UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 29 1982

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

Memorandum

SUBJECT: PP#1F2544/1H5323. Chlorpyrifos on corn forage and fodder. Evaluation of analytical method and residue data.

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Dow Chemical Company proposes tolerances for the residues of chlorpyrifos (which include the parent plus a metabolite, 3,5,6-trichloropyridinol (TCP)) on corn forage and fodder, both at 10 ppm. Also proposed are food additive tolerances for corn oil (3 ppm) and soapstock (1 ppm).

Several chlorpyrifos tolerances are established ranging from 0.01 ppm for eggs and poultry to 15 ppm for peanut hulls (40 CFR Section 180.342). Among established tolerances are those for field corn grain, corn forage and fodder, and fresh corn (includes sweet corn kernels plus cob), all at 0.1 (N) ppm. Many petitions are pending.

Conclusions

1. The nature of the residue is adequately understood. The residue of concern of chlorpyrifos plus TCP.

2. Adequate analytical methods are available for enforcement purposes.

3a. The proposed tolerances will not be exceeded as a result of the proposed use.

3b. The existing tolerances for fresh corn and field corn grain are adequate. However since the present petition proposes use on popcorn, the tolerance expression in the CFR for field corn grain should be revised to be expressed in terms of corn grain. This would include popcorn.

4a. Existing or pending tolerances for the meat, fat and meat byproducts of cattle, horses, hogs, sheep, and goats will accommodate any secondary residues added by the proposed use.

4b. Since no poultry feed items are involved in this forage and fodder proposal, there will be no problem of secondary residues in poultry tissues and eggs.

4c. The established poultry tissue and egg tolerances are adequate to cover any secondary residues resulting in these commodities from the feeding of treated grain.

5. An International Residue Limit Status sheet is attached. There are no CODEX proposals above step 6.

Recommendation

Toxicological considerations permitting, we recommend for the proposed tolerance. This recommendation is contingent upon establishment of pending tolerances for meat and milk (PP#OF2281).

P.M.: The tolerance expression for field corn grain in 40 CFR 180.342 should be changed to corn grian so that popcorn will be included.

DETAILED CONSIDERATIONS

Formulation

Lorsban 4E, which contains 4 lbs a.i./gallon, and Lorsban 15G, which is 15% a.i. by weight, are proposed for use. The inert ingredients of both formulations are cleared under Section 180.1001(c).

Technical chlorpyrifos has a minimum purity of 94%. The manufacturing process is described in our review of PP#4F1455 (memo of 5/3/74, A. Smith). The impurities consist of [redacted] The remainder of the nonvolatiles [redacted] consists of at least seven compounds. We do not expect the impurities in Lorsban to present a residue problem due to the high dilution on application.

Proposed Use

Lorsban 15G and Lorsban 4E are to be used for various pests infesting corn including corn rootworm larvae, cutworms, wireworms, symphylans, billbugs, lesser cornstalk borers, armyworms, grasshoppers, European corn borers, and Southwestern corn borers.

Lorsban 15G is to be applied preplant, at planting time, postplant at time of cultivation for soil insect control or postplant for foliar pest control. Apply 0.9 to 2.4 ounces of chlorpyrifos per 1000 linear feet of row (equivalent to 6 to 16 ounces of product per 1000 ft. of row or 3/4 to 2 lb of chlorpyrifos per acre based on a 40 inch row spacing) for preplant, at plant or cultivation time soil insect treatments. For postemergent foliar insects, the treatments are 0.9 to 1.2 ounces of chlorpyrifos per 1000 linear feet of row (equivalent to 6 to 8 ounces of product per 1000 feet of row or 3/4 to 1 lb of chlorpyrifos per acre based on a 40 inch row spacing) by ground application or 5.0 to 6.5 lb of product per acre (equivalent to 3/4 to 1 lb of chlorpyrifos per acre) by aerial application.

No more than one preplant, at plant or cultivation time treatment is to be made per season. No more than two broadcast foliar treatments are to be made per season. The maximum amount of chlorpyrifos from these treatments would be 4 lb/A.

Lorsban 4E is to be applied preplant as a broadcast spray to the soil surface in not less than 10 gallons of water per acre using ground spray equipment followed by incorporation into the soil. It is to be applied postemergent as a broadcast spray using either aerial or ground equipment. The rate is 1 to 2 lbs of chlorpyrifos per acre as a braodcast spray (equivalent to 2 to 4 pints of product per acre) and/or 0.25 to 1.5 lb of chlorpyrifos (equivalent to 1 1/2 to 3 pints product) per acre as a broadcast foliar spray. No more than 15 pints (7.5 lb a.i./A)of Lorsban 4E may be applied per season.

No application is to be made within 35 days before harvest of grain. Livestock are not allowed to graze in treated areas. Treated corn silage is not to be harvested as feed for meat and dairy animals within 14 days after last treatment. Treated corn fodder is not to be fed to meat and dairy animals within 35 days after last treatment.

Nature of the Residue

Plant

No metabolism studies were submitted with this petition.

The metabolism of radiolabeled chlorpyrifos (^{14}C and ^{36}Cl) has been studied in corn and bean plants (PP#3F1306). These studies show that chlorpyrifos is translocated only to a limited degree from soil or from treated leaves. Chlorpyrifos degrades in UV light in the presence of water by dechlorination to form diols and triols which can undergo ring cleavage. Under prolonged irradiation the products were apparently carbon dioxide, ammonium carbonate and sodium chloride.

Plant metabolism (as indicated by the corn and bean studies) is via hydrolysis to ethyl 3,5,6-trichloro-2-pyridylphosphate; 3,5,6-trichloro-2-pyridylphosphate; 3,5,6-trichloropyridinol (TCP); and material postulated to be a TCP conjugate. TCP can undergo dechlorination (as observed in UV degradation) to form diols and triols which can be conjugated or incorporated into natural plant constituents.

More recently apple and soybean metabolism studies have been submitted and reviewed (PP#0F2281, memo of 7/7/81, E. Leovey). In the apple metabolism study chlorpyrifos and TCP were observed as residues at levels of 36.3 and 5.1 - 5.6% respectively. Two metabolites were postulated to be mono-dechlorinated derivatives of chlorpyrifos from GC/MS data. The aqueous layers contained a metabolite designated B (4.9 to 5.4% of residue) which upon hydrolysis yielded TCP. The hydrolyzed insoluble material yielded metabolites C (5.2-5.7%), D (3.2 to 5.4%) and E(5.5 to 5.7%) which were not characterized due to a lack of sufficient material.

The remainder of the radioactivity was insoluble material (3.3-4.5%) and aqueous layer (1.4-1.5%). The material in the unidentified hydrolyzed fraction consisted of numerous radiolabelled compounds smeared throughout the HPLC fractions. From 90-95% of the radioactivity could be traced; the remainder was probably lost in sample handling.

The ^{14}C residue in soybeans was characterized as 17% incorporated into natural components of the oil; 2.5% chlorpyrifos; 11% TCP; 24% extracted into the aqueous layer and containing at least seven metabolites not hydrolyzable to TCP; 18% solubilized which individually constituted at most 3% of the total residue; 11% in the precipitate and deduced to be incorporated into protein and 8% remaining insoluble, according to our calculations. Unidentified metabolites were claimed to be compounds arising from the plant's natural constituents.

In conjunction with PP#s OF2281 and 9F2270 we deferred to Toxicology Branch as to the significance of apple metabolites B, C, D, and E and the undentified apple and soybean metabolites, particularly the water soluble metabolites. Toxicology Branch has recently concluded (Section 18 by the State of Ohio for Chlorpyrifos on soybeans, memo of 8/11/81, A. Mahfouz) that the unidentified metabolites that are water soluble are not of toxicological significance because water soluble metabolites of organophosphate insecticides are usually inactive degradation products. More recently (memo of 10/28/81, W. Dykstra) Toxicology Branch concluded that the organosoluble metabolites are not of concern. We therefore conclude that the nature of the residue in plants is adequately understood and consists of chlorpyrifos and TCP.

Animal Metabolism

Metabolism in animals has been described in our review of PP#3F1306 (memo of F.D.R. Gee, 3/1/73). In rats, ^{14}C and ^{36}Cl; chlorpyrifos and ^{14}C-TCP were extensively eliminated in the urine and feces. Only 1.1-2.5% of the dose remained in tissues with residues highest in the liver, kidney, stomach and blood. Five ppm chlorpyrifos was fed to a lactating cow for four days. The urinary metabolites were identified as diethylthiophosphate and diethyl phosphate which were 35.9 and 26.8% of the insecticide fed. No chlorpyrifos was found in milk or urine. Approximately 1.7% of the chlorpyrifos fed was found in the feces. Samples were not analyzed for TCP.

Chlorpyrifos was concluded as a result of PP#3F1306 to be metabolized in animals by oxidation and hydrolysis to phosphoric acid-type compounds and TCP which may be further broken down to CO_2. However, as a result of further information discussed in our review of PP#9F2270 we concluded that the animal metabolism of chlorpyrifos was not adequately delineated and the fate of chlorpyrifos in a lactating goat needed characterization. In conjunction with PP#OF2281 (memo of 7/7/81, E. Leovey) a goat metabolism study was submitted. Two lactating goats were orally dosed with 2, 6, ring labeled ^{14}C chlorpyrifos twice a day for 10 days. Feeding levels were 15 and 19 ppm for the goats. Urine and milk were collected during feeding and tissues analyzed at the conclusion of the experiment.

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Radioactive residues in tissues ranged from 0.01 ppm (bone) to 0.8 ppm (rumen). Residues in milk and muscle were 0.03 ppm; this was considered too low for further analysis. Residues at the 19 ppm feeding level were: fat, 0.10 ppm; liver, 0.22 ppm; and kidney, 0.29 ppm. These residues were considered sufficient for residue characterization and were comparable to the blood levels. Distribution of the dose in urine, feces, gut, tissues and milk was 75.5 and 85.1%, 3.5 and 3.7%, 1.2 and 0.6%, 0.7 and 0.3% and 0.14 and 0.05% at the two feeding levels, 15 and 19 ppm, respectively, for a total of 81 and 90.2%.

Urine was acidified and extracted with ether. Metabolites were partitioned into sodium bicarbonate. After acidification, residues were extracted into ether, concentrated, and analyzed by HPLC. TCP constituted at most 15.3% of the urine metabolites. A beta-glucuronide conjugate of TCP was the major urine metabolite, 80-91%. A minor metabolite was tentatively identified as S-ethyl, O-(3,5,6-trichloro-2-pyridyl) phosphorothioic acid. The results shown in the report were for a urine sample collected approximately six days into the diet. Other samples were reported to be similar (W.R. Bauriedil, Dow Chemical, April 27, 1981).

Fat was dissolved in hexane and the ^{14}C-labeled residues reportedly extracted into acetonitrile. After concentration the residue was cleaned up again with a hexaneacetonitrile partition. Solids remaining after hexane dissolution were hydrolyzed. Residues were extracted into ether after acidification and clean-up by hexane acetonitrile partition. Chlorpyrifos was the major component (confirmed by GC/MS). It constituted more than 95% of the residue as determined by HPLC, and the remainder was TCP or material, particularly in the solids, which could by hydrolyzed to TCP.

We conclude that the nature of the residue in animals is adequately understood. The residue of concern consists of the parent plus TCP.

Analytical Methods

The residue data in this petition were obtained by the PAM II methods described below. Chlorpyrifos and TCP are determined separately.

Chlorpyrifos

The plant sample is extracted with acetone. An aliquot of the acetone is evaporated to near dryness. The residue is transferred to a 5% sodium sulfate solution; the chlorpyrifos is then extracted into hexane. The sample is cleaned up by hexane-acetonitrile partitioning and column chromatography on silica gel. The chlorpyrifos is determined by GLC incorporating a flame photometric detector.

TCP

The plant sample is treated with methanol and NaOH at 130°. An aliquot of the methanol is evaporated to near dryness; the residue is taken up in water. Concentrated HCl and salt are added; the freed TCP is extracted into benzene. The benzene extract is chromatographed on acidic alumina using a diethyl ether/pH 6.5 buffer mix for elution. The ether eluate is partitioned with sodium bicarbonate. The bicarbonate solution is acidified and the TCP is extracted into benzene. An aliquot of the benzene solution is silylated with N,O-bis-(trimethylsilyl)acetamide (BSA). The pyridinol trimethylsilyl derivative is then determined by GLC using electron capture detection.

As the method determines total TCP the chlorpyrifos must be determined by an independent method; the TCP is then calculated by difference.

The following check and recovery values are submitted.

CHLORPYRIFOS	CHECK (ppm)	RECOVERY FORT. (ppm)	RANGE (%)	AVG. (%)
green forage	0.5 - 0.14	0.5 - 50	72 - 114	89
fodder	0.5 - 0.72	0.5 - 10	80 - 110	91
grain	0.01 - 0.02	0.01 - 1.0	70 - 98	92
soapstock	0.00	1.0 - 4.0	71 - 90	83
refined oil	0.00	1.0 - 5.0	64 - 67	65
3,5,6-TRICHLOROPYRIDINOL (TCP)				
green forage	0.5 - 0.14	0.5 - 2.0	75 - 109	89
fodder	0.5 - 0.86	0.5 - 5.0	78 - 102	88
grain	<0.05	0.05 - 1.0	76 - 106	89
soapstock	0.01	0.1 - 4.0	73 - 100	83
refine oil	0.01	0.05 - 4.5	62 - 78	69

The validated methods sensitivity for chlorpyrifos is about 1 ppm for forage and fodder and 0.05 ppm for grain. For TCP the validated sensitivities are about 1 ppm for forage and fodder, and 0.05 ppm for grain, oil and soapstock. Methodology for chlorpyrifos in oil and soapstock has not been validated below 1 ppm but we have no reason to believe that adequate recoveries could not be obtained at a level of 0.1 ppm. We conclude that adequate analytical methods are available for enforcement purposes.

Residue Data

Residue data were carried out in Illinois, Michigan, Mississippi and Nebraska. Ground applications of 5 or 6 treatments were made in Illinois, Michigan and Mississippi. In Nebraska a plot was treated once by ground followed by four aerial applications.

A summary of these experiments is presented in the following table. The figures given are not complete but represent the highest residues found at a PHI closest to that proposed (35 days).

STATE	PLANT PART	APPLICATION RATE (lb a.i./A)[d] No. of applications 15G	4E	PHI(days)	RESIDUE (ppm) CHLORPYRIFOS	TCP	TOTAL
Illinois	green forage	1.1 X 3	1.5 X 2	13	3.1	1.1	4.2
	green forage	1.1 X 3	1.5 X 5	20	2.2	ND	2.2
	green forage	1.1 X 1	1.5 X 5	20	3.9	5.4	9.3
	fodder	1.1 X 3	1.5 X 2	34	6.3	2.1	8.6
	fodder	1.1 X 1	1.5 X 2	34	2.3	2.1	4.4
	grain	1.1 X 3	1.5 X 2	34	0.02	<0.05	0.07
	grain	1.1 X 1	1.5 X 5	34	ND[a]	ND[a]	ND[a]
Michigan	green forage	1.3 X 3	1.5 X 2	11	3.4	0.6	4.0
	green forage	1.3 X 3	1.5 X 2	18	2.4	2.0	4.4
	green forage	1.3 X 1	1.5 X 5	18	1.7	1.9	3.6
	fodder	1.3 X 3	1.5 X 2	32	3.4	0.9	4.3
	fodder	1.3 X 1	1.5 X 5	32	1.6	3.3	4.9
	grain	1.3 X 3	1.5 X 2	32	<.01	ND[a]	<.01
	grain	1.3 X 1	1.5 X 5	32	ND[a]	ND[a]	ND[a]
Mississippi	green forage	1.0 X 3	1.5 X 2	17	7.8	1.4	3.2
	green forage	1.0 X 1	1.5 X 5	17	4.0	1.6	3.6
	green forage	1.0 X 1	1.5 X 5	11	1.9	3.5	5.4
	fodder	1.0 X 3	1.5 X 2	31	1.9	0.9	2.8
	fodder	1.0 X 1	1.5 X 5	31	2.2	0.7	2.9
	grain	1.0 X 3	1.5 X 2	31	0.02	<0.05	0.07
	grain	1.0 X 1	1.5 X 5	31	0.02	ND[a]	0.02
Nebraska	green forage	1.0[c]+1.3X2[b]	1.5 X 2[b]	0	10.9	ND[a]	10.9
	fodder	1.0[c]+1.3X2[b]	1.5 X 2[b]	35	7.7	ND[a]	7.7
	grain	1.0[c]+1.3X2[b]	1.5 X 2[b]	35	<0.01	ND[a]	<0.01

A. ND=less than twice the average for controls

B. Aerial applications

C. At plant application

D. The proposed use calls for application of up to 4 lb a.i./A/season as Lorsban 15G or up to 7.5 lb a.i./A/season as Lorsban 15E; the PHI is 35 days.

The data are representative or slightly exaggerative of the proposed use and support the proposed tolerances. Also, they indicate that the established tolerance for corn grain (0.1 ppm (N)) and fresh corn will not be exceeded by the proposed use.

We conclude that the proposed tolerance of 10 ppm for corn forage and fodder is adequate.

Also submitted with this petition is a corn processing study. Since the treated field corn grown for this experiment did not carry sufficient residues (<0.1 ppm) for a processing study corn was fortified in the lab to a theoretical level of 0.17 ppm. When analyzed the grain showed chlorpyrifos levels of 0.15 ppm at day 0 and 0.19 ppm ten days later (these figures are the average of 3 analyses). After processing (by extraction) and removal of soapstock the oil was found to carry residues of up to 5.63 ppm, a concentration of 30X. The soapstock carried residues of up to 1.92 ppm a 10X concentration. The solvent extracted corn showed a decrease in residues to about 0.08 ppm.

Based on the above study we conclude that the proposed tolerances for corn oil and soapstock are adequate.

Meat and Milk

A tolerance of 2.0 ppm for the meat, fat, and meat byproducts of cattle is pending (PP#OF2281; this tolerance includes residues realized as a result of a dip treatment). Since the tolerance proposed here for corn forage and fodder is less than that proposed for other feed items (alfalfa hay, 15 ppm, pending; citrus pulp, 15 ppm; soybean straw, 15 ppm, pending; peanut hulls, 15 ppm; dry tomato pomace, 35 ppm, pending) the ingestion of treated corn will not increase the dietary burden of chlorpyrifos to cattle. We therefore conclude that the pending 2.0 ppm tolerance is adequate.

By similar reasoning we conclude that the pending tolerancce for milkfat (0.50 ppm reflecting no more than 0.02 ppm in whole milk) is adequate.

For the meat, fat, and meat byproducts of goats, horses, and sheep tolerances of 1.0 ppm are pending. Based on cattle feeding studies most recently discussed in our review of the 9/10/81 amendment to PP#OF2881 (see memo of 11/6/81, K. Arne) we do not anticipate that the proposed tolerances would be exceeded should corn forage and fodder be used as feed for these animals.

Ensiled corn ears (with husks) can constitute 80% of a hogs diet. A diet for hogs with a maximum potential for chlorpyrifos residues would be 50% alfalfa hay (tolerance - 15 ppm) and 50% ensiled corn. This diet would add 12.5 ppm chlorpyrifos to the diet. Hog feeding studies at 10 ppm (most recently discussed in our review of the 9/10/81 amendment to PP#OF2281 (see memo of 11/6/81, K. Arne) showed residues of up to 0.33 ppm (liver). We therefore conclude that the pending tolerance of 0.5 ppm for the meat, fat, and meat byproducts of hogs is adequate.

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A favorable recommendation regarding the proposed corn forage and fodder tolerance is contingent on the establishment of pending meat and milk tolerances.

Poultry and Eggs

Since no poultry feed items are involved in the forage and fodder proposal, there will be no problem of secondary residues in poultry tissue and eggs.

The established poultry tissue and egg tolerances are adequate to cover any secondary residues in these commodities resulting from the feeding of treated grain.

Other Considerations

Since the present petition proposes use on popcorn and since registered uses for chlorpyrifos on popcorn exist the grain tolerance should be expressed as corn grain (which includes popcorn) rather than field corn grain (which does not include popcorn).

TS-769:RCB:K. Arne:gs:C1#2:RM810:X77324:1/22/82
cc: RF, Circ., Arne, Watts, FDA, TOX, EEB, EFB, PP#1F2544
RDI: Quick, 12/30/81: Schmitt: 12/30/81

INTERNATIONAL RESIDUE LIMIT STATUS

CHEMICAL Chlorpyrifos

PETITION NO. 1F2544

CCPR NO. 17

Codex Status

[ ] No Codex Proposal Step 6 or above

Proposed U.S. Tolerances

Residue (if Step 9):

Residue: Parent plus TCP

Crop(s)	Limit (mg/kg)
None (on this commodity)	

Crop(s)	Tol. (ppm)
Corn forage & fodder	10

CANADIAN LIMIT

Residue: Parent presumed

Crop	Limit (ppm)
Corn	0.1*

MEXICAN TOLERANCIA

Residue:

Crop	Tolerancia (ppm)
Corn	0.1**

* Negligible residue type limit; no knowledge of forage/fodder tolerance
** No knowledge of tolerance on fodder/forage.

Notes: