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Persistence of Captafol in Soils With and Without Amendments and its Effects on Soil Microflora

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Some of the findings on the effect of pesticides on soil microbial activities were reported (Venkatramesh et al. 1987a, 1987b). In this paper we present results of studies on the effects of captafol, a sulfanimide fungicide, on soil microflora and its degradation in soils.

MATERIALS AND METHODS

The study was conducted in red, laterite, black and alluvial soils. The important characteristics of these soils along with incubation techniques and treatment details are given in Venkatramesh et al. (1987a). Captafol (Foltaf 5G, Rallis India Ltd., India) was applied to the soils at 50 and 100 ppm. This is an experimental granular formulation, for soil application, being tested by Rallis India Ltd., for control of seedling diseases of some vegetable crops in nurseries. The amendments used were ammonium sulphate (500 ppm-N) and groundnut oil (GN Oil) cake powder (1.5 g). Hundred grammmes of seived soil was treated with appropriate amounts of captafol granules and amendments, where necessary, and incubated in polypropylene pouches. Moisture was maintained at field capacity.

Populations of bacteria, fungi, actinomycetes, and Azotobacter sp. were studies by standard methods (Venkatramesh et al. 1987a).

Captafol residues were analysed by taking the soil, remaining after sampling for plating, in 2000 ml conical flasks and shaking with 200 ml of benzene and 25 g of anhydrous sodium sulphate on a rotary shaker for one hour. The samples were then filtered and the remaining soil was washed twice with 50 ml portions of benzene and the filtrates were pooled and evaporated to dryness. The residues were redisolved in 25-75 ml of benzene. An aliquot of this was used

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for analysis.

Residues were analysed on Varian GC model 3700 equipped with thermionic specific detector and Varian recorder model 9176. The GC conditions were: column : 5% OV-101 on 60-80 mesh chromosorb G, 50 cm long, 0.3 cm dia.; temperatures (^{o}C): column: 185, detector: 270, injector: 280; gas flow rates (cc/min): nitrogen (carrier): 30, air: 140, hydrogen: 4; sensitivity: 1 x 10^{-10}; retention time: 2.1 min.

After an initial conditioning of the instrument 2 ul of the benzene extract was injected. All values were calibrated against a standard curve obtained by injecting 40 to 200 ng.

All data were statistically analysed by the factorial method where soil type, treatments and sampling date after treatment (interval) were the factors.

RESULTS AND DISCUSSION

Captafol persisted in all the four soils up to sixty days (Table 1a). There was no significant effect on the degradation of captafol by either of the amendments except in the case of laterite soil where ammonium sulphate significantly reduced the residue level over treatment with only 100 ppm captafol. GN oil cake amendment had no effect. Similarly, the interaction of treatment and interval showed significant reduction in residue level only where soils were amended with ammonium sulphate (Table 1b). This is in contrast to the effects seen in the case of carbofuran and phorate (Venkatramesh et al. 1987a, 1987b). There are no reports in the literature on the effects of amendments on the persistence of captafol.

The bacterial population increased with increasing concentrations of captafol (Table 2). This increase was significant in alluvial soil at 100 ppm and in GN oil cake amended treatments in all the four soils. In the case of laterite soil ammonium sulphate amendment also significantly increased the bacteria. Apart from these variations between soils, the interaction effect shows a significant stimulation in all the treatments over control (Table 4). Further, the stimulation due to ammonium sulphate amendment is also significant over treatments with captafol alone at 100 ppm. Captafol is stable under acidic and neutral conditions (Wolfe et al. 1976, Dhillon 1981). Ammonium sulphate and GN oil cake lowered the pH and they may have stabilized the activity of captafol and thus contributing to the stimulatory effect on bacteria.

The stimulatory effect of fungicides on bacteria is well documented though there are no reports in the case of captafol. It is suggested that this effect is indirect, mediated through availability of dead mycelial pabulum for bacterial nutrition (Anderson 1978).

Captafol was inhibitory to actinomycetes. The inhibition was significant only in the case of interactions. The inhibition was

Table 1a. Residues of Captafol in soils with and without amendments (mg Captafol/g soil)

SOIL	TREATMENTS	DAYS AFTER INCUBATION				
		3	10	25	40	60
RED	Control	ND	ND	ND	ND	ND
	50 ppm	0.05	0.04	0.04	0.05	0.01
	100 ppm	0.11	0.08	0.08	0.09	0.03
	100 ppm+$(NH_4)_2SO_4$	0.11	0.09	0.08	0.09	0.04
	100 ppm+GN oil cake	0.10	0.09	0.08	0.09	0.04
LATERITE	Control	ND	ND	ND	ND	ND
	50 ppm	0.05	0.04	0.04	0.05	0.02
	100 ppm	0.13	0.07	0.09	0.10	0.04
	100 ppm+$(NH_4)_2SO_4$	0.09	0.07	0.07	0.09	0.04
	100 ppm+GN oil cake	0.14	0.07	0.09	0.09	0.04
BLACK	Control	ND	ND	ND	ND	ND
	50 ppm	0.05	0.03	0.04	0.05	0.01
	100 ppm	0.11	0.09	0.08	0.11	0.04
	100 ppm+$(NH_4)_2SO_4$	0.10	0.08	0.07	0.10	0.03
	100 ppm+GN oil cake	0.10	0.09	0.07	0.11	0.04
ALLUVIAL	Control	ND	ND	ND	ND	ND
	50 ppm	0.04	0.03	0.02	0.04	0.01
	100 ppm	0.09	0.06	0.05	0.08	0.03
	100 ppm+$(NH_4)_2SO_4$	0.07	0.06	0.05	0.06	0.03
	100 ppm+GN oil cake	0.11	0.07	0.06	0.09	0.03

ND = Not detected

Table 1b. Two way table for treatment x interval interaction

INTERVAL / TREATMENT	3	10	25	40	60	TOTAL
Control	0.00	0.00	0.00	0.00	0.00	0.00
50 ppm	0.18	0.14	0.14	0.19	0.06	0.72
100 ppm	0.44	0.29	0.30	0.37	0.14	1.54
100 ppm+$(NH_4)_2SO_4$	0.38	0.30	0.28	0.34	0.14	1.43
100 ppm+GN oil cake	0.46	0.31	0.30	0.37	0.14	1.57
TOTAL	1.46	1.04	1.02	1.27	0.48	

$SE_{m+/-}$ = 0.02

$CD_{0.05}$ for soil = 0.06 $CD_{0.05}$ for interval= 0.06

$CD_{0.05}$ for treatment= 0.06 $CD_{0.05}$ for treatment x interval= 0.04

'-' indicates significant lower residues

Table 2. Effect of Captafol on bacteria and actinomycetes in soils with and without amendments (Counts/g soil)

SOILS	TREATMENTS	COLONY COUNT DAYS AFTER INCUBATION*				
		3	10	25	40	60
RED	Control	46.7	40.6	42.1	62.0	37.7
		(1.1)	(4.4)	(4.0)	(5.6)	(9.3)
	50 ppm	68.3	55.9	45.0	50.5	59.0
		(3.0)	(5.8)	(4.4)	(7.9)	(3.4)
	100 ppm	96.4	43.5	50.1	55.1	52.3
		(3.0)	(1.5)	(4.4)	(6.6)	(7.1)
	100 ppm + $(NH_4)_2SO_4$	257.4	147.3	35.9	13.5	0.4
		(0.8)	(1.5)	(0.0)	(0.4)	(0.0)
	100 ppm + GN oil cake	830.3	496.2	808.9	108.4	78.5
		(4.9)	(55.5)	(61.7)	(26.2)	(18.0)
LATERITE	Control	76.0	84.6	53.4	110.0	110.7
		(5.9)	(3.6)	(7.5)	(10.7)	(8.4)
	50 ppm	137.7	147.9	98.5	113.0	78.5
		(7.1)	(2.4)	(5.1)	(6.5)	(7.7)
	100 ppm	131.4	150.0	84.6	101.2	80.8
		(3.8)	(1.6)	(4.4)	(7.7)	(6.5)
	100 ppm + $(NH_4)_2SO_4$	189.3	150.7	200.9	96.6	86.2
		(1.3)	(2.0)	(0.4)	(0.4)	(1.5)
	100 ppm + GN oil cake	785.5	368.1	648.5	597.5	636.0
		(0.4)	(7.1)	(55.4)	(153.9)	(95.8)
BLACK	Control	46.4	29.7	58.9	50.2	57.3
		(0.5)	(1.3)	(0.9)	(1.0)	(3.3)
	50 ppm	27.3	51.2	40.0	50.7	56.3
		(0.0)	(1.3)	(0.0)	(1.9)	(4.3)
	100 ppm	37.7	91.6	46.9	73.9	62.0
		(0.5)	(2.2)	(0.9)	(1.0)	(1.4)
	100 ppm + $(NH_4)_2SO_4$	38.2	41.3	37.9	63.9	39.3
		(1.4)	(0.0)	(0.4)	(0.0)	(1.4)
	100 ppm + GN oil cake	492.0	329.6	369.7	227.3	468.8
		(3.6)	(5.2)	(73.1)	(47.4)	(90.0)
ALLUVIAL	Control	96.8	69.0	92.9	86.0	58.9
		(1.3)	(0.5)	(3.2)	(3.3)	(1.4)
	50 ppm	272.9	125.4	89.8	85.1	83.7
		(1.8)	(0.9)	(2.3)	(0.9)	(2.3)
	100 ppm	311.8	149.8	103.7	77.6	90.7
		(0.5)	(0.9)	(0.9)	(1.9)	(2.8)
	100 ppm + $(NH_4)_2SO_4$	499.6	123.1	39.2	36.5	79.0
		(0.9)	(0.5)	(0.0)	(0.0)	(1.4)
	100 ppm + GN oil cake	917.1	401.9	694.6	439.5	219.7
		(0.5)	(5.4)	(76.7)	(74.8)	(23.4)

* Figures within parentheses indicate actinomycete numbers, all values are average of three replicates and $x10^5$

$CD_{0.05}$ for soil= 323.3 $CD_{0.05}$ for interval= 282.0 (44.3)

$CD_{0.05}$ for treatment= 282.0 (44.3)

Table 3. Effect of Captafol on fungi and Azotobacter in soils with and without amendments (Counts/g soil)

SOILS	TREATMENTS	COLONY COUNT DAYS AFTER INCUBATION*				
		3	10	25	40	60
RED	Control	5.7 (39.5)	14.1 (27.1)	4.4 (18.9)	1.5 (38.5)	7.7 (7.9)
	50 ppm	7.6 (55.8)	3.3 (26.8)	4.7 (24.3)	2.6 (38.9)	1.1 (38.5)
	100 ppm	4.2 (137.8)	2.5 (31.6)	3.6 (16.0)	0.0 (20.5)	7.9 (20.6)
	100 ppm + $(NH_4)_2SO_4$	1.5 (113.9)	1.1 (46.4)	1.1 (37.0)	0.0 (18.3)	0.4 (20.6)
	100 ppm + GN oil cake	5.3 (543.5)	15.2 (912.6)	29.4 (58.0)	82.2 (115.9)	3.4 (325.1)
LATERITE	Control	1.7 (42.4)	6.3 (22.9)	1.6 (13.8)	56.5 (29.5)	3.1 (21.1)
	50 ppm	1.3 (142.7)	0.4 (119.8)	0.0 (78.7)	0.8 (93.9)	0.8 (41.0)
	100 ppm	1.3 (229.2)	1.2 (125.0)	1.2 (159.8)	0.4 (83.9)	1.2 (83.5)
	100 ppm + $(NH_4)_2SO_4$	0.0 (228.4)	0.0 (144.3)	0.0 (103.2)	0.0 (77.0)	0.0 (196.6)
	100 ppm + GN oil cake	3.4 (569.7)	5.5 (329.4)	34.8 (984.6)	0.4 (287.4)	2.7 (241.4)
BLACK	Control	4.1 (107.8)	6.5 (50.3)	9.5 (64.1)	1.4 (48.8)	9.0 (32.7)
	50 ppm	7.7 (107.3)	4.3 (56.3)	4.3 (60.6)	2.8 (51.1)	5.2 (54.5)
	100 ppm	10.9 (116.9)	0.9 (67.1)	6.5 (34.0)	4.7 (54.0)	2.8 (63.0)
	100 ppm + $(NH_4)_2SO_4$	5.5 (229.7)	6.9 (74.0)	1.7 (39.6)	2.4 (60.6)	0.5 (37.9)
	100 ppm + GN oil cake	4.6 (7239.6)	24.1 (4150.1)	2.2 (4511.8)	7.1 (2968.8)	1.9 (3456.4)
ALLUVIAL	Control	7.2 (110.2)	8.1 (46.5)	4.1 (97.0)	6.1 (67.8)	3.7 (48.2)
	50 ppm	7.6 (148.3)	2.7 (51.9)	2.7 (116.4)	4.7 (69.7)	9.4 (57.0)
	100 ppm	7.6 (276.0)	1.4 (74.4)	5.0 (111.4)	2.8 (65.5)	4.2 (43.0)
	100 ppm + $(NH_4)_2SO_4$	2.7 (188.2)	1.4 (68.1)	0.5 (64.1)	0.5 (88.4)	1.9 (91.6)
	100 ppm + GN oil cake	11.2 (7050.6)	37.9 (4434.4)	12.2 (4975.2)	8.5 (1729.8)	20.1 (3342.7)

* Figures within parentheses indicate Azotobacter numbers, all values average of three replicates.
Values expressed as $x10^3$ for fungi and $x10^2$ for Azotobacter
$CD_{0.05}$ for soil= (2569.4) $CD_{0.05}$ for treatment= 282.0 (44.3)
$CD_{0.05}$ for interval= 23.2 (2241.5)

Table 4. Two way table for treatment x interval interactions for bacteria and actinomycetes

INTERVAL / TREATMENTS	3	10	25	40	60	TOTAL
Control	265.9	223.9	247.3	308.2	264.6	1309.9
	(8.8)	(9.8)	(15.6)	(20.6)	(22.4)	(77.2)
50 ppm	506.2	380.4	273.3	299.3	277.5	1736.7^{+}
	(12.0)	(10.4)	(11.8)	(17.2)	(17.7)	(69.1)$_{+}$
100 ppm	577.3^{+}	434.9	285.3	307.8	285.9	1891.1^{+}
	(7.8)	(6.2)	(10.6)	(17.2)	(17.8)	(59.6)$_{+}$
100 ppm +	984.5	462.4	313.9	210.5	204.9	2176.2^{+}
$(NH_4)_2SO_4$	(4.4)	(3.9)	(0.8)	(0.8)	(4.3)	(14.2^{-})
100 ppm +	3024.9^{+}	1591.8^{+}	2521.7^{+}	1372.7^{+}	1403.0^{+}	9914.1^{+}
GN oil cake	(9.4^{+})	(73.2^{+})	(266.9^{+})	(302.3^{+})	(227.9^{+})	(879.7^{+})
TOTAL	5358.8	3093.4	3641.5	2498.5	2435.8	
	(42.4)	(103.5)	(305.7)	(358.1)	(290.1)	

$SE_{m+/-}$ = 101.6 (16.0)
$CD_{0.05}$ for treatment x interval = 215.4 (33.8)
'+' indicates significant stimulation and '-' indicates significant inhibition. Values within parentheses are for actinomycetes.

Table 5. Two way table for treatment x soil interaction for Azotobacter

TREATMENT / SOILS	CONTROL	50 ppm	100 ppm	100 ppm+ $(NH_4)_2SO_4$	100 ppm+ GN oil	TOTAL
Red	131.9	184.3	226.5	236.2	1964.1$_{+}$	2733.0
Laterite	129.7	476.1	681.4	749.1	2412.5^{+}	4449.2
Black	303.7	329.8	334.9	511.8	22326.7^{+}	23806.9
Alluvial	369.7	443.3	570.3	500.4	21532.7^{+}	23416.4
TOTAL	935.0	1433.5	1813.1	1997.9	48226.0^{+}	

$SE_{m+/-}$ = 807.5
$CD_{0.05}$ for treatment x soil = 1759.5
'+' indicates significant stimulation over control

concentration dependent, ranging from 8 to 34% (Table 2). Ammonium sulphate amendment further inhibited actinomycetes. This ranged from 51 to 89% and was significant for treatment and interval interactions (Table 4). GN oil cake amendment significantly stimulated actinomycetes. These observations could be compared to the effect of captafol on bacteria in general where stimulatory effect of captafol was further increased by ammonium sulphate. Similarly, the inhibition of actinomycetes by captafol is greater in ammonium sulphate amended soils than in unamended soils. Though there are no reports in the literature on the effects of captafol on actinomycetes, the results of the present study are in agreement with those reported for fungicides in general (Anderson 1978).

Captafol stimulated Azotobacter numbers (Table 3). This stimulation was concentration dependent. The amendments further stimulated the numbers as in the case of bacteria. However, the stimulation due to GN oil cake amendment alone was significant (Table 5). There are no reports in the literature on the effects of captafol on nonsymbiotic nitrogen fixers. The little information available for other fungicides indicates that they either have no effect or are inhibitory to this group of bacteria.

Captafol being a fungicide, inhibited fungi in all the four soils at both concentrations. The inhibition ranged from 7 to 77% but statistical significance was not observed. This may be due to the low numbers of colonies observed in the plates. The stimulation due to GN oil cake amendment was also not significant. This may again be attributed to the fungicidal action of captafol. These findings are consistent with earlier reports for fungicides in general.

The fungal species commonly encountered were Aspergilli and Pencillia. Aspergillus niger Van Tieghem was inhibited up to 40 days in red soil and up to 25 days in black soil. In laterite and alluvial soils there was no consistent effect. A. terreus Thom and A. ochraeus Wilhelm disappeared after 25 days in the amended red soil. In laterite and alluvial soils A. terreus was stimulated by GN oil cake amendment while Penicillium gresioazurium Moreau et Moreau ex Ramirez was stimulated in red soil.

From this study it is seen that though captafol is a fungicide it has varied effects on soil microflora indicating that it would be interesting to study such effects with other soil applied fungicides also.

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