Applied Organometallic Chemistry (1987) 1 303–309

0268–2605/87/01402303/$03.50

Antifeedant effects of mixed methylphenyl hexaorganoditin compounds of the type $Ph_nMe_{6-n}SnSn$ on larvae of *Spodoptera littoralis* and *Epilachna varivestis*

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Received 21 November 1986 Accepted 5 January 1987

Compounds of the series $Ph_nMe_{6-n}Sn_2$ were prepared and tested for their antifeedant effects against *Spodoptera littoralis* (Boisduval) and *Epilachna varivestis* (Mulsant) larvae. In addition, phytotoxicity towards bean seedlings was measured. The most active compound against both *Spodoptera* and *Epilachna* was $Ph_3Me_3Sn_2$. The compound at 50 mg dm^{-3} was comparatively innocuous in phytotoxicity tests against bean seedlings.

Keywords: Mixed phenylmethyl organoditins, antifeedant effects, *Spodoptera littoralis* larvae, cotton leaves, *Epilachna varivestis*, bean leaves, phytotoxicity, bean seedlings.

INTRODUCTION

Substituted hexaorganoditins (distannanes) have been tested as insecticides since the early 1960s. Thus, Blum and Pratt[1] in 1960 included hexa-n-butylditin among the organotins they assayed against the house fly. The compound was later found to be an excellent wood preservative equalling TBTO, but having much better wood-penetrating properties than this compound.[2]

Hexamethylditin was the experimental[3] insecticide TD-5032 of Pennsalt (today Pennwalt) Corporation, Philadelphia, PA, USA. The manufacturers' data sheet[3] stated that TD-5032 was highly effective against many species of insects. On topical application it exhibited pronounced toxicity for some species of noctuid moth larvae, but was practically inactive in some others[4]: hexamethylditin was highly active against the armyworm, *Pseudaletia unipuncta* (Haworth), and progressively less active (in this order) against the yellowstriped armyworm, *Spodoptera ornithogalli* (Guenée), the corn earworm, *Heliothis zea* (Boddie), the fall armyworm, *S. frugiperda* (J.E. Smith), and the variegated cutworm, *Peridroma saucia* (Hübner); against the black cutworm, *Agrotis ipsilon* (Hufnagel), it was practically inactive. Ascher and Moscowitz[5] investigated the toxicity of hexamethylditin for larvae of the Egyptian cotton leafworm, *Spodoptera littoralis* (Boisduval), by topical application and by feeding treated alfalfa. Compared with the results of Harrendorf and Klutts[4] for other noctuids, the larvae of *S. littoralis* were rather tolerant to hexamethylditin by topical application,[5] and the compound had a strong fumigant effect.[5,6] Since it was found on topical application that with concentrations increasing from 0.625 μg per larva, all surviving larvae were very small, the antifeedant properties, if any, of the compound were investigated with *S. littoralis* larvae and larvae of the potato tuber moth, *Gnorimoschema operculella* (Zeller). Hexamethylditin was a highly active antifeedant against *S. littoralis* on cotton and sugar beet leaves, both by foliar application and systemically. On treated eggplant leaves it was much more active by foliar than by systemic application in preventing the penetration of larvae of *G. operculella*.[7] TD-5032 also prevented penetration of females of the fruit bark beetle, *Scolytus mediterraneus* Eggers, into treated peach twigs.[8]

Since one of the drawbacks of hexamethylditin as antifeedant is its high volatility, which causes rapid loss of the substance from the treated leaves[7] (b.p. 182°C/760 mm and 62–63°C/12 mm),[9] it was decided to prepare the

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series $Ph_nMe_{6-n}SnSn$, progressively exchanging methyl groups by phenyl groups. Thus the compounds $Ph_3SnSnPh_3$, $Ph_3SnSnPh_2Me$ (**I**), $Ph_3SnSnPhMe_2$ (**II**), $MePh_2SnSnPh_2Me$ (**III**), $Ph_3SnSnMe_3$ (**IV**), $MePh_2SnSnPhMe_2$ (**V**), $MePh_2SnSnMe_3$ (**VI**), $Me_2PhSnSnPhMe_2$ (**VII**) and $Me_2PhSnSnMe_3$ (**VIII**) were synthesized and tested for their antifeedant effects against *Spodoptera littoralis* and *Epilachna varivestis* Mulsant larvae.

MATERIALS AND METHODS

Synthesis of methylphenylditins of the type $Ph_nMe_{6-n}SnSn$ ($n=1-5$)

A complete series of methylphenylditins of the type $Ph_nMe_{6-n}SnSn$ ($n=1$–5) has been synthesized via a series of Sn–Sn coupling reactions essentially similar to those described in the literature for the synthesis of symmetric and asymmetric hexaorganoditins of the types R_3SnSnR_3 and $R_3SnSnR'_3$.[10–15] The $Ph_nMe_{6-n}SnSn$ compounds were identified by elemental analysis and ^1H NMR spectroscopy. The ^1H NMR spectra of the asymmetric hexaorganoditin compounds show two distinct singlets which can easily be assigned to the different methyl groups. Within the whole series J(Sn–Me) (47/49–49/51 Hz) and J(Sn–SnMe) (15–18 Hz) values are almost identical for the various compounds.

Physical and analytical data for the complete series of $Ph_nMe_{6-n}SnSn$ ($n=1$–5) compounds are presented in Table 1. Synthetic procedures are briefly outlined below. All reactions were carried out in a nitrogen atmosphere. Starting materials were prepared according to known literature procedures. Except for compound V, equimolar amounts of the tin reagents were used.

$Ph_3SnSnPh_2Me$ (I)

A mixture of Ph_3SnCl (3.9 g), $MePh_2SnH$ (3.0 g) and Et_3N (1.1 g) in 45 cm^3 of dry Et_2O was refluxed for 12 h. After addition of toluene and water the organic layer was separated and evaporated. The residue was recrystallized from MeCN to give I (2.3 g) in 34% yield.

$Ph_3SnSnPhMe_2$ (II)

$PhMe_2SnBr$ (6.1 g) in dry Et_2O (20 cm^3) was added dropwise to a stirred solution of Ph_3SnH (6.95 g) and Et_3N (2.0 g) in dry Et_2O (40 cm^3). The mixture was refluxed for 6 h. Subsequently water and Et_2O were added and the organic layer was separated, dried on $MgSO_4$, and evaporated. The residue was recrystallized from MeCN to give II (3.0 g) in 27% yield.

$MePh_2SnSnPh_2Me$ (III)

Starting from $MePh_2SnH$ (3.0 g), $MePh_2SnCl$ (3.3 g) and Et_3N (1.1 g) in 50 cm^3 of Et_2O, III (1.0 g) was isolated in 16% yield by the same procedure as described for compound II.

$Ph_3SnSnMe_3$ (IV)

Starting from Ph_3SnH (6.9 g), Me_3SnCl (3.9 g) and Et_3N (2.0 g) in 60 cm^3 of Et_2O, IV (5.2 g) was isolated in 51% yield. The synthesis of this compound has been reported previously.[11–13]

$MePh_2SnSnPhMe_2$ (V)

A mixture of $Me_2PhSnNEt_2$ (1.5 g) and $MePh_2SnH$ (1.45 g) was heated at 60°C for 3 h. Distillation of the reaction mixture at reduced pressure (0.1 mm) afforded V (1.0 g), n_D^{20} 1.6390 in 39% yield.

$MePh_2SnSnMe_3$ (VI)

$MePh_2SnBr$ (5.3 g) was added to a solution of Me_3SnLi in THF (30 cm^3), prepared from Me_3SnCl (3.6 g) and Li (1.0 g). After the addition was completed the solvent was evaporated. Distillation of the residue at reduced pressure (0.2 mm) afforded VI (2.7 g), n_D^{20} 1.6164 in 41% yield.

$Me_2PhSnSnPhMe_2$ (VII)

A solution of $PhMe_2SnBr$ (13.5 g) in THF (40 cm^3) was added dropwise to 0.3 g of Li, cut in small pieces. After a reflux period of 3 h the reaction mixture was decomposed with 10 cm^3 of saturated NH_4Cl solution in H_2O. After the common work-up procedure and subsequent distillation at reduced pressure (0.1 mm), VII (2.0 g) n_D^{20} 1.6100 was isolated in 20% yield.

$Me_2PhSnSnMe_3$ (VIII)

$Me_2PhSnBr$ (6.3 g) was added dropwise to a solution of Me_3SnLi in THF (40 cm^3), prepared from Me_3SnCl (4.2 g) and Li (1.45 g). After the addition was completed, the solvent was evaporated. Distillation of the residue at reduced pressure (0.1 mm) afforded VIII (2.8 g) in 42% yield.

Table 1 Physical and analytical data for a series of $Ph_nMe_{6-n}Sn_2$ ($n = 1$–5) compounds

Compound	M.p. (°C)	B.p. (°C mm)	Analyses found (calc), %			^{1}H NMR data[a]	
			C	H	Sn	δCH_3	$\delta CH_3'$
$Ph_3SnSnPh_2Me$ (I)	90	—	59.7 (58.37)	4.4 (4.42)	36.5 (37.21)	0.77	—
$Ph_3SnSnPhMe_2$ (II)	52–53		54.3 (54.23)	4.6 (4.55)	41.2 (41.22)	0.60	—
$MePh_2SnSnPh_2Me$ (III)	93–94		54.3 (54.23)	4.6 (4.55)	41.4 (41.22)	0.70[b]	—
$Ph_3SnSnMe_3$ (IV)	106	—	50.0 (49.09)	4.8 (4.71)	44.6 (46.20)	0.40	—
$MePh_2SnSnPhMe_2'$ (V)	—	160–170/0.1	50.4 (49.09)	4.9 (4.71)	44.2 (46.20)	0.66[b]	0.47[b]
$MePh_2SnSnMe_3'$ (VI)	—	126–128/0.1	43.6 (42.54)	5.0 (4.91)	50.5 (52.55)	0.57	0.30
$Me_2PhSnSnPhMe_2$ (VII)	—	113–136/0.1	43.5 (42.54)	5.2 (4.91)	51.3 (52.55)	0.43[b]	—
$Me_2PhSnSnMe_3'$ (VIII)	—	95–110/0.2	34.7 (33.91)	5.3 (5.17)	59.7 (60.92)	0.42	0.28

[a] In $CDCl_3$ solution, δ ppm downfield from TMS.
[b] In CCl_4 solution.

Biological antifeedant assays

Spodoptera littoralis

Larvae of *S. littoralis* were reared on alfalfa as described by Ascher *et al.*,[16] and Ascher and Moscowitz.[17] The assays of antifeedant effects of residues were conducted with 170–190 mg *S. littoralis* larvae on cotton leaves using the test method described in detail by Ascher and Rones[18] and Ascher and Nissim.[19] Emulsions for leaf treatments were prepared as follows: xylene solutions of the hexaorganoditins were prepared according to the solubility in xylene of the respective compounds (20% solutions in the case of V–VIII; 10% in the case of II and III; and 1% in the case of I and IV). An amount of Triton X-100 equal to the dissolved substance was added to the solutions. These emulsifiable concentrates were diluted with water to the desired concentrations, which were used for treating the leaves. Percentage larval starvation was calculated as described previously.[19]

The systemic antifeedant effect on cotton was assayed as detailed previously,[7] with leaves stood with their petioles for 24 h in the dilute aqueous emulsions prepared as described above.

All experiments with *S. littoralis* were conducted at 27°C.

Epilachna varivestis

The rearing of *E. varivestis* and the antifeedant bioassay were conducted on bean leaves at 24°C as described previously.[20]

Mortalities were corrected for control mortality, if any, according to Abbott's formula.[21] Control mortality was nearly always negligible.

Phytotoxicity

Phytotoxicity of the compounds was evaluated by spraying aqueous emulsions on bean (cv. Contender') seedlings.

RESULTS AND DISCUSSION

Spodoptera littoralis

The results of the antifeedant bioassays of dipping residues on cotton leaves against *S. littoralis* larvae are given in Table 2. Based on percentage larval starvation, the compounds having a terminal trimethyl group were highly active as antifeedants in the order IV ($Ph_3SnSnMe_3$) > VI ($MePh_2SnSnMe_3$) > VIII ($Me_2PhSnSnMe_3$). The only other compound showing lesser but still sizable activity was V ($MePh_2SnSnPhMe_2$) which has three methyls (but no terminal trimethyl

Table 2 The weight gain or loss ± standard error ($\Delta W \pm$ S.E.) of 170–190 mg *Spodoptera littoralis* larvae due to 48 h feeding on $Ph_nMe_{6-n}SnSn$-treated cotton leaves. (Numbers in brackets denote $\Delta W \pm$ S.E. of larvae on control leaves treated with the aqueous dilution of the inert ingredients at the highest concentration tested)

		Concentration of compound in leaf painting solution in methanol, mg dm^{-3}											
		500		100		50		10		5		1	
No.	Compound	$\Delta W \pm$ S.E.[a] (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)
I	$Ph_3SnSnPh_2Me$	+255.7 ± 32.4 [+309.1 ± 23.8]	0	+237.0 ± 9.9 [+309.1 ± 23.8]	0								
	Starvation (%)[b]	*14.8*		*19.7*									
II	$Ph_3SnSnPhMe_2$	+257.1 ± 23.9 [+309.1 ± 23.8]	0	+271.4 ± 18.3 [±309.1 ± 23.8]	0								
	Starvation (%)	*14.4*		*10.4*									
III	$MePh_2SnSnPh_2Me$	+106.3 ± 24.9 [±309.1 ± 23.8]	0	+218.5 ± 31.8 [±309.1 ± 23.8]	0								
	Starvation (%)	*56.1*		*25.1*									
IV	$Ph_3SnSnMe_3$	−61.8 ± 3.3 [+289.2 ± 23.5]	44.5	−70.5 ± 5.4 [+275.9 ± 11.9]	43	−58.2 ± 7.8 [+207.9 ± 20.0]	43	+87.9 ± 25.1 [+215.5 ± 20.8]	0	±160.8 ± 16.1 [+245.0 ± 12.6]	0	258.0 ± 19.6 [+245.0 ± 12.6]	0
	Starvation (%)	*104.3*		*107.1*		*104.2*		*48.5*		*28.8*		*−4.4*	
V	$MePh_2SnSnPhMe_2$	−17.9 ± 9.0 [+141.5 ± 11.5]	0	+6.8 ± 22.7 [±189.3 ± 36.9]	0	−5.8 ± 13.9 [+110.2 ± 22.3]	5	±84.5 ± 20.7 [+134.2 ± 34.0]	10				
	Starvation (%)	*85.3*		*77.1*		*73.6*		*27.4*					
VI	$MePh_2SnSnMe_3$	−64.4 ± 5.1 [+141.5 ± 11.5]	30	−52.0 ± 13.1 [+189.3 ± 36.9]	10	−27.5 ± 18.6 [+83.5 ± 27.3]	11.5	+43.0 ± 31.7 [+83.5 + 27.3]	11.5				
	Starvation (%)	*109.0*		*109.9*		*84.8*		*30.9*					
VII	$Me_2PhSnSnPhMe_2$	−21.0 ± 17.7 [+141.5 ± 11.5]	0	+175.9 ± 27.8 [+189.3 ± 36.9]	0								
	Starvation (%)	*86.0*		*5.7*									
VIII	$Me_2PhSnSnMe_3$	−64.6 ± 4.6 [+141.5 ± 11.5]	20	40.8 + 6.9 [+189.3 ± 36.9]	0	−27.6 ± 11.4 [+83.5 ± 27.3]	0.5	+46.5 ± 26.4 [+83.5 ± 27.3]	11.5				
	Starvation (%)	*109.1*		*97.2*		*84.9*		*28.3*					

[a]Based on weight of survivors.

[b]Starvation calculated taking the mean value of −52.2 mg 48 h weight loss of starved larvae for the experiments with compounds I–III.

[c]Starvation calculated taking the mean value of −47.4 mg 48 h weight loss of starved larvae for the experiments with compounds IV–VIII.

group). Compound IV and, to a lesser extent VI, caused at the higher concentrations some conventional type mortality in *S. littoralis* larvae.

Compound IV, the most active one in the previous test, was further assayed as systemic antifeedant for *S. littoralis* (Table 3). It was highly active by this mode of administration on cotton, but less so on fodder beet. The systemic effect of compound IV is not totally surprising since as mentioned before the parent compound of the present series, hexamethylditin, acted as a systemic antifeedant against *S. littoralis*[5,7] and *G. operculella*.[7]

Epilachna varivestis

Table 4 shows the antifeedant activity of the hexaorganoditins tested against *E. varivestis*. Based on percentage larval starvation, the compounds having a terminal trimethyl group were again the most active ones, with the order of activity being the same as with *S. littoralis*: $Ph_3SnSnMe_3$ (IV) > $MePh_2SnSnMe_3$ (VI) > $Me_2PhSnSnMe_3$ (VIII). The only other compound having three methyl groups (but not a terminal trimethyl) $MePh_2SnSnPhMe_2$ (V) was more active than compounds having 1, 2 or 4 methyls, I ≃ II ≃ VII > III. As evidenced from mortality rates, some of the compounds were toxic to *E. varivestis* in a conventional sense at the two highest concentrations, 1000 and 500 mg dm^{-3}.

We found, moreover, that hexaphenylditin was not an antifeedant for *S. littoralis* and *E. varivestis*. It was also inactive as a mothproofer.[22]

Phytotoxicity

Table 5 shows the results of phytotoxicity assays on a very susceptible plant, bean seedlings. At 100 mg dm^{-3} compounds II–VII were highly phytotoxic, whereas at 50 mg dm^{-3}, I, II, IV, (which was the best antifeedant among the hexaorganoditins assayed in this study) and VII were innocuous. It should be mentioned that the fentin (Ph_3Sn) fungicides, such as fentin acetate or hydroxide, can be used safely only on a limited number of crops, e.g. sugar beet, potato, celery, cocoa, coffee, etc., because of their phytotoxicity for many other crops.[23]

Acknowledgement This is contribution No. 1892-E, 1986 series from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel.

Table 3 The weight gain or loss ± standard error (($\Delta W \pm$ S.E.) of 170–190 mg *Spodoptera littoralis* larvae due to 48 h feeding on cotton or fodder beet leaves treated systemically (leaves stood with their petioles for 24 h in emulsions) with $Ph_3SnSnMe_3$ (IV). (Numbers in brackets denote $\Delta W \pm$ S.E. of larvae on control leaves previously stood with their petioles in the aqueous dilution of the inert ingredients at the highest concentration tested)

	Concentration of compound in the emulsion used for the systemic treatment, mg dm^{-3}									
	500		100		50		25		10		5	
Treated plant	$\Delta W \pm$ S.E.[a] (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)	$\Delta W \pm$ S.E. (mg)	Mortality (%)
Cotton	−56.5 ± 13.5 [+228.3 ± 21.4]	90	−62.9 ± 4.0 [+228.3 ± 21.4]	5	− 58.5 ± 5.8 [+228.3 ± 21.4]	20	+ 35.3 ± 13.0 [+334.0 ± 16.9]	10	+ 101.8 + 20.9 [+250.6 ± 33.1]	9.5	+ 213.5 ± 20.1 [+250.6 ± 33.1]	0
Starvation (%)[b]	*103.8*		*108.2*		*106.5*		*79.9*		*51.0*		*12.7*	
Fodder beet			4.7 ± 13.9 [+394.7 + 2.5]	0	+ 183.9 ± 27.0 [+469.8 ± 20.8]	0						
Starvation (%)			*91.6*		*56.0*							

[a] Based on weight of survivors.
[b] Starvation (%) calculated taking the mean value of −40.9 mg 48 h weight loss of starved larvae.

Table 4 The weight gain or loss ± standard error ($\Delta W \pm$S.E.) of L_4 *Epilachna varivestis* larvae due to 48 h feeding on $Ph_nMe_{6-n}SnSn$-treated bean leaves. (Numbers in brackets denote $\Delta W \pm$S.E. in the methanol control accompanying every experiment; all mortalities corrected for control mortality, if any)

		Concentration of compound in leaf painting solution in methanol, mg dm^{-3}											
		1000		500		100		50		10		5	
No.	Compound	$\Delta W \pm$S.E.[a] (mg)	Mortality (%)	$\Delta W \pm$S.E. (mg)	Mortality (%)	$\Delta W \pm$S.E. (mg)	Mortality (%)	$\Delta W \pm$S.E. (mg)	Mortality (%)	$\Delta W \pm$S.E. (mg)	Mortality (%)	$\Delta W \pm$S.E. (mg)	Mortality (%)
I	$Ph_3SnSnPh_2Me$		100	−4.3 ± 0.5 [+8.2 ± 1.3]	0	+2.9 ± 1.0 [+8.2 ± 1.3]	0	+9.8 ± 0.9 [+8.2 ± 1.3]	0				
	Starvation (%)[b]			*83.9*		*35.6*		*10.7*					
II	$Ph_3SnSnPhMe_2$	−7.0 ± 0.5 [+3.1 ± 1.5]	10	−0.4 ± 0.7 [+3.4 ± 1.1]	0	+1.4 ± 0.5 [+6.6 ± 0.9]	5	+6.4 ± 1.0 [+9.9 ± 1.1]	0	+14.4 ± 0.8 [+9.9 ± 1.1]	0		
	Starvation (%)	*103.1*		*37.6*		*39.1*		*21.1*		*−27.1*			
III	$MePh_2SnSnPh_2Me$	−5.3 ± 0.6 [+3.1 ± 1.5]	20	−3.8 ± 0.7 [+3.8 ± 1.2]	30	+2.2 ± 1.0 [+3.8 ± 1.2]	0	+5.5 ± 1.0 [+3.8 ± 1.2]	0	±15.1 ± 1.5 [+19.9 ± 1.1]	0		
	Starvation (%)	*83.7*		*72.4*		*15.2*		*−16.2*		*28.9*			
IV	$Ph_3SnSnMe_3$					−6.1 ± 0.7 [+12.7 ± 0.9]	0	−4.7 ± 0.5 [+8.6 ± 0.6]	2.7	+1.7 ± 0.5 [+8.1 ± 0.6]	0	−0.2 ± 1.0 [+10.8 ± 0.6]	2.3
	Starvation (%)					*96.9*		*86.7*		*43.2*		*62.9*	
V	$MePh_2SnSnPbMe_2$	−5.2 ± 0.6 [+3.1 ± 1.5]	30	−7.0 ± 0.4 [+10.1 ± 1.2]	0	+0.4 ± 0.5 [+10.1 ± 1.2]	0	+2.6 ± 0.7 [+10.1 ± 1.2]	0	+11.3 ± 1.2 [+19.9 ± 1.1]	5		
	Starvation (%)	*84.7*		*101.8*		*57.7*		*44.6*		*32.3*			
VI	$MePh_2SnSnMe_3$		100	−9.2 ± 0.7 [+16.3 ± 0.8]	80	−4.0 ± 0.7 [+16.3 ± 0.8]	0	−1.1 ± 0.7 [+12.8 ± 0.8]	2.5	+4.3 ± 0.8 [+8.0 ± 1.2]	0	+15.0 ± 1.2 [+19.9 ± 1.1]	0
	Starvation (%)			*110.9*		*88.3*		*71.3*		*25.2*		*18.4*	
VII	$Me_2PhSnSnPhMe_2$	−6.3 ± 2.2 [+10.2 ± 0.8]	85	−4.8 ± 0.4 [+9.2 ± 1.2]	35	+2.5 ± 0.7 [+9.2 ± 1.2]	0	+6.9 ± 3.1 [+9.2 ± 1.2]	0				
	Starvation (%)	*97.6*		*88.1*		*42.1*		*14.5*					
VIII	$Me_2PhSnSnMe_3$	−7.3 ± 0.6 [+10.2 ± 0.8]	75	−7.0 ± 1.5 [+11.3 ± 1.2]	40	−0.9 ± 0.9 [+11.3 ± 1.2]	5	+0.3 ± 0.5 [+10.2 ± 0.5]	0	+5.0 ± 1.0 [+8.0 ± 1.2]	0	+12.5 ± 0.8 [+19.9 ± 1.1]	0
	Starvation (%)	*103.6*		*101.7*		*67.8*		*55.0*		*20.4*		*27.8*	

[a]Based on weight of survivors.

[b]Starvation calculated taking the mean value of −6.7 mg 48 h weight loss of starved larvae.

Table 5 Phytotoxicity of emulsions of organotins of the series $Ph_nMe_{6-n}SnSn$ to bean (cv. 'Contender') seedlings

No.	Compound name	Concentration of spray liquid, mg dm^{-3} 100 Damage[a] after 1 day	2 days	3 days	4 days	5 days	50 1 day	2 days	3 days
I	$Ph_3SnSnPh_2Me$		1		2	2	0		0
II	$Ph_3SnSnPhMe_2$		5		5	5	0		0
III	$MePh_2SnSnPh_2Me$		5		5	5	3		4
IV	$Ph_3SnSnMe_3$		2		3	4	0		0
V	$MePh_2SnSnPhMe_2$	3	3	4			2	2	2
VI	$MePh_2SnSnMe_3$	4	4	5			2	2	2
VII	$Me_2PhSnSnPhMe_2$	3	4	5			0		0
VIII	$Me_2PhSnSnMe_3$	4	4	5			1		2

[a]0 = No phytotoxicity
1 = Trace of phytotoxicity
2 = Little phytotoxicity on leaf and its borders
3 = Intermediate burns
4 = Strong burns
5 = Total damage

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