultures of rice and fish, or rice, fish and azolla are increasingly common in rice area in Asian countries. Although the behavior of fenitrothion in soil and water, and the metabolism of fenitrothion in plants and mammals have been extensively studied[1-6], and the accumulation of fenitrothion in fish sampled from paddy field has been studied recently[7], the fate and affection of fenitrothion on rice- fish ecosystem have not been reported yet. Therefore, the investigation above- described has been undertaken to evaluate the safety of fenitrothion on rice- fish mixed culture.

I . MATERIALS AND METHODS

1. Chemicals

^{14}C- fenitrothion (^{14}C- F) (sp. act. 188.7 MBq $mmol^{-1}$; radiochemical purity: greater than 90%). Commercial formulation of fenitrothion (50% a. i. EC). ^{14}C- F was prepared into 53.90% (a.i.) EC for spray. All the solvents used in the study were of analytical grade.

2. Soil, rice plants and fish

Paddy soil (pH 7.22, organic matter content 1.06%) was collected from the experimental farm of Zhejiang Agricultural University. An early season variety, Zao

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Lian, a late season variety, glutinous rice "85225" and fish (*Tilapia nilotica L.*) with an average length of 8 cm and weight of 8.3 g were used in the study.

3. Model ecosystem and treatment

Three model ecosystem tanks (each one 1×1 m^2 with a depth of 50 cm) were kept under natural condition. Two tanks contained 30 sampling tubes (1.5 cm in diameters)[8]. For each tank, rice seedlings were transplanted, 30 fish were intro duced and water was maintained 9 cm level during the test period.

^{14}C– F (EC) at rates of 0.75 kg (a.i.)/ha, 7.4×10^6 Bq (I) and 1.5 kg (a.i.)/ha, 1.48×10^7 Bq (II) were diluted to 1000 times and sprayed respectively. After 15 days, ^{14}C– F was sprayed again as described above. After harvest, glutinous rice seedlings were transplanted into tanks. All tanks in the study were managed as normal rice field, but protected from excessive rain.

4. Sampling, preparation and analysis

Table 1

Sampling schedule for water, soil, plants and fish

Day[a]	0.042	1	3	7	14	15 (1h)	16 (1)	18 (3)	22 (7)	29 (14)	36 (21)	43 (28)	58[b]—149[c]	
Water	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Soil			*	*	*		*	*		*		*	*	*
Plants					*		*	*	*	*		*	*	*
Fish					*		*	*	*	*		*	*	*

[a] The figures in parentheses express the times after the second spray.
[b,c] Harvest for the early and late season rice respectively

1) Water Water samples were taken from I and II for counting, while another smaples (50ml$\times$2) were taken, extracted and counted[1,2,8]. *2) Soil* The dried samples were combusted and counted[8]. *3) Plants* Two hills of plants were taken, and separated into shoots and roots. Fresh samples were homogenized[5]. The concentrated aliquots were counted, and the extracted residues were combusted and counted[8]. *4) Fish* Two fish were taken from each tank, divided into meat, bones, scales, viscera and egg, dried at 40°C. The grind samples were combusted and counted[8]. *5) Sampling at harvest* Water and soil: As described above, except soil samples(upper layer) in the late season were extracted with acetone for 24 h. Plants: All plants were pulled out, separated into shoots, roots, cargo rice, and husk. Each part were extracted as soil. Fish: The left fish were cultivated continuely until harvest of the late season rice, all fish were sampled, treated as mentioned above, except the meat were extracted as plants.

II. RESULTS AND DISCUSSIONS*

1) Residues of $^{14}C-F$ in water As shown in Fig.1, fenitrothion could contaminate

* All the counting errors were controlled below 5%

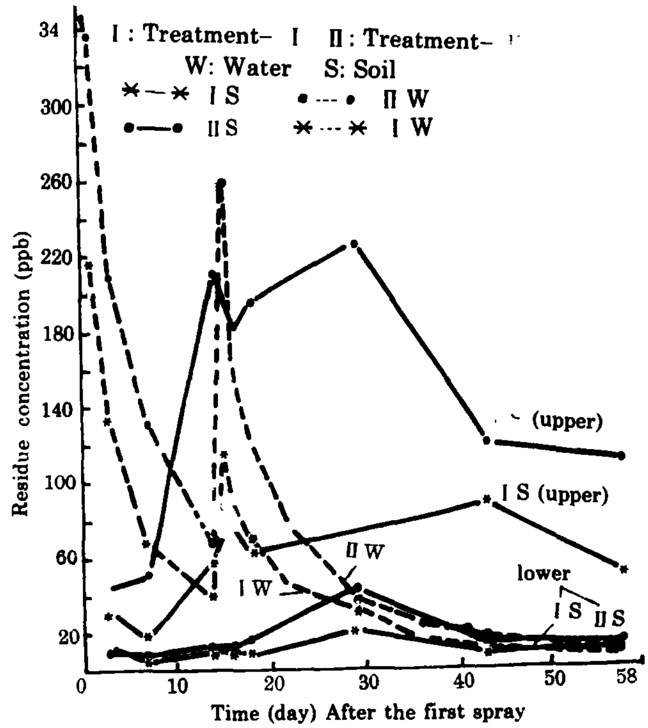

Fig. 1 Residues of ^{14}C- fenitrothion in water and soil

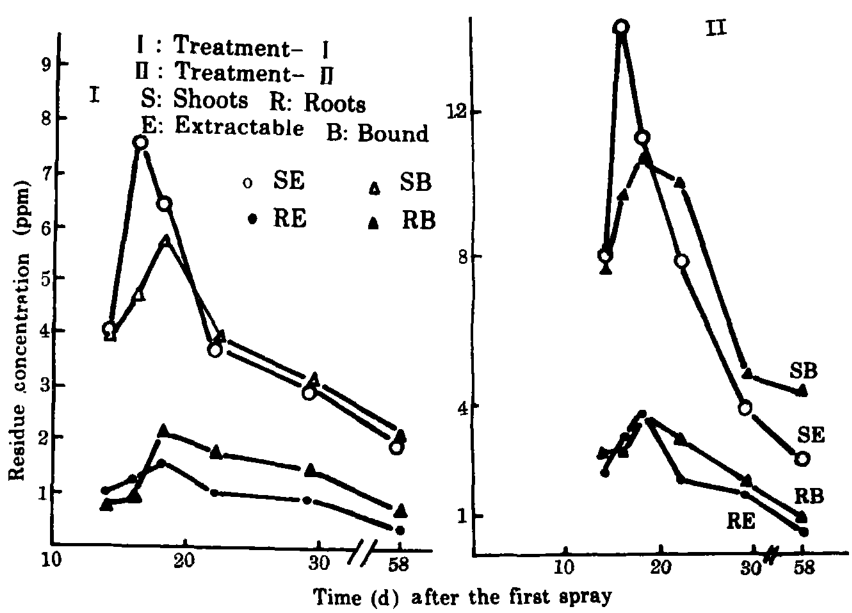

Fig.2 Residues of ^{14}C- fenitrothion in plants

water after spray. Fenitrothion in water disapeared quickly with time. The same findings were reported by Nobuyoshi Mikami et al.[4,7]. Most of fenitrothion were converted into water soluble products 3 days after spray, which might be hydrolysis or photolysis of fenitrothion. At harvest, only 8 and 11 ppb were detected in I and II respectively.When Ⅰ and Ⅱ were compared, it was found the disappearence of fenitrothion in water was very similar, and the concentration of fenitrothion in Ⅱ attributed to hydrolysis or photolysis of fenitrothion. At harvest, only 8 and 11 ppb were detected in Ⅰ and Ⅱ respectively. When Ⅰ and Ⅱ were compared, it was found the disappearence was higher than that in Ⅰ, which resulted from the application rate. However, this difference gradually decreased with time (Fig.1).

2) Residues in soil $^{14}C-F$ in water could be adsorbed by soil. However, its concentration in soil was low, and most of fenitrothion appeared in upper layer. The dynamics of $^{14}C-R$ were similar in Ⅰ and Ⅱ (Fig.1).

Table 2

Residues of ^{14}C- fenitrothion in ear

Day[a]		Ⅰ (ppm)[b,c]		Ⅱ (ppm)[b,c]	
		E	B	E	B
22	(7)	2.58±0.0	1.03±0.02	4.94±0.17	1.38±0.00
29	(14)	1.95±0.0	1.36±0.02	2.70±0.00	2.03±0.10
43	(28)	0.43(1.89)	2.22(7.02)	0.75(2.90)	4.23(9.05)
58	(43)	0.36(0.64)	2.78(5.68)	0.58(1.05)	4.13(6.61)

[a] The figures in parentheses indicate the times after the second spray [b] E: Extractable B: Bound [c]. The figures from 43 – 58 days indicate the residues in cargo rice and the figures in parentheses indicate residues in husk

Table 3

Residues and distribution of ^{14}C- fenitrothion in fish after spraying Ⅰ [a]

Day[b]		Bones (ppm)	Viscera (ppm)	Meat (ppm)	Scales (ppm)	Egg (ppm)
14		3.36±0.08	10.04±0.41	1.49±0.25	3.67	
		(36.78)	(39.94)	(20.56)	(2.73)	
16	(1)	4.73±0.34	13.28±0.52	1.84±0.00	2.55	
		(37.82)	(42.12)	(18.26)	(1.77)	
18	(3)	5.52±0.03	10.38±0.05	2.71±0.16	3.68	
		(48.98)	(23.23)	(25.47)	(2.23)	
22	(7)	5.35±0.51	5.98±0.30	1.80±0.17	1.36	
		(60.52)	(18.43)	(19.25)	(1.69)	
29	(14)	1.64±0.34	8.32±1.38	1.35±0.20	2.51±0.14	9.02±0.79
		(37.58)	(27.37)	(26.27)	(1.94)	(3.97)
43	(28)	2.81±0.06	2.34	1.26±0.0	3.10	9.29
		(58.92)	(12.64)	(11.03)	(6.54)	(10.83)
58	(43)	1.09	1.82	0.92	0.49	1.62
(Harvest)		(55.26)	(11.11)	(28.67)	(2.56)	(2.40)

[a] Figures in parentheses indicate the percentages in whole fish
[b] Figures in parentheses indicate the time aftér the second spray

3) Residues in plants Plants could absorb and transfer $^{14}C-F$ into whole plants after spray. $^{14}C-F$ in plants were much higher than that in water and soil (Fig.1, 2). The dynamics of fenitrothion in Ⅰ and Ⅱ were very similar and $^{14}C-R$ in shoots were much higher than that in roots (Fig.2). Comparing Ⅰ and Ⅱ, $^{14}C-R$ in plants in Ⅱ were always much higher than that in I ; in cargo rice, the extractable residues were 0.36 and 0.58 ppm, while bound $^{14}C-R$ were 2.78 and 4.13 ppm in I and II respectively (Table 2), which also resulted from the application rate. The bound residues in plants were predominant.

4. *Residues in fish* As shown in Table 3-4, $^{14}C-F$ in water could contaminate fish in ecosystem. The distribution of $^{14}C-R$ in fish were different. The percentage accounted for the total ^{14}C in bones was the highest, next viscera, meat and scales. The dynamics of $^{14}C-R$ in meat and bones in I were similar to that in II (Fig.3).

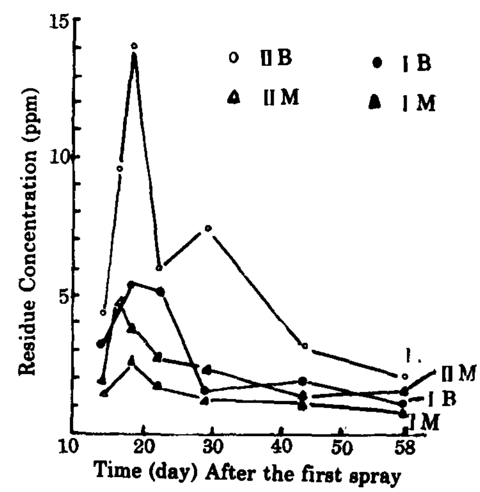

Fig.3 Residues of ^{14}C-fenitrothion in bones and meat of fish

Table 4

Residues and distribution of ^{14}C- fenitrothion in fish after spraying II [a]

Day[b]	Bones (ppm)	Viscera (ppm)	Meat (ppm)	Scales (ppm)	Egg (ppm)
14	4.49±0.32	14.21±0.69	2.06±0.08	3.69	
	(31.18)	(45.17)	(21.23)	(2.41)	
16 (1)	9.71±0.75	20.68±1.39	4.90±0.25	5.00	
	(40.75)	(30.53)	(26.83)	(1.83)	
18 (3)	14.25±0.45	18.47±1.67	3.83±0.11	9.71	
	(30.27)	(50.39)	(17.59)	(1.75)	
22 (7)	6.23±0.64	9.83±0.63	2.88±0.11	3.45	25.0
	(47.35)	(14.91)	(14.91)	(1.36)	(21.40)
29 (14)	7.47±0.15	14.98±0.15	2.38±0.02	4.76±0.16	12.90
	(57.76)	(20.04)	(14.00)	(3.55)	(4.63)
43 (28)	3.19±0.09	18.59	1.49±0.31	5.22	
	(41.87)	(27.53)	(14.81)	(15.76)	
58 (43)	2.09	4.93	1.77	2.34	6.15
(Harvest)	(39.07)	(20.63)	(26.79)	(4.87)	(8.72)

[a] Figures in parentheses indicate the percentages in whole fish
[b] Figures in parentheses indicate the times after the second spray

$^{14}C-R$ in meat were high, 0.92 and 1.77 ppm in I and II at harvest respectively, which might result from metabolites accumulated and should be identified next year.

5) The impact of $^{14}C-R$ remained in water and soil on the rice-fish ecosystem in the late season At harvest, $^{14}C-R$ in water, soil, plants and fish are listed in Table 5. $^{14}C-R$ in water, soil and cargo rice were very low, while that in other parts were high. It might be speculated that some of $^{14}C-R$ were metabolites and accumulated in

Table 5

^{14}C- residues(ppm) in each part of the late season rice ecosystem at harvest[a]

Part	I[b]			II[b]		
	E	B	B/E + B(%)	E	B	B/E + B(%)
Cargo rice	0.035	0.051	59.30	0.042	0.105	71.43
Husk	0.100	0.071	41.52	0.100	0.153	61.47
Shoots	0.200	0.088	30.56	0.313	0.155	33.12
Roots	0.063	0.043	40.57	0.054	0.113	67.66
Soil upper	0.025	0.031	55.36	0.027	0.057	67.86
lower		0.004			0.005	
Fish bone		3.55			5.78	
intestine		1.23			2.45	
meat	0.34	1.17	77.48	0.57	1.83	76.25
scales		2.98			4.12	
egg		3.22			6.73	
Water		0.004			0.006	

a $^{14}C-R$ were expressed in $^{14}C-F$ b E: Extractable B: Bound

other parts. Regarding plants growth and fish survival, the model ecosystem worked well. The main difference between the model ecosystem and the paddy field is that the water in the model ecosystem could not flow over and be lost, so residues of fenitrothion in it might be slightly high than that in paddy field.

Ⅲ. CONCLUSION

After $^{14}C-F$ sprayed on rice plants, it could contaminate water, fish, soil and plants in rice – fish ecosystem. The disappearance of fenitrothion in water was very rapid. Most of $^{14}C-F$ in soil existed in upper layer. In fish, the distribution of $^{14}C-F$ fell off in order of bones, viscera, meat and scales. The residue dynamics of fenitrothion in water, soil, fish and plants were similar in I and II treatments. Under the same conditions, the residues of fenitrothion in components in ecosystem were influenced by the application rate. The $^{14}C-R$ remained in water and soil affected the rice – fish ecosystem in the next season. However, the $^{14}C-R$ in water, soil and cargo rice were very low except husk, shoots and fish.

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