BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

BSS249 PREPAREDNESS FOR BORER INCURSION

SUMMARY OF EFFECTIVENESS OF LAMBDA-CYHALOTHRIN FOR CONTROL OF SUGARCANE STEMBORERS

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PR02005

BSES, Meringa

BSES Publication
Project Report PR02005 **November 2002**

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SUMMARY

Following a search of the literature, lambda-cyhalothrin (Karate 2.5EC) was identified as a potential candidate insecticide for emergency use in Australia following an incursion of a stemborer.

Lambda-cyhalothrin is a stomach and contact pyrethroid used to control a wide range of pests. The insecticide (as Karate®) is registered against *Sesamia grisescens* in Papua New Guinea and *Eldana saccharina* in South Africa. It is also used against *Busseola fusca* in Ethiopia, *Chilo partellus* in Pakistan, and *Ostrinia nubilalis* in Poland.

Lambda-cyhalothrin is an essential management component that fits well within an overall Integrated Pest Management program for stemborer pests. Data on its chemical structure and physiochemical properties are presented in this report.

1.0 INTRODUCTION

An effective insecticide will be an important component of any control strategy for an exotic stemborer of sugarcane, should an incursion occur in Australia. To use any insecticide, an emergency use permit will have to be obtained from the National Registration Authority under their 'Off-label permits for minor and emergency uses of agricultural and veterinary chemicals'. Before NRA issues such a permit, it must assess the proposed use to ascertain whether, amongst other aspects, the use will be effective in controlling the pest.

Sugarcane stemborers have considerable potential as incursion agents into Australia. Any insecticide used against stemborers needs to be effective, and also to have minimal side effects against beneficials, especially wasp parasitoids. These parasitoids are likely to be another important component of any IPM program for stemborers.

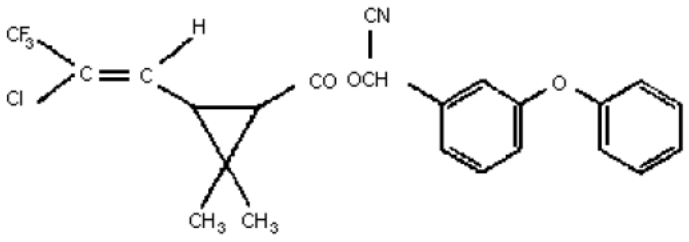
Literature searches have been conducted, and two chemicals have been identified as potential insecticides that can be used in case of incursion of a stem borer. The first chemical was tebufenozide (Mimic®, Confirm® or RH-5992) (Allsopp 2001). The second chemical that could be used is lambda-cyhalothrin.

Lambda-cyhalothrin is a pyrethroid insecticide and acaricide used to control a wide range of pests in a variety of applications. Pests controlled include a range of sugarcane and grass stemborers, such as *Sesamia grisescens* in Papua New Guinea (Kuniata 2000), *Eldana saccharina* in South Africa (Leslie 2000), *Busseola fusca* in Ethiopia (Getu 1996), *Chilo partellus* in Pakistan (Talpur *et al*. 1995) and *Ostrinia nubilalis* in Poland (Lisowicz 1999). Lambda-cyhalothrin is available as an emulsifiable concentrate, wettable powder or ULV liquid, and is commonly mixed with buprofezin, pirimicarb, dimethoate or tetramethrin (Kid and James 1991; Meister 1993).

The following information on the physiochemical properties of lambda-cyhalothrin is extracted from the Health and Safety Guide No. 38 compiled in 1990 by IPCS (International Programme on Chemical Safety), Kid and James (1991) and Wauchope *et al*. (1992).

2.0 PHYSIOCHEMICAL PROPERTIES

Chemical structure of lambda-cyhalothrin:



Molecular formula: $C_{23}H_{19}ClF_3NO_3$

Trade names: Trade names for products containing lambda-cyhalothrin include Charge, Excaliber, Grenade, Hallmark, Icon, Karate, Matador, OMS 0321, PP321, Saber, Samurai and Sentinel.

Synonyms: Lambda-cyhalothrin: R119321, PP321

CAS chemical name: (R+S)-alpha-cyano-3-(phenoxyphenyl)methyl- (1S+1R)-cis-3-(z-2-chloro-3,3,3,-trifluoroprop-1-enyl)-2,2- dimethylcyclopropane- carboxylate.

Chemical name: alpha-cyano-3-phenoxybenzyl-3-(2-chloro-3,3,3-trifluoropropenyl)-2,2-dimethyl-cyclopropane-carboxylate.

CAS registry number: lambda-cyhalothrin: 91465-08-6
Molecular Weight: 449.9
Water Solubility: 0.005 mg/L @ pH 6.5 and 20°C
Melting Point: 49.2°C
Vapour Pressure: Negligible at 20°C
Partition Coefficient: 10,000,000
Adsorption Coefficient: 180,000

Exposure Guidelines:
ADI: Not Available
MCL: Not Available
RfD: 0.005 mg/kg/day

3.0 REFERENCES

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APPENDIX 1

IPCS INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY
Health and Safety Guide No. 38
Cyhalothrin and lambda-cyhalothrin health and safety guide
United nations environment programme
International labour organisation
World health organization
Geneva 1990

Uses
Lambda-cyhalothrin is a pyrethroid insecticide that is active against a wide range of Lepidoptera, Hemiptera, Diptera, and Coleoptera. Lambda cyhalothrin is available as an emulsifiable concentrate, wettable powder or ULV liquid and is commonly mixed with buprofezin, pirimicarb, dimethoate or tetramethrin. The compound is a stomach and contact insecticide. It shows adulticidal, ovicidal and, particularly, larvicidal activity.

Human Exposure
Residues in food arising from the use of cyhalothrin and lambda-cyhalothrin on crops and in animal health are low, usually less than 0.2 mg/kg. No results are available on the total dietary intake in man, but it can be assumed that the dietary exposure of the general population will not exceed the ADI of 0.02 mg/kg body weight.

Environmental Exposure and Fate
On soil surfaces and in aqueous solutions at pH 5, lambda-cyhalothrin is degraded in sunlight with a half-life of approximately 30 days. The main degradation products are 3-(2-chloro-3,3,3-trifluoroprop1-enyl)-2-dimethylcyclopropane carboxylic acid, the amide derivative of cyhalothrin, and phenoxybenzoic acid.

Degradation in soil occurs primarily through hydroxylation followed by cleavage of the ester linkage to give two main degradation products that are further degraded to carbon dioxide. The initial half-lives are in the range of 22-82 days. Cyhalothrin and lambda-cyhalothrin are adsorbed on soil particles and are non-mobile in the environment.

On plants, lambda-cyhalothrin degrades at a moderate rate (half-life up to 40 days) and the major constituent of the residue on plants is usually the parent compound. Lower levels of metabolites, resulting from a range of hydrolytic and oxidative reactions, are also found.

No data are available on actual levels of cyhalothrin and lambda-cyhalothrin in the environment, but with the current use pattern and low application rates, these are expected to be low.

Uptake, Metabolism, and Excretion
Metabolic studies have been carried out on the rat, dog, cow, and goat. In the rat and dog, cyhalothrin was shown to be well absorbed after oral administration, extensively metabolized, and eliminated as polar conjugates in urine. Cyhalothrin levels in rat tissues declined on cessation of exposure to the compound. Residues in rat carcasses were low (< 5% of the dose after 7 days) and were found to be almost entirely due to cyhalothrin contained in fats. Residues in fats were eliminated with a half-life of 23 days. After oral

administration to lactating cows, cyhalothrin was rapidly eliminated, an equilibrium between ingestion and elimination being reached after 3 days; 27% of the dose was eliminated in the urine, 50% in the faeces, and 0.8% in the milk. Urinary material consisted entirely of ester cleavage metabolites and their conjugates; 60-70% of the faecal [14C]-material was identified as unchanged cyhalothrin.

Tissue residues, 16 h after the last dose, were low, the highest concentrations being detected in fat. The [14C]-residues in milk and fatty tissues were almost entirely unchanged cyhalothrin, no other component being detected. In all mammalian species investigated, cyhalothrin was extensively metabolized to the cyclopropane carboxylic acid and 3-phenoxybenzoic acid, as a result of ester cleavage, and eliminated as conjugates. In fish, the main residue in tissues consisted of unchanged cyhalothrin, with lower levels of the ester cleavage products.

Effects on Organisms in the Environment

Under laboratory conditions of constant toxicant concentrations, cyhalothrin and lambda-cyhalothrin were highly toxic for fish and aquatic invertebrates. The 96-h LC50s for fish ranged between 0.2 and 1.3 µg/L; the 48-h LC50s for aquatic invertebrates ranged between 0.008 and 0.4 µg/L.

Accumulation studies, conducted under laboratory conditions with constant concentrations, showed that rapid uptake takes place in fish (accumulation factor approximately 1000-2000). However, in the presence of soil and suspended sediment, the bioaccumulation factors were greatly reduced - to 19 in the case of fish and 194 in the case of *Daphnia*. When exposed fish and *Daphnia* were placed in clean water, the residues declined rapidly, with half-lives of 7 days and 1 day, respectively. The concentrations of cyhalothrin and lambda-cyhalothrin that are likely to arise in water from normal agricultural application will be low. Because the compound is rapidly adsorbed and degraded under natural conditions there will not be any practical problems concerning the accumulation of residues or the toxicity of cyhalothrin or lambda-cyhalothrin in aquatic species.

Cyhalothrin and lambda-cyhalothrin are virtually non-toxic for birds; the single dose LD50 was greater than 3950 mg/kg in all species tested and the lowest 5-day dietary LD50 was 3948 mg/kg (lambda-cyhalothrin fed to 8-day-old mallard ducks). Under laboratory conditions, both cyhalothrin and lambda-cyhalothrin were toxic for honey bees; the oral LD50 for lambda-cyhalothrin was 0.97 µg per bee. However, in the field, the hazard is lower since current formulations have a repellent action that causes a suspension of foraging activity in the treated crop. When foraging in the crop restarts, there is no significant increase in bee mortality.

Effects on Experimental Animals and In Vitro Test Systems

The acute oral toxicity of cyhalothrin is moderate in rats and mice and low in guinea pigs and rabbits (rat LD50, 144-243 mg/kg; mouse LD50, 37-62 mg/kg; guinea-pig LD50, >5000 mg/kg; rabbit LD50, >1000 mg/kg). The acute oral toxicity of lambda-cyhalothrin is higher than that of cyhalothrin (rat LD50, 56-79 mg/kg; mouse LD50, 20 mg/kg). The dermal toxicities are: rat LD50, 200-2000 mg/kg (cyhalothrin), 632-696 mg/kg (lambda-cyhalothrin); rabbit LD50, >2000 mg/kg (cyhalothrin). Cyhalothrin and lambda-cyhalothrin are Type II pyrethroids; clinical signs include ataxia, unsteady gait, and

hyperexcitability. In the rabbit, cyhalothrin is a moderate eye irritant and lambda-cyhalothrin a mild eye irritant; both are mild skin irritants. Cyhalothrin is not a skin irritant in the rat. However, it is a moderate skin sensitizer in the guinea pig. Lambda-cyhalothrin is not a skin sensitizer. In a 90-day feeding study in which rats were fed cyhalothrin at dose levels of up to 250 mg/kg diet, reduced body weight gain was observed in males at 250 mg/kg diet. Marginal effects on mean erythrocyte volumes were noted in some treated groups, as well as some liver changes, which were considered to be an adaptive response. In a 90-day feeding study in which rats were fed lambda-cyhalothrin at dose levels of up to 250 mg/kg, reduced body weight gain was observed in both sexes at 250 mg/kg. Some effects on clinical chemistry were observed, as well as liver effects similar to those noted with cyhalothrin. The no-observed-effect level was 50 mg/kg. In a 26-week oral study in which doses of up to 10 mg cyhalothrin/kg per day were administered to dogs, signs of pyrethroid toxicity were observed at 10 mg/kg per day. The no-observed-effect level was 2.5 mg/kg body weight per day. A similar study was conducted in which up to 3.5 mg lambda-cyhalothrin/kg body weight per day was administered to dogs for 52 weeks. Clinical signs of pyrethroid toxicity (neurological signs) were observed in all animals dosed with 3.5 mg/kg body weight per day. The no-observed-effect level was 0.5 mg/kg per day. A 21-day study was conducted in which cyhalothrin in polyethylene glycol was applied dermally to rabbits at dose levels of up to 1000 mg/kg per day. Clinical signs of toxicity were observed in some animals at the highest dose level. Slight to severe skin irritation was observed in all groups, including controls. Cyhalothrin was tested in two 104-week feeding studies, one on rats and one on mice. In the rat study, no oncogenic effects were observed at dose levels up to 250 mg/kg diet (highest level tested). The no-observed-effect level for systemic toxicity was 50 mg/kg diet (1.8 mg/kg body weight per day). Decreased body weight gain was observed in both sexes at 250 mg/kg diet. In the mouse study, no oncogenic effects were observed at dose levels up to 500 mg/kg diet (highest level tested). Clinical signs of pyrethroid toxicity were observed at 100 and 500 mg/kg diet and reduced body weight gain was observed at 500 mg/kg diet. The no-observed-effect level for systemic toxicity was 20 mg/kg diet (1.9 mg/kg body weight per day). No histological evidence of damage to the nervous system was observed in either study.

Cyhalothrin and lambda-cyhalothrin gave negative results in a range of in vivo and in vitro assays designed to detect gene mutations, chromosomal damage, and other genotoxic effects. When orally administered to the rat and rabbit during the period of major organogenesis, cyhalothrin was neither embryotoxic nor teratogenic at dose levels that elicited maternal toxicity (15 mg/kg per day for rats and 30 mg/kg per day for rabbits, both highest dose levels tested). A three-generation reproduction study was conducted on rats with cyhalothrin at dose levels of up to 100 mg/kg diet. Minor decreases in litter size and small reductions in weight gain were seen at 100 mg/kg diet; the no-observed-effect level for reproductive effects was 30 mg/kg diet.

Effects on Human Beings

No cases of accidental poisoning have been described. In manufacturing, formulation, laboratory work, and field usage, symptoms of subjective facial sensation have been reported. This effect generally lasts only a few hours, but occasionally persists for up to 72 h after exposure; medical examination has not revealed any neurological abnormalities. Subjective facial skin sensations, which may be experienced by people who handle cyhalothrin and lambda-cyhalothrin, are believed to be brought about by repetitive firing

of sensory nerve terminals in the skin; they may be considered as an early warning signal indicating that overexposure of the bare skin has occurred. There are no indications that cyhalothrin and lambda-cyhalothrin, used under the present recommended conditions and application rates, will have any adverse effects on human beings.

CONCLUSIONS AND RECOMMENDATIONS

General population. The exposure of the general population to cyhalothrin and lambda-cyhalothrin is expected to be very low and is not likely to present a hazard under recommended conditions of use.

Occupational exposure. With good work practices, hygiene measures, and safety precautions, cyhalothrin and lambda-cyhalothrin are unlikely to present a hazard to those occupationally exposed.

Environment. It is unlikely that cyhalothrin, lambda-cyhalothrin, or their degradation products will attain levels of adverse environmental significance with recommended application rates. Under laboratory conditions, cyhalothrin and lambda-cyhalothrin are highly toxic for fish, aquatic arthropods, and honey-bees. However, under field conditions, lasting adverse effects are not likely to occur under recommended conditions of use.

Recommendations

Although dietary levels from recommended usage are considered to be very low, confirmation of this through inclusion of cyhalothrin and lambda-cyhalothrin in monitoring studies should be considered. Cyhalothrin and lambda-cyhalothrin have been used for several years and cases of transient effects from occupational exposure have occurred. Observation of human exposure should be maintained.

HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

Main Human Health Hazards, Prevention and Protection, First Aid

Cyhalothrin is a pyrethroid insecticide of moderate acute toxicity (rat oral LD50, 44-243 mg/kg), unlikely to present an acute hazard in normal use. Lambda-cyhalothrin is slightly more toxic (rat oral LD50, 56-79 mg/kg). No cases of poisoning have been described in the general population and none from occupational exposure. The results of experimental animal studies suggest that, following massive overexposure or accidental ingestion, neurological signs and symptoms, such as tremors and convulsions, could occur. The human health hazards associated with certain types of exposure to cyhalothrin, together with preventive and protective measures and first-aid recommendations, are listed in the International Chemical.

Advice to physicians

No specific antidote is known. A hazard with liquid formulations is aspiration of the solvent into the lungs, resulting in chemical pneumonitis. Therefore, do not induce vomiting; empty stomach only on specialist advice using appropriate equipment. Treat symptomatically. In case of convulsions, diazepam should be given slowly intravenously or rectally in an appropriate dose (10 or 20 mg in an adult), and repeated if necessary.

Health surveillance advice
A pre-employment and an annual general medical examination are advised for regularly exposed workers. Occurrence of 'facial skin sensations' is an indication of exposures that should be corrected.

Explosion and Fire Hazards
Some solvents in pyrethroid formulations are highly flammable. Use dry powder, carbon dioxide, alcohol-resistant foam, sand, or earth for dealing with fires. Do not use water. Cool nearby drums with water spray. If pyrethroid products are involved in a major fire or in a fire involving other products, advise the fire service that protective clothing and breathing apparatus should be worn. Also, warn the authorities that pyrethroids are highly toxic for fish, and that the use of water should be confined to the cooling of unaffected stock, thus avoiding accumulation of polluted run-off from the site.

Storage
Store technical material and formulations away from heat, under lock and key, and out of reach of children, animals, and unauthorized personnel. Store in an area designated for pesticide storage. Prevent spills from leaking into watercourses. Store away from foodstuffs and animal feed.

Transport
Pyrethroids are classified as harmful or low hazard for transport purposes. Formulations based on flammable solvents may be subject to local transport controls. Ensure that containers are sound and that labels are securely fixed and undamaged before dispatch. Comply with local transport regulations. Do not load together with foodstuffs and animal feed.

Spillage and Disposal
Spillage
Empty any product remaining in damaged or leaking containers into a clean empty drum and affix the correct label. Absorb spillage with lime, damp sawdust, sand, or earth and dispose of safely (see below). If spillage is large, contain it by building a barrier of earth or sandbags. Decontaminate empty, damaged, or leaking containers with a 10% sodium carbonate solution added at the rate of at least 1 L per 20-L drum. Puncture containers to prevent reuse.

Disposal
Waste containing cyhalothrin or lambda-cyhalothrin should be burnt in a suitable high-temperature incinerator fitted with a high-efficiency gas scrubbing system. Where no incinerator is available, contaminated absorbents or surplus products should be decomposed by hydrolysis at pH12 or above. Contact with a suitable hydrolysing agent is required to ensure degradation of the active ingredient to a safe concentration.

For emulsifiable material:
5% sodium hydroxide (caustic soda) solution or saturated (7-10%) sodium carbonate (washing soda) solution can be used.

For non-emulsifiable material:

Use a 1:1 mixture (by volume) of either of the above solutions and a water/oil soluble solvent, such as denatured alcohol, monoethylene glycol, hexylene glycol, or 2-propanol. Cover the material with a hydrolysing agent and leave to stand for 7 days. Before disposal of the resultant waste, the material must be analysed to ensure that the active ingredient has been degraded to a safe level. Never pour untreated waste or surplus products into public sewers or where there is any danger of run-off or seepage into streams, watercourses, open waterways, ditches, fields with drainage systems, or the catchment areas of boreholes, wells, springs, or ponds.

HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

Cyhalothrin and lambda-cyhalothrin are very toxic for fish, aquatic invertebrates, and honey-bees but, because very low exposure levels normally occur, this would only cause a problem in the case of spillage. The toxicity for birds is low. With recommended techniques and rates of application, it is unlikely that cyhalothrin and lambda-cyhalothrin and their degradation products will attain levels of adverse environmental significance. Avoid spraying over bodies of water. Do not contaminate ponds, waterways, or ditches with the product or used containers.

INTERNATIONAL CHEMICAL SAFETY CARD

This card should be easily available to all health workers concerned with, and users of, cyhalothrin and lambda-cyhalothrin. It should be displayed at, or near, entrances to areas where there is potential exposure to cyhalothrin and lambda-cyhalothrin, and on processing equipment and containers. The card should be translated into the appropriate language(s). All persons potentially exposed to the chemicals should also have the instructions on the chemical safety card clearly explained. Space is available on the card for the insertion of the National Occupational Exposure Limit, the address and telephone number of the National Poison Control Centre, and for local trade names.

APPENDIX 2 Paper by Leslie (2000)

Sugarcane Pest Management Strategies in the New Millennium PG Allsopp and W Suasa-ard (Eds)
Proceedings of the IV ISSCT Sugarcane Entomology Workshop, Khon Kaen, Thailand, 7-10 February 2000
International Society of Sugar Cane Technologists, Brisbane. 2000, pp. 19-27

Approaches to the use of insecticides against the sugarcane borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae)

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APPENDIX 3 Extract from Kuniata (2000)

Table 3. Parasitism (%) of *Sesamia grisescens* larvae and pupae observed between January and June each year. Estimated cane losses due to this borer are also shown for each season.

Year	*Cotesia flavipes*		*Pediobius furvus*		Combined parasitism*		Cane loss
	Mean	Range	Mean	Range	Mean	Range	(t ha^{-1})
1986	-	-	-	-	-	-	18
1987	0	0	-	-	0	0	31
1988	19.3	0-68	-	-	19.3	0-68	12
1989	11.2	2-22	0	0	10.7	0-37	8
1990	3.8	0-22	5.8	0-29	11.0	0-60	11
1991	25.2	4-40	0	0	20.8	5-41	4
1992	30.2	12-56	3.5	0-7	34.5	13-63	3
1993	27.8	3-45	5.5	0-17	36.8	9-58	0
1994	19.8	0-51	5.7	0-18	30.7	0-55	2
1995	28.2	4-52	6.0	1-12	37.2	14-62	10
1996	30.0	6-62	1.7	0-3	32.3	7-65	10

- data not available.

*also includes parasitism by *Enicospilus terebrus*.

INSECTICIDAL CONTROL

In March 1996, 10 blocks (total of 130 ha, 3-4 months old) were sprayed with lambda-cyhalothrin (Karate® 2.5EC) at 25 g ai ha^{-1} using high-clearance tractors for the control of *S. grisescens*. Flat-fan nozzles (110°) were used on a standard boom to spray directly above the canopy and also from extensions to spray from the side (interspace) below the cane canopy (cabbage area). Spray volumes were 200-400 L ha^{-1}. A further 10 blocks adjacent to the sprayed blocks were used as unsprayed controls. At 2 weeks and 4 weeks after spraying, 200 stalks were randomly sampled in each block and life stages of *S. grisescens* and damage were assessed.

Data from these observations confirmed that spraying significantly reduced numbers of larvae, pupae and bored stalks (Table 4), and cane yields were increased by more than 57%.

Table 4. Control of *Sesamia grisescens* in semicommercial trials sprayed with lambda-cyhalothrin (Karate 2.5EC) in the 1996 season.

Treatment	*S. grisescens* per 100 stalks		% bored	Cane yield
	Larvae	Pupae	stalks	(t ha^{-1})
Sprayed	11.3	0.3	10.7	75.0
Unsprayed	62.4	12.2	66.0	47.7
t-test	2.97	2.18	4.98	7.20
p	<0.01	<0.05	<0.001	<0.001

Three strip trials were established in the 1997 season to test application of permethrin. In each block (about 8-14 ha), 20 rows on one side were left unsprayed. A custom-built Scorpion spray rig, using the Irvin spray system, was used to apply permethrin at 250 g ai ha^{-1}. Larval mortality was estimated at 3, 5 and 10 d after spraying, from 20 randomly collected infested stalks in each strip. Borer damage was