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TRIALS IN THE U.K. WITH NRDC 161: A SYNTHETIC PYRETHROID INSECTICIDE

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Summary The effectiveness of the light-stable synthetic pyrethroid NRDC 161 in controlling a wide range of insect pests in U.K. horticultural and agricultural crops was determined over a four-year period. It was found to give equivalent control, to that of standard materials, of lepidopterous pests (pea moth, brassica caterpillars, codling and winter moths on apple) homoptera (damson hop aphid on hops and plums, apple aphids, cereal aphids, apple and pear suckers, and whitefly on glasshouse crops) and coleoptera (pollen beetle). Although NRDC 161 had an initial effect against red spider mite on apple, less persistent control was obtained than with the other pests examined. No phytotoxicity was observed with any crop even at rates considerably higher than commercially recommended, and the product was found to be compatible as a tank mix, with a number of other pesticides.

Resumée L'activité du NRDC 161, pyréthrinoïde photo-stable, a été etudiée au cours des 4 dernières années vis-à-vis d'un grand nombre de ravageurs dans le domaine agricole et horticole. Le produit s'est révélé parfaitement efficace sur les groupes de ravageurs suivants: lépidoptères (carpocapse du pois, piéride du chou, carpocapse des pommes) homoptères (pucerons du houblon, du chou, du pommier et des céréales - psylle du pommier et poirier - aleurode des serres) coléoptères (méligèthe du colza). Bien que possédant un effet choc appréciable sur Panonychus ulmi sur pommier le produit a manifesté une persistance d'action inférieure à celle observée sur les autres ravageurs. Aucune phytotoxicité n'a été observée sur toutes cultures quelles que soient les doses appliquées même lorsqu'elles étaient considérablement plus élevées que celles recommandées dans la pratique. La formulation étudiée s'est révélée également compatible en mélange extemporané avec un grand nombre d'autres produits phytosanitaires.

INTRODUCTION

NRDC 161, previously known by the proposed common name decamethrin, is one of a group of photo-stable synthetic pyrethroid insecticides isolated by Elliot and his co-workers at Rothamstead (Elliot *et al*, 1974). The physical and chemical properties together with results of world-wide field trials in agricultural crops were presented at the 1977 British Crop Protection Conference (Hervé *et al*, 1977). Papers have also been published on trials carried out in France for control of pear sucker (*Psylla piri*) (Roa *et al*, 1978), oilseed rape pests (Pastre *et al*, 1978) and whitefly (*Trialeurodes vaporiarium*) (Della Giustina & Le Rumeur, 1977). Experimental work in the U.K. has been described by Thompson and Percival (1978) and Biddle (1979). Extensive field evaluation has been carried out by Hoechst U.K. Ltd.

since 1976, and the object of this paper is to present the results from four years' work in agricultural and horticultural crops in the U.K.

METHODS AND MATERIALS

In the four years 1976 to 1979 trials were carried out in the U.K. on a range of insect pests in fruit and hops, arable and vegetable crops. The trials, all on commercial farms or orchards, were situated in East Anglia, South-East England and the West Midlands.

Plot sizes were adjusted according to the crop as follows:- peas and cereals, 2 x 5 metres; mustard, 4 x 4 metres; brassicas, 4 rows x 5 metres; hops, 8 hills, and top fruit and glasshouse crops, 3 trees or plants. A randomised block design was employed and treatments were replicated four times.

Application to arable and vegetable crops was made with a Van der Weij AZO precision sprayer, at a pressure of 1,850 mmHg and 600 l/ha of water. Motorised knapsack sprayers were used to treat hops and top fruit, and hand-operated sprayers for glasshouse crops, spraying at high volume to the point of "run off". Time of application varied according to the crop/pest and is given in the Results section.

A formulation containing 25 g a.i./l as an emulsifiable concentrate (trade name Decis) was used throughout the four year trial period. The standard products in these trials (amitraz, 20% e.c.; DDT, 25% e.c.; dimethoate, 40% e.c.; endosulfan, 35% e.c.; omethoate, 57.5% e.c.; permethrin, 25% e.c.; pirimicarb, 50% w.p. and triazophos, 40% e.c.) were applied at the recommended rates for each product. Untreated control plots were also included in each trial.

RESULTS

Results are presented separately for vegetable crops, fruit and hops, arable and glasshouse crops.

Vegetable Crops

Peas

In all trials two applications for control of pea moth (*Cydia nigricana*) were made according to warnings issued by the Processors and Growers Research Organisation or threshold counts of male moths in pheromone baited traps placed in the crops. Assessment of control of the pest was made, just prior to harvest, on the number of pods with larvae/damaged seeds in a sample of one hundred randomly collected in each plot. Results are summarised in Table 1. At all rates of application NRDC 161 tended to give more effective control than either triazophos or permethrin. There was no phytotoxicity with the highest rate of NRDC 161 tested, and no loss of pea moth control when NRDC 161 (10 g a.i./ha) was tank mixed with manganese sulphate. The lower levels of control in 1976 - 1978 reflected problems in achieving optimum application timing which were alleviated by the introduction of the pheromone traps.

Brassicas

Control of caterpillars of the Cabbage White Butterfly (*Pieris brassicae* and

Pieris rapae) was evaluated after a single application made as soon as pest damage was first seen. Assessments were based on counts of larvae made on ten plants per replicate 18 days after application. The trials covered crops of cabbage, cauliflower and broccoli.

Table 1

Percentage reduction in pods damaged by pea moth larvae

Treatment	g a.i./ha	1976	1977	1978	1979
NRDC 161	7.5	-	-	76	99
NRDC 161	10	-	-	-	97
NRDC 161	12.5	85	74	79	-
NRDC 161	25	87	86	87	-
triazophos	340	72	58	57	70
permethrin	50	-	-	61	93
Mean % damaged pods on untreated controls (range)		23.9 (8.8-56.5)	18.9 (5.5-32.3)	9.0 (3.3-12.8)	17.0 (12.0-23.0)
No. of trials		3	2	3	3

Over the three years reported (Table 2), NRDC 161 gave equivalent control of larvae (range of instars) to that of the standard materials.

Table 2

Percentage control of larvae of the Cabbage White butterfly

Treatment	g a.i./ha	1976	1977	1978
NRDC 161	7.5	-	-	96
NRDC 161	10	-	-	-
NRDC 161	12.5	92	92	97
NRDC 161	25	100	100	98
triazophos	340	69	71	96
DDT	700	-	-	95
permethrin	25	-	-	94
Mean no. caterpillars/ 10 plants on untreated controls (range)		11.0	11.0	9.0 (3.0-18.0)
No. of trials		1	1	3

In addition to controlling brassica caterpillars NRDC 161 has an effect on the mealy cabbage aphid (*Brevicoryne brassicae*). This can be seen from the results of a trial in 1976 on Brussels sprouts where the percentage reduction in aphid numbers 7 days after spraying was 67 and 82 for NRDC 161 at 12.5 and 25 g a.i./ha compared with 84 for pirimicarb at a rate of 300 g a.i./ha. On the untreated controls there was a mean of 207 aphids per 10 plants. The relatively low level of control with all treatments is probably a reflection of inadequate crop cover.

Taint tests

In tests carried out over a three year period no significant taints or off-flavours were recorded on peas, Brussels sprouts and carrots.

Fruit and Hops

Apples

NRDC 161 was evaluated against a number of pests of apple. In trials to control codling moth (*Cydia pomonella*) two applications were made; the first according to catches of adults in pheromone traps and the second 3 weeks later. The results (Table 3) based on 100 fruits/replicate at harvest show NRDC 161 to be highly active against this pest. In these trials NRDC 161 was tank mixed with binapacryl and binapacryl + pyrazophos without any loss of efficacy, or adverse effect on the crop.

Table 3

Percentage reduction in fruit damaged by codling moth larvae

Treatment	g a.i./100 l	1978	1979
NRDC 161	0.75	94	94
NRDC 161	1.0	-	96
NRDC 161	1.25	92	-
NRDC 161	2.5	95	-
triazophos	40	73	88
permethrin	0.5	83	80
Mean % damaged fruit on untreated controls (range)		6.0 (0.75-15.25)	12.5
No. of trials		4	1

NRDC 161 was also very effective in controlling apple sucker as shown by a trial on the cultivar Laxton Superb sprayed at the beginning of June 1978, one week after 80% petal fall, when both adults and nymphs were present. Assessed 28 days later, NRDC 161 at 0.75 - 2.5 g a.i./100 l and triazophos (40 g a.i./100 l) both gave complete kill of a population which on untreated trees was recorded at 14 adults/100 leaves.

One of the few pests not adequately controlled by NRDC 161 is the red spider mite (*Panonychus ulmi*). Although there can be an initial reduction in pest numbers as shown by the trial on cv. Worcester sprayed on 7th and 21st July 1976 with NRDC 161 at 1.25 and 2.5 g a.i./100 l, when all summer stages were present, the population built up again 7 - 14 days after application. However, persistent control was obtained with triazophos at 30 g a.i./100 l, even 25 days after application.

NRDC 161 was, however, very effective in controlling apple grass aphids (*Rhopalosiphum insertum*), winter moth (*Operophtera brumata*) and fruit tree tortrix moth (*Archips podana*) when applied at green cluster or pink bud in trials in 1978 and 1979. Assessments were made 15 days after application in 1978 and after 35 days in 1979 (Table 4). In these trials NRDC 161 was found to be compatible with captan.

Table 4

Percentage control of pre-blossom pests of apple

Treatment	g a.i./100 l	Apple grass aphids		Winter moths	Fruit tree tortrix moths
		1978	1979	1978	1978
NRDC 161	0.5	-	100	100	-
NRDC 161	0.75	82	100	87	100
NRDC 161	1.0	100	100	96	100
triazophos	40	100	100	92	50
permethrin	0.5	100	95	92	95
Mean no. pests/25 clusters on untreated controls (range)		21	280 (250-309)	6	6
No. of trials		1	2	1	1

The following apple varieties were sprayed as for codling moth at a rate of 2.5 g a.i./100 l without any signs of phytotoxicity:-

Bramley's Seedling
Cox's Orange Pippin
Discovery
Egremont Russett
Grenadier
Jonared
Laxton Fortune
Laxton Superb
Lord Derby
Lord Lambourne
Scarlet Pimpernel
Worcester Permain

Plums

In a trial carried out in 1979 to control the damson hop aphid (*Phorodon humuli*) application at the cot-split stage resulted in excellent control up to 21 days after application (Table 5).

Treatment against plum fruit moth (*Cydia funebrana*) was applied at the green fruitlet stage and again four weeks later. Assessments were made at harvest on 250 fruits per replicate. NRDC 161 at 0.75 - 1.0 g a.i./100 l gave 100% control in both the trials, where the mean number of larvae on the untreated controls was 33 per 250 fruits. The varieties Victoria and Yellow Egg showed no signs of phytotoxicity at the rates given.

Table 5

Percentage control of the damson hop aphid on plums

Treatment	g a.i./100 l	days after spraying			
		1	3	14	21
NRDC 161	2.0	97	99	100	99
endosulfan	88	61	84	93	86
omethoate	57.5	88	98	99	93
Mean no. aphids/25 leaves on untreated control		178	218	290	238

Pears

Due to the occurrence of more than one generation of pear sucker (*Psylla simulans*) two applications were made. In the 1977 trials these were at 80% petal fall and in August. In 1978 and 1979 the pyrethroid insecticides and triazophos were applied at bud burst while amitraz and endosulfan were sprayed 7 days after 80% petal fall. Second applications with all treatments were made in August. Assessments were made about 3 weeks after the final spray by taking counts of adults and nymphs from 100 randomly selected leaves per replicate and the results are summarised in Table 6. Cultivars Williams, Conference and Comice were all successfully treated.

Table 6

Percentage control of pear sucker

Treatment	g a.i./100 l	1977	1978	1979
NRDC 161	0.75	-	92	92
NRDC 161	1.25	96	94	95
NRDC 161	2.5	98	93	-
endosulfan	88	-	88	-
amitraz	32	60	87	-
triazophos	40	90	77	85
permethrin	2.5	-	84	86
Mean no. of adults and nymphs on 100 leaves on untreated controls (range)		316 (145-486)	109 (37-206)	34 (18-64)
No. of trials		2	3	3

Hops

Programmed applications for the control of the damson hop aphid (*P. humuli*) were initiated in June when winged adults transferred from their primary hosts

(*Prunus* spp.) to the immature hop bines. At least four applications, separated by 10 - 14 day intervals were made during the season. The level of control was assessed at the end of July by counts of the numbers of apterae on 25 leaves from different heights on the bines taken at random from each replicate. Results are presented in Table 7.

NRDC 161 was found to be compatible with pyrazophos, sulphur and triademefon. Crops of Bullion, Northern Brewer, Northdown and Wye Challenger were treated at rates twice that commercially recommended without any signs of phytotoxicity.

Table 7

Percentage control of damson hop aphid on hops

Treatment	g a.i./100 l	1977	1978	1979
NRDC 161	2	-	-	100
NRDC 161	2.5	100	99	-
endosulfan	87.5	99	94	96
Mean no. of apterae per 25 leaves on untreated controls (range)		1,500 (50-3,000)	120 (4-400)	550 (370-750)
No. of trials		2	4	4

Arable crops

Cereals

NRDC 161 was also included in trials to control the grain aphid (*Sitobion avenae*) on cereals. Applications were made when the pests reached the threshold described by the Ministry of Agriculture (ADAS) as 5 aphids per ear, while the crop was in anthesis. Assessment of control was based on counts of aphids on twenty-five randomly selected ears from each replicate, 7 days after application. In the seven trials, carried out over three years, NRDC 161, at all rates gave 98 - 99% control. Over this same period, pirimicarb gave a mean control of 96% (Table 8).

Oilseed rape

In 1977 two trials were carried out to control Pollen beetle in mustard at the beginning of June when the crop was at the green-yellow bud stage. Counts of adults were made 19 days later on 25 flower heads per plot followed by assessing blind stalks on 25 racemes (Table 9).

Glasshouse crops

Geranium sp. stocks were treated when a significant population of glasshouse whitefly (*Trialeurodes vaporariorum*) developed on the plants. All stages were present at the time of application and results (Table 10) therefore, are based on

Table 8

Percentage control of the grain aphid

Treatment	g a.i./ha	1976	1977	1978
NRDC 161	12.5	99	98	99
NRDC 161	25	99	99	-
dimethoate	340	-	99	-
pirimicarb	300	99	96	94
Mean no. aphids per 10 ears on the untreated controls (range)		220 (23-425)	150 (18-333)	122 (68-175)
No. of trials		2	3	2

Table 9

Percentage reduction in pollen beetles and blind stalks

Treatment	g a.i./ha	adult pollen beetles	blind stalks
NRDC 161	12.5	50	47
NRDC 161	25	76	61
triazophos	400	66	54
endosulfan	490	48	36
Mean no. on untreated controls		16	21.9

counts of scales, adults and pupae taken on 10 leaves per replicate 4 days after treatment. Both rates of NRDC 161 and the standard, triazophos, gave 95 - 96% control of adults. Control of the scales and pupae was, however, less effective. Control of mealy bug (*Planococcus citri*) was recorded from a trial on grape ivy with NRDC 161 at 1.25 g a.i./100 l giving 86% control compared to triazophos at 40 g a.i./100 l and permethrin at 4 g a.i./100 l, 66% and 52% control respectively.

DISCUSSION

The results have shown that NRDC 161 has given effective control of a range of important pests found on fruit and hops, arable, vegetable and glasshouse crops. The results confirm the effectiveness of the product against codling moth, apple and cereal aphids, pollen beetle, whitefly and brassica caterpillars (Hervé *et al*, 1977), pollen beetles (Pastre *et al*, 1978), pear sucker (Roa *et al*, 1978), whitefly (Della Giustina & Le Rumeur, 1977) and pea moth (Biddle, 1979).

Table 10

Percentage control of whitefly

Treatment	g a.i./100 l	Scales	Adults	Pupae
NRDC 161	1.25	73	96	54
NRDC 161	2.5	82	96	73
triazophos	60.0	85	95	0
Mean no. from 10 leaves on untreated control		1094	130	112

An outstanding feature of NRDC 161 is the high activity of the product which permits the use of rates of active ingredient often far lower than other materials. This results in extremely low levels of residues and allows a zero day harvest interval. In fact, NRDC 161 was even more active than initially thought, and currently recommended rates of application are, therefore, lower than those originally tested. Despite the low rate of application, persistent control of most pests was recorded which was equivalent to that of the standard materials. NRDC 161 was also found to be very safe to the crop. No phytotoxicity or taint was recorded with any crop or at any rate tested.

The results confirm that NRDC 161 is a very useful new broad-spectrum insecticide with added advantages of persistent control of the pest, safety to the crop, and no harvest interval.

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AC 222,705, A NEW PYRETHROID INSECTICIDE:

PERFORMANCE AGAINST CROP PESTS

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Summary AC 222,705, (*RS*)-*α*-cyano-3-phenoxybenzyl (*S*)-2-(4-difluoromethoxyphenyl)-3-methylbutyrate, is a new, highly active, broad-spectrum pyrethroid insecticide with excellent residual efficacy. In addition to its outstanding insecticidal activity, AC 222,705 controls or suppresses phytophagous mites and is highly active against ticks. Performance, toxicologic, metabolic and residue studies are under way to support registration and worldwide commercial development of the product.

INTRODUCTION

AC 222,705 is a novel pyrethroid insecticide discovered by researchers at American Cyanamid Company at its Agricultural Research Center in Princeton, New Jersey, USA. This compound has outstanding activity against a wide spectrum of agricultural pests and is presently undergoing worldwide development. The purpose of this paper is to briefly describe the compound and to present some representative trial results.

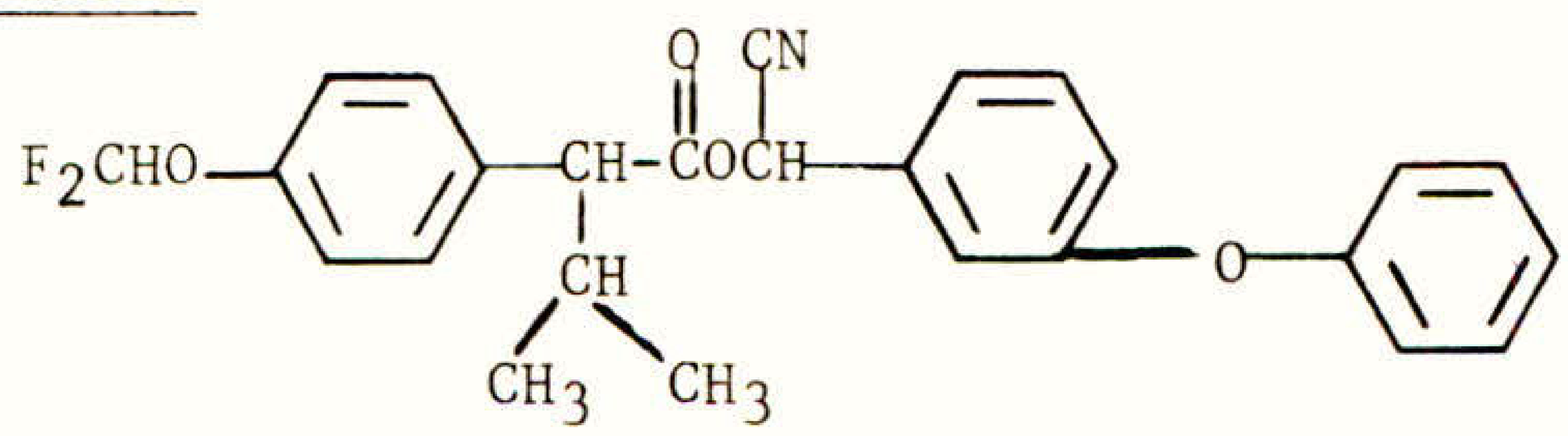
CHEMICAL AND PHYSICAL PROPERTIES

Chemical name: (*RS*)-*α*-cyano-3-phenoxybenzyl (*S*)-2-(4-difluoromethoxyphenyl)-3-methylbutyrate (IUPAC).

Other designations: OMS 2007 (WHO). A13-29391 (USDA).

Molecular formula: $C_{26}H_{23}F_2NO_4$

Structural formula:



Molecular weight: 451.5

Physical state and color: Viscous, dark amber liquid.

Density: 1.189 g/ml at 22 °C.

Odor: Very slight, faintly ester-like.

Boiling point: 108 °C at 0.35 mm Hg.

Vapor pressure: 2.4×10^{-7} mm Hg at 45 °C.

Viscosity: 5150 cps at 21.5 °C.

Solubility (g/100 ml solvent at 21 °C):

Acetone	>82
Corn oil	>56
Hexane	9
Propanol	>78
Water	0.00005
Xylene	181

Partition coefficient (n-octanol/water): 110

Hydrolysis rates (half-life in days):

	27 °C	35 °C
pH 3	ca. 40	ca. 40
pH 6	52	31
pH 9	6.3	2.6
distilled water	40	29

Photolysis: Half-life was 22 days when thin-layer ^{14}C-AC 222,705 treated soil plates were exposed to high-intensity lamps simulating tropical sunlight.

Mobility in soil: Immobile.

FORMULATIONS

AC 222,705 is formulated as emulsifiable concentrates: the 300-E contains 300 g a.i./l. (sp. gr. 0.995) and the 100-E contains 100 g a.i./l. (sp. gr. 0.907).

TOXICOLOGY, METABOLISM AND RESIDUES

All studies required for product registration are either completed or in progress.

Toxicity to mammals

The technical and formulated products are moderately toxic by single oral doses and are less toxic by single dermal applications (Table 1).

Table 1

Acute LD_{50} values (mg/kg body wt) for AC 222,705 in laboratory animals

Test / Species & sex	AC 222,705 Technical	AC 222,705 300-E
Acute oral		
Rat, male	81	87
female	67	53
Mouse, female	76	58
Acute dermal		
Rabbit, male & female	>1000	>995

A 90-day rat study was conducted with 0, 15, 30, 60 and 120 ppm in the diet with no overt signs of toxicity. The only treatment-related effect seen was a slight depression of body weight gains in the 120-ppm group.

Dogs were fed diets containing 0, 30, 150 and 300 ppm a.i. for 90 days. Although food consumption and body weights were reduced in the 300-ppm group, all dogs survived and no treatment-related gross or microscopic lesions were found.

Standard tests in rats showed that AC 222,705 is not teratogenic.

Chronic toxicity and multiple-generation studies are in progress.

Toxicity to birds

Tests were conducted to determine the acute oral LD_{50} and the 8-day dietary LC_{50} values for 14-day-old Mallard ducklings (*Anas platyrhynchos*) and Bobwhite quail chicks (*Colinus virginianus*). The acute oral LD_{50} values were >2510 and 2708 mg/kg body wt for ducks and quail, respectively. The LC_{50} values (ppm in diet) were 4885 and 3443 for ducks and quail, respectively.

Toxicity to fish

Like other pyrethroid insecticides, AC 222,705 is highly toxic to fish. However, given the very low effective dosages for crop pest control and the immobility of AC 222,705 in soil, the compound should not present undue hazards to fish when appropriately used for crop pest control.

Metabolic and bioaccumulation studies

Animal, plant and soil studies are under way. Results to date indicate no toxicological or environmental problems in this area. Studies with fish continuously exposed to ^{14}C-labelled AC 222,705 showed that the compound and its metabolites did not accumulate. Plant and soil studies show that AC 222,705 does not translocate systemically.

Residues

Numerous studies in cotton have shown no detectable residues (<0.05 mg/kg) in seed at harvest following multiple spray applications of AC 222,705 300-E to plants in the field even at exaggerated dosages. Residue studies in other crops are also under way.

PERFORMANCE

Laboratory, greenhouse and field tests have shown that AC 222,705 is a highly active, broad-spectrum insecticide with excellent residual efficacy. A representative listing of some arthropods controlled by AC 222,705 is given in Table 2.

Table 2

Some groups of arthropods controlled by AC 222,705 in laboratory, greenhouse and field tests

CLASS Order	Family
INSECTA	
Coleoptera:	Chrysomelidae, Curculionidae, Scarabaeidae
Diptera:	Agromyzidae, Culicidae, Cuterebridae Muscidae, Oestridae
Hemiptera:	Aleyrodidae, Aphididae, Cicadellidae, Delphacidae, Miridae, Pentatomidae, Psyllidae
Lepidoptera:	Arctiidae, Gelechiidae, Lyonetiidae, Noctuidae, Olethreutidae, Pieridae, Pyralidae, Yponomeutidae
Orthoptera:	Blattellidae, Gryllidae, Tettigoniidae
Thysanoptera:	Thripidae
ARACHNIDA	
Acari:	Ixodidae, Tarsonemidae, Tetranychidae

Residual efficacy and effects of temperature on activity

The excellent initial and residual activity of AC 222,705 on treated cotton foliage is illustrated in Table 3. On the basis of the dosages required to produce 50% mortality in bioassays with 3rd-instar tobacco budworm larvae (*Heliothis virescens)* at several different time intervals after treatment of the foliage, AC 222,705 was twice as effective as fenvalerate and was greatly superior to permethrin.

Table 3

Initial and residual efficacy of AC 222,705, fenvalerate and permethrin against 3rd-instar larvae of *Heliothis virescens* after exposing treated cotton foliage to simulated tropical sunlight. (Greenhouse/ laboratory tests)

Days residual	LC_{50} (ppm a.i. in spray solution) AC 222,705	Fenvalerate	Permethrin
0	4.7	7.7	18.6
3	7.4	13.4	45.5
6	10.9	22.8	96.5
14	23.6	47.8	(N.K.120)*
21	28.6	50.8	(N.K.120)

*N.K.120=No kill at 120 ppm a.i. in spray solution.

Pyrethroid insecticides generally exhibit a negative temperature-activity relationship. Preliminary topical application LD_{50} data (Table 4) indicate that AC 222,705 follows a pattern similar to NRDC 161 and fenvalerate, but is less affected by high temperature than permethrin.

Table 4

Effects of posttreatment temperature on pyrethroid toxicity to *Heliothis virescens*

Insecticide	LD_{50} (ng/3rd-instar larva) 7 °C	27 °C	38 °C
AC 222,705	7.2	13.2	15.2
NRDC 161	1.4	3.6	3.1
Fenvalerate	13.2	20.1	31.0
Permethrin	14.1	31.0	108.4

Representative field trial results on various crops

Cotton Extensive testing was carried out with AC 222,705 in various countries during 1978 and is continuing this year.

In the USA, for example, rates of 28 to 90 g a.i./ha were established as an effective range for control or suppression of a wide spectrum of cotton pests. AC 222,705 at 28 to 67 g a.i./ha effectively controlled the bollworm/budworm complex (*Heliothis zea* and *H. virescens*), the pink bollworm (*Pectinophora gossypiella*), the cotton leafperforator (*Bucculatrix thurberiella*), the cabbage looper (*Trichoplusia ni*) and the saltmarsh caterpillar (*Estigmene acrea*). In addition, significant control and/or suppression of aphids (*Aphis gossypii* and others), plant bugs (*Lygus* spp.), whiteflies (*Trialeurodes* spp.) and spider mites (*Tetranychus* spp.) was obtained at rates of 45 to 67 g a.i./ha. Rates of 45 to 90 g a.i./ha effectively suppressed populations of the boll weevil (*Anthonomus grandis*).

AC 222,705 shows high promise against cotton pests in the Mideast and Africa, where rates of 25 to 100 g a.i./ha generally have given excellent control of bollworms (*H. armigera, P. gossypiella, Earias* spp.), leafworms (*Spodoptera littoralis*), leafhoppers (*Empoasca* spp.) and whiteflies (*Bemisia tabaci*) in field trials. Suppression of spider mites has been reported also. In Egypt it is well known that cotton insecticide rates/ha are typically 2 to 4 times greater than rates required in most other cotton-growing countries. While early results of Egyptian trials with AC 222,705 indicate dosages in the range of 100 to 200 g a.i./ha are highly effective, the optimum rate has not yet been established. We expect that the Egyptian rates will be clearly defined in official and private trials which are in progress.

Field trials against cotton pests in Latin America have shown excellent control of bollworms (*Heliothis* spp.), leafworms (*Alabama argillaceae, Pseudoplusia includens* and *Trichoplusia ni*), and aphids (*Aphis gossypii*) with AC 222,705 at rates of 25 to 100 g a.i./ha. Populations of and damage by the broad mite (*Polyphagotarsonemus latus*) were effectively suppressed by applications of AC 222,705 at 50 to 100 g a.i./ha.

Cotton plants treated with AC 222,705 present a vigorous, healthy appearance and have shown no signs of phytotoxicity. Substantial increases in cotton yields were associated with the control of pests by AC 222,705.

<u>Other crops</u> Trials against major pests of various crops have demonstrated that AC 222,705 has a broad potential (Table 5). Specific effective rates for use on tree crops, vines and other high-volume spray applications are being developed but appear to lie in the range of 0.0025 to 0.0075% a.i. for most insect pests. The higher rates (0.005 to 0.0075% a.i.) also control mites such as *Panonychus ulmi* and *Tetranychus urticae*.

Effective rates for control of various major insect pests on vegetables, field crops, tobacco and ornamentals are being established also and appear to lie in the range of 12.5 to 50 g a.i./ha.

<u>Noncrop uses</u> In addition to the excellent performance of AC 222,705 against crop pests, this new pyrethroid insecticide is highly active against public health, household and livestock pests. It has outstanding activity against cattle ticks at low dosages.

Table 5

Some examples of pests effectively controlled by AC 222,705 on crops other than cotton

Crop	Pests Controlled
Alfalfa (*Medicago sativa*)	Pea aphid (*Acyrthosiphon pisum*)
Apple (*Malus sylvestris*)	Codling moth (*Laspeyresia pomonella*)
	European red mite (*Panonychus ulmi*)
	Fruit moth (*Carposina nipponensis*)
	Rosy apple aphid (*Dysaphis plantaginea*)
Beans (*Phaseolus* spp.)	Aphids (*Aphis* spp.)
	Bean fly (*Ophiomyia phaseoli*)
	Flea beetle (*Longitarsus manilensis*)
	Leafhoppers (*Empoasca* spp., *Nirvana philippinensis*)
	Leafworms (*Spodoptera* spp.)
	Mexican bean beetle (*Epilachna varivestis*)
	Pod borers (*Heliothis (Helicoverpa) armigera, Maruca testulalis*)
	Twospotted spider mite (*Tetranychus urticae*)

Table continues

Table 5 (continued)

Crop	Pests Controlled
Cabbage, cauliflower, etc. (*Brassica* spp.)	Aphids (*Hyadaphis erysimi, Lipaphis pseudobrassicae, Myzus persicae*)
	Cabbage loopers (*Plusia nigrisigna, Trichoplusia ni*)
	Cabbage moth (*Mamestra brassicae*)
	Cutworm (*Spodoptera litura*)
	Diamondback moth (*Plutella xylostella*)
	Imported cabbageworm (*Pieris rapae*)
	Soybean looper (*Pseudoplusia includens*)
Castor-oil plant (*Ricinus communis*)	Carmine spider mite (*Tetranychus cinnabarinus*)
	Leafhopper (*Empoasca lybica*)
	Onion thrips (*Thrips tabaci*)
Coffee (*Coffea arabica*)	Leafminer (*Perileucoptera coffeella*)
Grape (*Vitis vinifera*)	Berry moth (*Clysia ambiguella*)
	European red mite (*Panonychus ulmi*)
	Leaf folder (*Sparganothis* sp.)
	Twospotted spider mite (*Tetranychus urticae*)
Maize (*Zea mays*)	Corn earworm (*Heliothis zea*)
	Fall armyworm *Spodoptera frugiperda*)
	African stalkborer (*Busseola fusca*)
Peach (*Prunus persica*)	Green peach aphid (*Myzus persicae*)
Pear (*Pyrus communis*)	Pear psylla (*Psylla pyricola*)
Potato (*Solanum tuberosum*)	Colorado beetle (*Leptinotarsa decemlineata*)
Rice (*Oryza sativa*)	Green leafhoppers (*Nephotettix* spp.)
	Stemborers (*Chilo* spp.)
Roses (*Rosa* spp.)	Greenhouse whitefly (*Trialeurodes vaporariorum*)
	Twospotted spider mite (*Tetranychus urticae*)
Soybean (*Glycine max*)	Leafworms (*Spodoptera* spp.)
	Velvetbean caterpillar (*Anticarsia gemmatalis*)

Table continues

Table 5 (continued)

Crop	Pests Controlled
Sugar beet (*Beta vulgaris*)	Cabbage moth(*Mamestra brassicae*)
	Cutworms (*Agrotis* spp.)
Tobacco (*Nicotiana tabacum*)	Leaf beetle (*Epilachna philippinensis*)
	Budworm (*Heliothis armigera*)
	Tree cricket (*Oecanthus indicus*)
Tomato (*Lycopersicon esculentum*)	Fruitworm (*Heliothis armigera*)

CONCLUSIONS

Many highly promising results have been obtained with AC 222,705, a new photostable pyrethroid insecticide from American Cyanamid Company. The compound is in full-scale development. Its broad spectrum and high level of activity in association with its excellent residual efficacy, non-phytotoxicity and acaricidal action, plus the minimal negative effects of high temperatures on insecticidal activity indicate that AC 222,705 will have many agricultural uses.