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THE CONTROL OF AIRBORNE DISEASES OF CEREALS WITH CGA 64250

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Summary: CGA 64250, 1-[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-ylmethyl]-1,2,4-triazole, is a new systemic fungicide with protective and curative properties. At low concentrations it controls a wide range of Ascomycetes, Basidomycetes and Deuteromycetes, both *in vitro* and *in vivo*.

The chemical is especially suited for the control of airborne diseases in small grain cereals. One or two applications at 125 g a.i./ha perform well against *Erysiphe graminis*, *Puccinia spp.* and *Rhynchosporium secalis* on barley and wheat, respectively. In preliminary tests it has also shown activity against *Septoria spp.* and *Pseudocercosporella herpotrichoides* on wheat. Depending on the disease complex and severity, it will be recommended for use alone or in combination with other fungicides.

Résumé: CGA 64250 est un nouveau fongicide systémique à action préventive et curative.

Des essais *in vitro* et *in vivo* ont montré que ce fongicide présente à faible concentration une remarquable activité contre de nombreux champignons Ascomycètes, Basidomycètes et Deuteromycètes.

Cette substance convient particulièrement pour la lutte contre les maladies aériennes dans les céréales. Une ou deux applications à la dose de 125 g m.a./ha assurent une bonne protection contre *Erysiphe graminis*, *Puccinia spp.* et *Rhynchosporium secalis* sur orge et blé. Dépendant de la complexité des maladies et de leur importance, CGA 64250 est recommandé comme produit seul ou en association avec d'autres fongicides.

INTRODUCTION

CGA 64250 is the code number of a new fungicide which was originally discovered by Janssen Pharmaceuticals, Belgium, and which is now being developed by Ciba-Geigy Ltd., Switzerland.

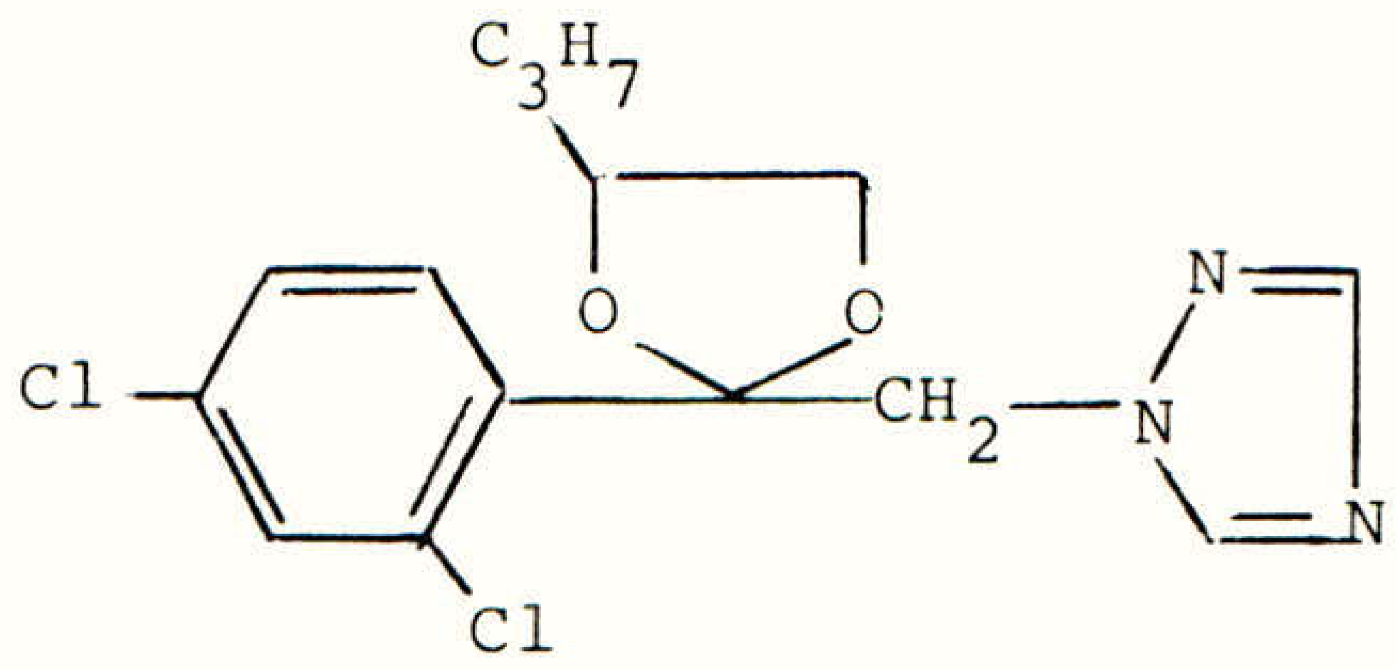
It belongs to the same chemical class as CGA 64251, which was recently described by Staub *et al.*, 1979. Due to its high level and wide spectrum of activity, CGA 64251 is especially suited for control of powdery mildews and scab of deciduous fruit and *Monilinia* spp.

On cereals and peanuts, CGA 64250 shows superior activity and, therefore, is being developed for these crops. Both fungicides are systemic and have protective and curative properties.

The aim of this paper is to describe the performance of CGA 64250 against airborne diseases on wheat and barley.

CHEMICAL PROPERTIES

Structural formula :



Systemic chemical name:	1-[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-ylmethyl]-1,2,4-triazole
Molecular weight	: 342.2
Molecular formula	: $C_{15}H_{17}Cl_2N_3O_2$
Formulations	: wettable powder (25% a.i. w/w)
	emulsifiable concentrate: 250 g a.i./l

<u>Physical properties</u>

Appearance	: yellowish viscous liquid
Boiling point	: $180^{\circ}C$ at 0.1 mm Hg
Solubility	: 110 mg/l water at $20^{\circ}C$
	soluble in most organic solvents

TOXICOLOGY

CGA 64250 is a product with slight toxicity to mammals, as follows:

Rat	acute oral	LD_{50}: 1517 mg a.i./kg (slight)
"	acute dermal	LD_{50}: >4000 mg a.i./kg (not measurable)
Rabbit	skin irritation	slight
"	eye irritation	minimal
Guinea-pig	sensitizing effect	none
Fish toxicity		practically non-toxic
Bird toxicity		practically non-toxic

METHODS AND MATERIALS

All trials reported here laid down as randomised complete block trials with 4 replicates. The plot size varied from 20-50 m^2. Usually ratings were made by estimating the % infection on leaves or ears. The growth stages were described according to the new EUCARPIA coding.

RESULTS AND DISCUSSION OF FIELD TESTING

Diseases on barley. Two trials against *Erysiphe graminis* are presented in Table 1, both with moderate disease infection. They show that CGA 64250 has good activity, the slight visual superiority of the standard not being reflected in the yield.

Table 1

Control of *Erysiphe graminis* on barley

Trial No. and country: NW 268-78, NW 275-78 Germany   cv. Doris (NW 268) Multum (NW 275)

Treatment	g (a.i.) /ha	Flag leaf infection (1-9)*		Yield			
		Days after application 19	24	kg/ha		% of un-treated	
		Trial 268	Trial 275	Trial 268	Trial 275	Trial 268	Trial 275
CGA 64250	125	1.46	2.48	4550	4046	108	106
Triadimefon	125	1.02	2.28	4491	3965	107	104
Untreated		5.9	3.53	4204	3816	100	100
LSD (P=0.05),(CV; %)				472(4)	336(3)		

*1 = no flag leaf infection

Application timing and disease situation:
  Trial 268 at growth stage 32, 40 % leaf infection
  Trial 275 at growth stage 30, 15 % leaf infection

As seen in Tables 2 and 3, CGA 64250 performed well against *Puccinia hordei* and *Rhynchosporium secalis*. Its lasting effect seems to be more pronounced than that of the standard, especially against *R. secalis*. Statistically significant yield increases over untreated plots were obtained in both trials. From visual observations it was evident that CGA 64250 also controlled *Pyrenophora teres*.

Table 2

Control of *Puccinia hordei* on winter barley

Trial No. and country: RM 880-78, France   cv. Thibault

Treatment	g (a.i.) /ha	% infection on leaf 2		Yield	
		Days after second application		kg/ha	% of untreated
		8	18		
CGA 64250	125	7	5	4455	144
Triadimefon	125	7	5	4286	139
Untreated		23	49	3092	100
LSD (*P*=0.05), (CV; %)				393(4)	

Application timing and disease situation:
First at growth stage 32, 2 % on uppermost leaves
Second at growth stage 65, 2 % on flag leaf

Table 3

Control of *Rhynchosporium secalis* on winter barley

Trial No. and country: AD 881-78, France   cv. Sonja

Treatment	g (a.i.) /ha	% infection on		Yield	
		leaf 3	leaf 2	kg/ha	% of untreated
		Days after second application			
		9	21		
CGA 64250	125	4	4	5877	128
Triadimefon	125	7	16	5319	116
Untreated		23	74	4589	100
LSD (*P*=0.05), (CV; %)				290(2)	

Application timing and disease situation:
First at growth stage 32-37, 1.5 % on leaf 3
Second at growth stage 51-59, 8 % on leaf 3

Diseases on wheat. A trial against *Puccinia striiformis* (Table 4) was infested artificially. CGA 64250 showed initial control equal to the triadimefon standard under high infection pressure but persistence of CGA 64250 was about 1 week longer. This led to statistically significant yield differences between CGA 64250 and triadimefon. In trials not reported in this paper CGA 64250 was also effective against *Puccinia triticina*. Both compounds sprayed on infected leaves eradicated the disease.

Table 4

Control of *Puccinia striiformis* on winter wheat

Trial No. and country: LF 29-78, Netherlands cv. Lely

Treatment	g (a.i.) /ha	% infection on flag leaf		Yield	
		Days after second application		kg/ha	% of un-treated
		15	20		
CGA 64250	125	1	7	5128	184
Triadimefon	125	1	10	4725	170
Untreated		95	100	2783	100
LSD (P=0.05), (CV; %)				380 (2)	

Application timing and disease situation:
First at growth stage 32-37, 15-20 % on leaf 3
Second at growth stage 59, 5 % on leaf 2

Table 5 demonstrates the control of *Erysiphe graminis*. CGA 64250 was apparently slightly inferior to the commercial standard but no statistically significant differences were found between any of the treatments. Both products prevented further sporulation when sprayed on existing pustules and suppressed the outbreak of powdery mildew when sprayed during the incubation period.

Table 6 shows that *Septoria tritici* is obviously more sensitive to CGA 64250 than *Septoria nodorum* (Table 7). Significant yield differences occurred only when *S. tritici* was controlled, indicating the value of achieving good protection against this disease by using CGA 64250. Slight to moderate infections by *S. nodorum* may also be controlled with the compound.

CGA 64250 possesses a moderate activity against eyespot (*Pseudocercosporella herpotrichoides*) (Table 8) where it reduced both the amount of stem infection and lodging. There was no statistical difference between the treatments. More work is needed to determine practical conditions when the activity of CGA 64250 alone is sufficient and when mixtures with other fungicides are required.

CGA 64250 is well tolerated by both barley and wheat even when used at up to 3 times the recommended rate.

Table 5

Control of Erysiphe graminis on winter wheat

Trial No. and country: WG 587-78, Germany cv. Jubilar

Treatment	g (a.i.) /ha	Infection (1-9)* on		Yield	
		Flag leaf	Ear	kg/ha	% of untreated
		Days after application			
		14	33		
CGA 64250	125	1.2	3.6	6350	109
Triadimefon	125	1.5	3	6727	116
Untreated		5	7.2	5822	100
LSD (P=0.05),(CV; %)				713(4)	

*1 = no infection

Application: At growth stage 51-59

Table 6

Control of Septoria tritici on winter wheat

Trials No. and country: AD 064-79, France cv. Capitole

Treatment	g (a.i.) /ha	% infection on flag leaf		Yield	
		Days after application		kg/ha	% of untreated
		15	29		
CGA 64250	125	5	6	6350	112
Triadimefon + captafol	125 +1300	6	16	6243	110
Untreated		12	51	5670	100
LSD (P=0.05),(CV; %)				317(1)	

Application timing and disease situation:
At growth stage 61, 2 % infection on flag leaf

Table 7

Control of *Septoria nodorum* and *Puccinia striiformis* on winter wheat

Trial No. and country: FR 059-78, Switzerland cv. Probus

Treatment	g (a.i.) /ha	% infection: S. nodorum, Flag leaf, Days after application 29	S. nodorum, Ear, 29	S. nodorum, Ear, 35	P. striiformis, Flag leaf, 29	Yield kg/ha	Yield % of untreated
CGA 64250	125	4	4	8	0.8	5423	100
Halacrinate + captafol	500 +1000	17	2	2	18	5280	108
Untreated		44	17	23	16	4908	111
LSD (P=0.05), (CV; %)						535(4)	

Application timing: At growth stage 55

Table 8

Control of *Pseudocercosporella herpotrichoides* on winter wheat

Trial No. and country: BX 876-78, France cv. Top

Treatment	g (a.i.) /ha	% stem infection, Days after application 54	% lodging	Yield kg/ha	Yield % of untreated
CGA 64250	125	41	10	6267	112
Carbendazim	200	12	0	6341	114
Untreated		81	44	5586	100
LSD (P=0.05), (CV; %)				130(1)	

Application timing and disease situation:
At growth stage 32, 3 % stem infection

CONCLUSIONS

1. The broad spectrum of activity of CGA 64250 ensures excellent control of the economically important diseases on barley (*Erysiphe graminis*, *Puccinia spp.*, *Rhynchosporium secalis*, *Pyrenophora* spp.)with one or two applications depending on the severity and time of attack.

2. On wheat, CGA 64250 gives full protection against *Erysiphe graminis* for 3-4 weeks and against *Puccinia spp.* for 4-6 weeks. CGA 64250 shows considerable activity against *Septoria* spp. and *Pseudocercosporella herpotrichoides*. Further studies are needed to define the conditions when *Septoria* spp. and *Pseudocercosporella herpotrichoides* can be controlled with CGA 64250 alone and when mixtures with other fungicides are necessary.

3. The marked curative action of CGA 64250 observed in the field, and its long-lasting effect, will allow more flexibility in application timing.

Reference

STAUB, Th., SCHWINN, F., URECH, P.A. (1979)

CGA 64251 a new broad spectrum fungicide

Proceedings of the 9th International Congress of Plant Protection, Washington, Abstracts of Papers, 309.

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PROPETAMPHOS FOR THE CONTROL OF ECTOPARASITES ON CATTLE AND SHEEP

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Summary In laboratory and field trials, propetamphos proved active against both OP-susceptible and resistant strains of the cattle tick species *Boophilus microplus*, *B. decoloratus*, *Rhipicephalus appendiculatus*, *R. evertsi*, and *Amblyomma hebraeum*. Furthermore, its was effective in the laboratory against larvae of the sheep blow fly (*Lucilia cuprina*) and adults of the sheep scab mite (*Psoroptes ovis*).

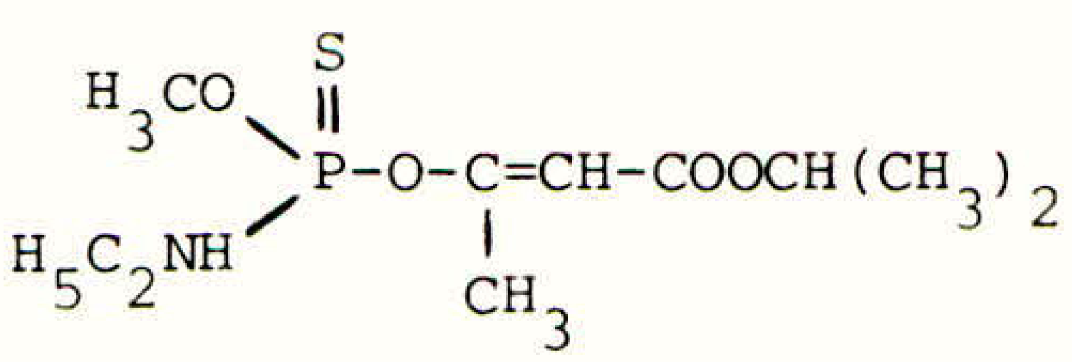
Résumé Les essais de laboratoire et de plein champ ont montré l'activité de propetamphos contre les souches sensibles et résistantes aux esters phosphoriques des tiques du bétail: *Boophilus microplus*, *B. decoloratus*, *Rhipicephalus appendiculatus*, *R. evertsi*, et *Amblyomma hebraeum*. Deplus, il a montré au laboratoire une efficacité contre la larve de la mouche des ovins (*Lucilia cuprina*) et les adultes de l'acarien de la gale des moutons (*Psoroptes ovis*).

INTRODUCTION

Propetamphos (=SAN 322 I) was discovered and patented by Sandoz Ltd., Basle, Switzerland, and is being developed as an ixodicide/insecticide under the trade name BLOTIC®.

TECHNICAL DATA

Structural formula:



Chemical name (C.A. usage) : (E)-1-methylethyl 3- [[(ethylamino)methoxyphosphinothioyl] oxy] -2-butenoate.

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Common name	:	propetamphos (ISO, BSI and ANSI accepted)
Empirical formula	:	$C_{10}H_{20}NO_4PS$
Molecular weight	:	281.3
Physical state	:	oily liquid
Solubility	:	at 24° C in water — 110 ppm
		in all common polar or non-polar organic solvents — completely miscible
Thermostability	:	good
Hydrostability	:	stable in neutral aqueous buffer solution
Photostability	:	good in sunlight
Formulations	:	e.c., 350 g a.i./l

TOXICOLOGY

Table 1

Acute toxicity of propetamphos, as a.i. and as formulation, to male rats

	Route	LD_{50} (mg a.i./kg)
Active ingredient	Oral	82
	Dermal	2'825
Formulation (e.c., 350 g a.i./l)	Oral	173 ± 10.9

The acute oral LD_{50} lies within the range of comparable products recommended for cattle and sheep treatment. The dermal toxicity is only slight.

In feeding tests with dogs for more than 6 months, and with rats for over 1 year the no-effect level proved to be acceptable. From this, it can be deduced that the residues, found in cows 4, 8 and 12 weeks after treatment, do not appear to be toxicologically important.

The active ingredient is not neurotoxic. An antidote study on rats showed that atropine, or atropine with toxogonine, had a good therapeutic effect. Tests with rabbits have not shown propetamphos to be teratogenic; in the mutagenicity test the result was negative.

Studies with birds and fish provided no indication of any particular risks.

The toxicity for heifers and bull calves, approximately 6 months old, was tested by the South African Bureau of Standards (SABS). The animals were treated weekly by handspraying for up to 6 weeks with concentrations between 0.05% and 0.4% a.i.. The highest concentration tested was 11.5 times higher than the recommended concentration of 0.035% a.i..

No signs of poisoning were observed at the dosages and times of exposure investigated.

Calves younger than 1 month old were treated by hand-spraying at a concentration of 0.07% a.i.. No toxic symptoms were observed.

In all toxicity tests on cattle, the examination of the cholinesterase activity showed a depression which is common when using organophosphorous compounds. However, this depression was never excessive, and there was normal recovery.

IXODICIDAL ACTIVITY

Laboratory results

The ixodicidal activity of propetamphos was discovered by Gothe, who also described the screening method used (Gothe and Mieth, 1978). Using 0.05% a.i., 75% reduction of the reproductive potential was achieved against blue, brown and red cattle tick species, *Boophilus decoloratus*, *Rhipicephalus appendiculatus* and *R. evertsi evertsi* respectively. Furthermore, propetamphos proved to be effective against the following strains of *B. microplus*, as shown in Table 2.

OP susceptible	OP resistant
Mexico	Biarra
Yeerongpilly	Mackay

Table 2

% Reduction of reproductive capacity by propetamphos and comparative products at 500 ppm a.i. (for an exposure time of 5 min.)

Product	B. decoloratus	R. appendiculatus	R. evertsi evertsi	Boophilus microplus strain: Yeerongpilly	Biarra	Mackay	Mt. Alford	Mexico
Propetamphos	99	100	100	100	94	100	42	100
Chlorpyrifos	67	-	-	-	50	-	0	82
Chlorfenvinphos	100	100	-	-	0	-	52	97
Coumaphos	-	-	-	98	33	98	16	-

The reduction of the reproductive capacity, in relation to concentration and exposure time for different strains of *B. microplus*, is given in Table 3.

Table 3

% Reduction of reproductive capacity of four strains of B. microplus by propetamphos at different concentrations and exposure times

Strain	Exposure time (min.)	ppm 32	64	128	256	512
Yeerongpilly	1	100	96	99	100	100
	5	94	100	100	100	100
	110	100	99	100	100	100
Biarra	1	72	90	77	99	94
	5	58	93	93	84	95
	10	86	86	93	100	99
Mackay	1	79	100	100	100	100
	5	89	100	100	100	100
	10	100	99	100	100	99
Mt. Alford	1	0	18	36	36	31
	5	10	21	11	16	17
	10	15	30	58	47	76

The most remarkable fact, which is evident from Tables 2 and 3, is the good activity against the OP-resistant strain, Biarra. The highly resistant Mt. Alford strain is, however, not sufficiently controlled.

Furthermore, propetamphos was tested against larvae of OP-resistant local strains of B. decoloratus, A. hebraeum (bont tick) R. evertsi and R. appendiculatus, at the SABS by standard methods. Propetamphos gave 100% control against all strains at 100 ppm a.i., the lowest concentration tested.

When the same tests were carried out against adults of the same strains of B. decoloratus, A. hebraeum and R. appendiculatus, the lowest concentration of 100 ppm was again highly effective, except for A. hebraeum, against which 250 ppm proved satisfactory.

Field tests

In Nicaragua, a series of hand spray trials was carried out on cattle. Six groups of 25 animals, with medium to high infestations of B. microplus, were sprayed in July and October, 1977, the treatments being as follows:

4 l/animal at 262 ppm = 1.05 g a.i./animal
4 l/animal at 175 ppm = 0.7 g a.i./animal
4 l/animal at 87.5 ppm = 0.35 g a.i./animal
0.8 l/animal at 350 ppm = 0.28 g a.i./animal
0.9 l/animal at 750 ppm = 0.68 g a.i./animal
0.8 l/animal at 750 ppm = 0.6 g a.i./animal

All the treatments gave almost total mortality of the ticks 2, 4 and 6 days after the application. In one case, some surviving ticks were observed in the ears of the treated cattle. When observed 24 h after application, the ticks were still on the animals, but dead, wheras by the second day most of the dead ticks had fallen off.

Hand-spray field results in South Africa

Tests were carried out by the SABS according to standard methods. The concentrations of propetamphos tested were 0.01%, 0.0175%, 0.025%, 0.035%, 0.07% and 0.105% a.i..

After regularly counting living tick adults and, separately, engorged females on the test animals, propetamphos at the concentration of 0.0175% a.i. was juged by the experimenter to have satisfactory activity against brown tick (*R. appendiculatus*), red tick (*R. evertsi*), bont tick (*A. hebraeum*) and blue tick (*B. decoloratus*). At a concentration of 0.035% a.i., which is envisaged for registration in the Republic of South Africa, the following observations were obtained; the quotation marks refer to verbal comments of the experimenter. *R. appendiculatus* (slight OP-resistance): The effectiveness of propetamphos was equal to that of the standard chlorfenvinphos at 0.05% a.i.. *R. evertsi* (slight OP-resistance): "The treatments reduced the population considerably in both larval and nymphal stages. The results of the treatments proved to be very satisfactory". No special comment was given on the effectiveness against adults, which was obviously comparable to that of the standard. *A. hebraeum* (OP-susceptible): "The population of bont tick nymphs was reduced considerably by the different treatments. The treatments proved to be satisfactory." Regarding adults: "The treatments proved to be highly effective". *B. decoloratus* (highly resistant to all tickicides including arsenical compounds): "Taking into account the high infestation with larvae and the final results obtained with fully engorged adults, this proved that the treatments were highly effective in comparison with the reference (chlorfenvinphos)".

INSECTICIDAL ACTIVITY

Laboratory results against blowfly larvae

Propetamphos has been tested against larvae of the resistant Riversdale strain of *Lucilia cuprina* by the SABS. Known insecticidally-resistant eggs were collected and allowed to hatch. Propetamphos, emulsified in tap water in a geometric series of dilutions, was evenly applied in 1.5 ml amounts of each dilution to 90 x 40 mm strips of Whatman No. 3MM chromatography paper on a drying board at room temperature, and compared to diazinon as a standard insecticide of known activity (3 replicates). After drying the strips for 1 hour, they were rolled and inserted in flat bottomed glass tubes of 50 x 16 mm. 1.5 ml of sterile bovine serum was evenly applied to each strip and 30 first instar larvae were transferred to each tube. The foam-plugged tubes were conditioned in a humidity room at 28° C/70% R.H.. After 24 h, the average percentage mortalities were determined. The results are compiled in Table 4.

Table 4

Mean % mortality of blowfly larvae

Preparation	Concn. of a.i. (ppm)	Mean % mortality			
		1st instar		2nd instar (48 h-old)	
		trial no. 1	2	1	2
Propetamphos	0.5	69	-	6	-
	1	80	78	57	13
	2	92	90	88	86
	4	-	97	-	98
	8	-	100	-	100
Diazinon	1	-	53	-	14
	2	85	75	4	6
	4	93	99	4	23
	8	-	98	-	56
Untreated check	-	5	5	0	6

Laboratory results against sheep scab mites

The first laboratory results against adults of *Psoroptes ovis* were reported from the SABS, and are summarised in Table 5 .

Table 5

Mean % mortality of scab mite adults 48 h after treatment with propetamphos

Preparation	Concn. of a.i. (ppm)	Mean % mortality
Propetamphos	2	92
	4	95
	8	95
	16	100
	25	100
Untreated check	--	20

USE IN CATTLE SPRAY RACES AND DIPS

Depletion of the active ingredient in cattle spray races

In trials, undertaken by the SABS in spray races, the decrease in concentration in the spray tank (sump) (stripping rate) on 250 animals per trial run was determined by analysis of the a.i. in the spray tank before and after the treatment, and by measuring the spray consumption. The trials were done at 0.035% and 0.05% a.i. on short-haired and on long-haired cattle, each being repeated three times.

A stripping rate of about 35% was found after spraying 250 head of cattle. This is regarded as normal.

Results form a dip tank trial

In a field trial with cattle in Uruguay, samples of dip wash, initially containing 0.035% propetamphos, were taken after every 50 treated animals up to a total of 500 head of cattle. The samples were taken from the bottom of the dip tank, from 70 cm below the surface and from the surface of the tank. All samples were sent to Sandoz Ltd., Basle, and were individually analyzed for their propetamphos content.

The first group of 500 dipped cattle removed 2.5 litres of dip wash and 2.56 g a.i. per animal. In consecutive runs at lower a.i. concentrations, the stripping was diminished. After dipping 3783 animals and analyzing 72 samples of dip wash, it was deduced by the experimenters that, under local Uruguayan conditions, propetamphos could be used at 175 ppm a.i. as an initial concentration in dips. Replenishment with 1000 l containing 525 ppm a.i. could be done after removal by the animals of 1000 l of dip wash.

Stability of active ingredient in cattle dips

A sample of wash from a cattle dip, containing chlorfenvinphos, and which had been used in practice for 15 months, was brought to our laboratories, where a stability test at various temperatures, with added propetamphos, was started in the second half of 1978. The tests have shown that propetamphos remained unchanged in the dirty dip water during the test period of 6 months.

RESIDUES IN MILK AND TISSUES OF CATTLE

A study was conducted to determine the residues of propetamphos and its P=O metabolite that might occur in milk and tissues of cattle sprayed with a 0.05% aqueous emulsion of propetamphos.

The residues of 0.5 - 1.0 ppm, present in the milk samples taken from a group of Jersey cows 6 h after the last of four weekly applications of propetamphos, decreased to less than 0.1 ppm in 24 h. The residues were not detectable 48 h after the last treatment.

Muscle, liver, fat and kidney, of ox, bull and heifer, which had been sprayed with propetamphos, were examined for the residues. Only the fat had detectable residues (0.05 - 0.08 ppm) 72 h after the last of the four weekly applications. One week after eight weekly applications, only the fat (0.4 ppm) and muscle (0.2 ppm) of heifer contained detectable residues. Two weeks after twelve weekly applications, the only tissues with detectable residues was the fat of heifer (0.06 - 0.09 ppm).

On the basis of these residues and their dissipation, the milk of animals treated with propetamphos is usable 12 h after the last application. Treated animals can be safely slaughtered after 8 days, if all safety factors are considered.

Acknowledgements

We thank Mr. B.K. Louw of the South African Bureau of Standards, and his collaborators, for carrying out most of the above-mentioned trials in the period 1975 to 1979.

References

GOTHE, R.; MIETH, H. (1978) Untersuchungen zur ixodiziden Wirksamkeit eines neuen Phosphorsäureesters. Berl. Münch. Tierärztl. Wschr. 91, 193-196.

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ETRIMFOS - A NEW INSECTICIDE FOR STORED GRAIN PEST CONTROL

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Fisons Limited, Agrochemical Division, Chesterford Park
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Summary In a series of trials carried out in the laboratory and farm stores, etrimfos was evaluated for stored grain pest control. As an admixture at concentrations of 5 and 10 ppm a.i., it had a wide spectrum of control and outstanding persistence. Total control of foreign grain beetles and saw-toothed grain beetles, including a malathion-resistant strain was still being obtained 6 months after treatment. Etrimfos applied at 0.5 g.a.i/m^2 also has a very good residual activity on all types of surface normally found in grain stores, including concrete, iron, hessian and brick. Though persistent when admixed with grain, etrimfos is rapidly degraded during baking or brewing. It also has no adverse effect on the germination of cereal seed.

Résumé Dans une série d'essais, réalisés au laboratoire et dans des locaux de fermes, etrimfos a été testé pour la lutte contre les parasites des denrées stockées. En applications directes aux grains, cette substance a montré un large spectre d'action et une rémanence exceptionnelle aux doses d'emploi de la matière active de 5 et 10 ppm. L'élimination totale de *Ahasverus advena* et de *Oryzaephilus surinamensis* y compris une souche résistante au malathion a été encore obtenue six mois après application. Les traitements de surface révèlent que l'application de 5 g/m^2 d'etrimfos offre une très bonne activité rémanente sur tous les types de surface normalement rencontres dans les locaux de stockage des grains, y compris le béton, le fer, les toiles d'emballage et la brique. Bien que persistant en mélange avec le grain, etrimfos est rapidement dégradé au cours de la panification ou du brassage. Il a été également démontré que les traitements n'ont aucun effet adverse sur la germination des graines de céréales.

INTRODUCTION

Surveys carried out by the Ministry of Agriculture on farms in the main cereal growing areas of the U.K. have revealed that at least 10% of farm grain stores are infested with insect pests. The most important are the saw-toothed grain beetle (*Oryzaephilus surinamensis*), the grain weevil (*Sitophilus granarius*), the rust-red grain beetle (*Cryptolestes ferrugineus*), the foreign grain beetle (*Ahasverus advena*) and mites (*Glycyphagus spp and Acarus siro*). All these pests can cause considerable loss. In addition, pest-infested seed grain and malting barley can be downgraded as a result of damage to the grain germ. Effective control is therefore important, particularly as grain must be free from living pests to be acceptable for export, standard feed wheat or intervention storage.

To protect grain from pest damage, stores are thoroughly cleaned and all surfaces sprayed with a residual insecticide prior to harvest. For long term protection, particularly on farms where pests have been a problem in the past, further insecticide is admixed with the grain as it enters the store. Resistance to some of the commonly used insecticides is, however, becoming an increasing problem. Saw-toothed grain beetles from many countries abroad have become resistant to malathion and, although not yet established in the U.K., there is a risk of resistant beetles being imported in foodstuffs (Green, 1975). Widespread resistance to HCH in grain mites has also considerably reduced the value of this product (Wilkin, 1975).

Etrimfos (trade name Satisfar*) is an organophosphorus insecticide discovered by Sandoz Ltd., Basle, Switzerland. The compound combines efficacy against a wide range of pests through stomach and contact activity with very low mammalian toxicity and was first described by Knutti and Reisser (1975). Preliminary trials have since shown that etrimfos is extremely effective against stored grain pests including HCH-resistant mites (Good *et al*, 1977) and malathion-resistant saw-toothed grain beetle (Wildey, 1977; Pers.comm.). The product has, therefore, been evaluated in the U.K. as a surface and admixture treatment, both in the laboratory and farm stores.

METHOD AND MATERIALS

Surface Treatments

The surface treatment trials were conducted in two stages. Firstly, insecticide deposits on typical grain store surfaces were evaluated by bioassay tests. Then the effect of a number of commercial surface treatments to farm buildings, mills and grain stores containing stored grain insect infestations was monitored.

Bioassay tests. Bioassays were carried out on several farms in early 1979. Four surfaces - brick, concrete, galvanised iron and hessian were selected for testing as being typical of those normally found in grain stores. Etrimfos 50% e.c. was compared with a 25% e.c. formulation of pirimiphos-methyl and both were applied using a knapsack sprayer to give a deposit of 0.5 g a.i/m^2. All surfaces except hessian were integral parts of the building in which they were situated. Two separate areas 1m high x 0.5m wide were marked on the wall and brushed to remove superficial dust. The hessian was treated by pinning a piece of the fabric to a wall. When dry 13.5 cm-diam. discs were cut from the treated cloth and placed in petri-dishes for

* Satisfar is a registered trade mark of Sandoz Ltd., Basle, Switzerland.

the duration of the trial. These were kept in a barn and left uncovered between assays so they were subject to weathering by a farm environment. The bioassay technique was similar to that used by the M.A.F.F. Slough Laboratory. Two 6.5 cm-diam. cones with a hole in the apex were fixed to each treated area with 'Blue-tac' thus giving 4 replicates per treatment. Cones were removed between assays and always placed on portions of the treated area not previously tested. Twenty, 2 month-old adult susceptible confused flour beetles (Tribolium confusum) were introduced into each cone and the hole sealed with cotton wool. After 24 h the beetles were removed and mortality assessed immediately and again after a further 24 h. The deposit on hessian was tested by tipping 20 beetles onto each cloth disc in a petri-dish and covering with a lid. Beetles were again removed after 24 h and mortality assessed as before. Bioassay tests were carried out 3 days after treatment and then at 2-week intervals until control of the insects became inadequate.

Farm trials. The treatment of field infestations of mites and insects took place at 12 sites during summer 1979. The sites ranged from small farm silos to 10000 tonne industrial grain stores. A gear-pump driven by a Land-Rover p.t.o. and feeding two lances was used to apply the insecticide to all available surfaces. Equipment such as elevators etc. were treated by means of appropriate insecticide dust blown in with a Kyoritsu rotary duster. Etrimfos 50% e.c. was applied at eight sites and pirimiphos-methyl 25% e.c. and fenithrothion 40% w.p. at two other sites each for comparison. All were used at a rate of 0.5 g a.i/m^2.

Density and distribution of infestations were assessed by means of bait bags, plastic mesh sachets containing a mixture of nuts, etc. and attractive to pest insects. (Dyte et al, 1975). A number of the bags, usually 10-20 were placed around the buildings at places likely to harbour insects and left for a fixed period of time. Each bag was shaken 10 times over a white tray and the insects that fell out identified and counted. Assessments were carried out prior to spraying and again every 1-2 weeks after treatment.

Admixture treatments

A food-incorporation test carried out by the Huntingdon Research Centre demonstrated that etrimfos applied at 5 - 10 ppm a.i. to grain will give complete control of Sitophilus, Trogoderma, Cryptolestes, Oryzaephilus, Plodia and Sitotroga species up to 6 months after treatment. Laboratory and farm scale admixture trials were conducted using both a 2% dust and a 50% e.c. formulation of etrimfos to confirm these results on a larger scale.

Laboratory trials. Etrimfos was evaluated in two laboratory trials as a 2% dust formulation. In one trial it was admixed at a concentration of 5 ppm a.i. with 50 kg of wheat infested with a natural population of foreign grain beetle. The treated grain was monitored 24 h and 1, 4 and 6 months after treatment for control of beetles and at the same time bioassayed at 20^{o}C using a standard technique involving sub-sampling 200 mls of grain and placing it in a conical flask. Twenty foreign beetles were then carefully added to the grain. Each test was replicated four times and mortality assessed at 6, 24 and 48 h after introduction.

In the second laboratory trial etrimfos at 5 and 10 ppm a.i. was admixed to grain using a 'Bluefin Stowaway' rotary cement-type mixer. The dust was added to the mixer and the grain tumbled for 5 mins to ensure an even distribution of chemical. In this trial confused flour beetle was used.

Farm scale trials. Two large scale admixture trials were then conducted in farm grain stores. In one trial, etrimfos 50% e.c. was applied to 20 tonne lots of winter wheat at 5 and 10 ppm a.i. while in the other trial 10 tonne lots of winter barley were treated with etrimfos 50% e.c. at 5 ppm and pirimiphos-methyl 25% e.c. at 4 ppm. Treatment was carried out using a Cooper Grain Sprayer adjusted to apply the required dose as the grain passed along a conveyor system. Storage temperatures ranged between 4 and 20°C.

In both trials the effectiveness and persistence of applied treatments was measured using the bioassay technique as in the laboratory trials. The saw-toothed grain beetle was used and bioassays were carried out at 24 h, 2 weeks, 2, 4 and 6 months after treatment. In addition, malathion-resistant saw-toothed grain beetle (Strain 484) was used in tests conducted at 2, 4 and 6 months after treatment.

RESULTS

Surface treatments

The bioassay results indicated differences in the persistence of etrimfos on different surfaces (Table 1). It was active longest on hessian and iron and shortest on the more absorbent mineral surfaces, brick and concrete. Mortality was variable initially when very low night temperature, sometimes below 0°C, reduced mobility of the insects and hence pick up of insecticide. However, the persistence of etrimfos at 0.5 g a.i/m^2 was generally satisfactory and compareable with the standard, pirimiphos-methyl.

Table 1

Active life of etrimfos in bioassay tests using Tribolium

Surface treated		Concrete	Galvanised iron	Hessian	Brick
Effective persistence of etrimfos ** (days)		15	42	70	14
Mortality on deposit (%)	Etrimfos	100	76	100	70
	Pirimiphos-methyl	86	73 *	100	45

* Deposit of 140 g a.i/m^2

** $>$70% mortality 48 h after initial contact with surface

Results from treatments of field infestations of pests (Table 2) showed that etrimfos gave good control of saw-toothed grain beetle, foreign grain beetle, rust-red grain beetle, grain weevil and grain mites when applied at 0.5 g a.i/m^2 to all available surfaces. Good results were obtained in various types of grain stores. These ranged from modern purpose built floor stores that were relatively easy to treat, to old grain stores in stone-built barns with many harbourages and containing considerable quantities of old spilt grain. At 2 months following treatment, no beetles or mites were detected at any site after spraying with etrimfos, fenitrothion or pirimiphos-methyl.

Table 2

Summary of results of field treatments of stored grain infestations two months after treatment.

	No. and type of site		
	8 sites Old farm silos and 2000 tonne floor stores	2 sites Old farm silos and 10000 tonne floor store	2 sites Old farm silos and dock-side grain handling complex
Pests present before treatment (max. number per bait bag)	*O. surinamensis* at 6 sites (117) *C. ferrugineus* at 2 sites (50) *Ahasverus advena* at 1 site (20) Mites at 6 sites (high)	*O. surinamensis* at 1 site (35) *C. ferrugineus* at 1 site (4) Mites at 1 site (moderate)	*O. surinamensis* at 2 sites (47) *C. ferrugineus* at 1 site (1) *Sitophilus granarius* at 1 site (9) Mites at 2 sites (high)
Treatment	Etrimfos 50% e.c. at 0.5 g a.i/m^2 and etrimfos 2% dust where appropriate.	Fenitrothion 40% w.p. at 0.5 g a.i/m^2 and 2% dust where appropriate.	Pirimiphos-methyl 25% e.c. at 0.5 g a.i/m^2 and 2% dust where appropriate.
Beetles or mites detected.	None	None	None

Admixture treatments

In the laboratory trials etrimfos applied as a 2% dust at 5 ppm a.i. gave complete control of a natural population of foreign grain beetle for at least 6 months, while numbers in the untreated grain remained at about 130/kg. Bioassays at regular intervals after treatment confirmed these results with beetles being killed after 24 h exposure up to 6 months after treatment. The treated grain also remained free of mites for the duration of the trial though untreated samples contained a high natural population. The excellent persistence of etrimfos at both 5 and 10 ppm a.i. was confirmed in the second laboratory trial where it gave complete control of confused flour beetle in bioassays conducted up to 5 months after treatment.

In the farm scale admixture trials on winter barley, etrimfos at 5 ppm a.i. compared favourably with pirimiphos-methyl at 4 ppm a.i., both treatments giving complete control of saw-toothed grain beetle, susceptible and malathion-resistant strains, after 36 h exposure, 6 months after treatment (Table 3). There was also an indication that etrimfos gave a more rapid knock-down than pirimiphos-methyl.

Table 3

Results of bioassays using Oryzaephilus surinamensis on winter barley treated with etrimfos and pirimiphos-methyl

	Susceptible					Malathion-resistant	
Time after treatment ...	4 months		6 months			4 months	
Exposure time (h) ...	6	24	6	24	36	6	24
Etrimfos 5 ppm a.i.	59	100	10	60	100	44	100
Pirimiphos-methyl 4 ppm a.i.	13	100	0	37	100	18	100
Untreated	0	18	0	0	10	0	10

Table 4

Results of bioassays with Oryzaephilus surinamensis on winter wheat treated with etrimfos

	Susceptible						Malathion-resistant			
Time after treatement ...	24 h		2 months		6 months		2 months		6 months	
Exposure time (h) ...	6	24	6	24	6	24	6	24	6	24
Etrimfos 5 ppm a.i.	100	100	100	100	100	100	84	100	64	100
Etrimfos 10 ppm a.i.	100	100	100	100	100	100	95	100	66	100
Untreated	11	14	10	11	0	5	9	20	0	0

The good knock-down effect and persistent control was further confirmed in the farm trial on winter wheat where total control of saw-toothed grain beetle was achieved after only 6 and 24 h exposure for the susceptible and the malathion-resistant strain respectively 6 months after treatment (Table 4). There were no apparent differences between treatment with 5 or 10 ppm etrimfos.

Germination tests

Tests carried out on wheat (cv. Kador) and barley (cv. Mazurka) treated with etrimfos 50% e.c. at 10 ppm a.i. indicated that there was no adverse effect on germination 1 week and 3 months after treatment.

Residues

Extensive residue analyses have been conducted on grain, grain fractions, bread, malted barley and wort. Whilst etrimfos was persistent on the grain, rapid degradation occurred during the baking and brewing process.

DISCUSSION

The results have confirmed that etrimfos is an effective product for the control of a wide range of insect pests and mites which occur in grain stores.

Applied under practical conditions to various grain store surfaces prior to harvest, etrimfos at a concentration of 0.5 g a.i/m^2 gave at least 2 months control of pests and was comparable with pirimiphos-methyl 25 e.c. and fenitrothion 40 w.p. applied at recommended rates.

As an admixture treatment applied at 5 ppm a.i. both as a 2% dust and 50% e.c. formulation, etrimfos has given at least 5-6 months control of all pests tested, saw-toothed grain beetle, foreign grain beetle, confused flour beetle and grain mites. It had a very good knock-down effect on saw-toothed grain beetle and was also effective against the malathion-resistant strain 484. Trials conducted by the M.A.F.F. Slough Laboratory have demonstrated that etrimfos also controls HCH-resistant mites in both grain and stored oilseed rape (Good *et al*, 1977).

Tests showed that etrimfos had no adverse effect on germination. Wheat and barley seed may, therefore, be safely treated.

CONCLUSIONS

Etrimfos may be used effectively both as an admixture treatment with grain at 5 ppm a.i. or as a surface treatment at 0.5 g a.i/m^2 to protect stored grain from pest attack.

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