RISK ASSESSMENT OF FENOXAPROP-ETHYL

(ACCLAIM®)

VOLUME Ia
RISK CHARACTERIZATION DOCUMENT

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Medical Toxicology Branch

Department of Pesticide Regulation

California Environmental Protection Agency

EXECUTIVE SUMMARY

Introduction

Fenoxaprop-ethyl is a herbicide which is selective against perennial and annual grass weeds in many crops. It is a member of the aryloxy phenoxy-propionate class of herbicides, and its mechanism of action is to inhibit fatty acid biosynthesis, in both plant chloroplasts and mammalian liver. The formulation Acclaim® 1EC, is a 12.5% emulsifiable concentrate, containing 1 lb/gallon, for which registration is currently being requested in California for use on turfgrass, ornamentals and rights of way. A formulation of fenoxaprop-ethyl, Whip,® has been registered for use on rice in California since 1994. The high potential toxicity of fenoxaprop-ethyl, which was shown in developmental toxicity studies in the rat and monkey, along with possible liver toxicity in longer term studies, was the reason for it entering the risk assessment process. This document addresses the risk from occupational and recreational exposure to fenoxaprop-ethyl (Acclaim® 1EC) from use on turfgrass. Combined exposures were also calculated for the additional, hypothetical dietary exposure from use on rice.

The Risk Assessment Process

The risk assessment process consists of four aspects: hazard identification, dose response assessment, exposure assessment, and risk characterization.

Toxicology

Based on the currently available data, the Department of Pesticide Regulation has concluded that the principal toxicological effects of fenoxaprop-ethyl probably result from hepatotoxicity. The inhibition of fatty acid biosynthesis, in the liver, may account for the majority of the effects observed. However, increases in liver weight, seen in acute and sub-chronic studies, and decreases in liver weight, which are seen in chronic studies, alone, do not necessarily reflect an adverse effect. This is because liver weight changes have often been found to be reversible, in subchronic studies following the discontinuation of dosing, or through adaptation mechanisms, with the continued dietary intake of fenoxaprop-ethyl, in chronic studies. Developmental toxicity studies showed an increased level of fetal anomalies in the rat and rabbit, as well as maternal mortality of the Cynomolgus monkey. There was no evidence of oncogenicity in the rat, mouse or dog and genotoxicity studies were negative. Additionally, specific effects on (rat) reproduction were not observed.

Exposure Analysis

Estimates of occupational exposure were made using PHED (Pesticide Handlers' Exposure Database) for the golf course operator, the sod farm manager and the landscape PCO and from surrogate studies, using 2,4-D for mowing and chlorpyrifos for recreational activities on treated turfgrass. The greatest potential exposure is likely for landscape PCOs using hand-held sprayboom equipment. Occupational exposure on golf courses and sod farms is anticipated to be lower, as also are exposure to mowers and recreational users of treated turfgrass. The season of application of Acclaim® is approximately three months and it is expected that the maximum number of workdays during this period would be 28.

Conclusions

A margin of safety (MOS) of at least 100 is generally recognized as protective of human health when the NOEL is based on toxicology data from animal studies. MOS values were calculated using currently available acute exposure and toxicity data. Mean, short-term worker-exposure data and developmental abnormalities in the rat fetus and mortality in the pregnant monkey, resulted in MOS values above 100 for all occupational categories. For seasonal exposure, mixer-loader-applicators on golf courses, sod farms and landscape had MOS values, based on liver toxicity in a sub-chronic study, which were above 100. Combined occupational and hypothetical dietary exposure, from the consumption of rice which had been treated with fenoxaprop-ethyl, also resulted in MOS values above 100.

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I SUMMARY

Fenoxaprop-ethyl is a herbicide which is selective against perennial and annual grass weeds in many crops. It is a member of the aryloxy phenoxy-propionate class of herbicides, and its mechanism of action is to interfere with fatty acid biosynthesis; specifically to inhibit acetyl CoA carboxylase. This enzyme is found both in plant chloroplasts and mammalian liver.

The formulation Acclaim® 1EC, is a 12.5% emulsifiable concentrate of fenoxaprop-ethyl. Registration was requested for this product in California for use as a turfgrass herbicide. A formulation of fenoxaprop-ethyl (Whip®) has been registered for use on rice in California since 1994.

The parent compound, fenoxaprop-ethyl, is inactive but it rapidly breaks down in the environment to the free acid, fenoxaprop, which is biologically active. This undergoes further degradation to other species containing the 6-chlorobenzoxazol-2-one moiety. Environmental chemistry studies conducted with fenoxaprop-ethyl indicate that it should degrade rapidly in the environment and show little, if any, tendency to accumulate or leach into groundwater.

A human health risk assessment has been conducted for fenoxaprop-ethyl because of low NOEL values for effects reported in animal studies. The risk assessment specifically addressed the potential exposure of workers performing the mixing, loading and application of fenoxaprop-ethyl to turfgrass. The toxicology endpoints used in the assessment were fetal anomalies (rat) and maternal mortality (teratology study using Cynomolgus monkeys) for acute occupational exposure; liver toxicity (increased liver weight and abnormal liver histopathology in a sub-chronic mouse study) for seasonal occupational exposure.

Several (9) developmental toxicity studies have been conducted using fenoxaprop-ethyl involving 4 species: rat, rabbit, mouse and monkey. In only one (rat) study did the NOEL for developmental toxicity (10 mg/kg/day) fall below that for maternal toxicity (32 mg/kg/day). However, in another study, with the Cynomolgus monkey, the developmental NOEL ($\geq$50 mg/kg/day) was greater than the maternal NOEL (10 mg/kg/day) and in the other 7 studies, these NOEL values were equivalent. The endpoints for developmental toxicity were increased fetal anomalies (skeletal and visceral); for maternal toxicity, mortality. The NOEL for maternal and developmental toxicity was, therefore, 10 mg/kg/day.

Subchronic toxicity was measured in four dietary, one dermal and one inhalation studies, using either rat, mouse or dog. The duration of each study was 21-days to 3-months. Signs of possible liver and/or kidney toxicity were consistently observed, the lowest NOEL being 1.9 mg/kg/day for liver toxicity in a 30-day mouse study. In this report, liver toxicity included increased absolute and relative liver weight with abnormal histopathology. Reversibility of hepatic effects, which was noted (in four of these studies) whenever dosing was discontinued for 4 weeks, was not reported in this 30-day mouse study.

Chronic toxicity from repeated exposure to fenoxaprop-ethyl was identified in a 2-year dog study. A fall in body weight gain without a change in food consumption was reported, with a NOEL of 0.9 mg/kg/day. In addition, the liver weight was increased at all dose levels, including the lowest of 0.18 mg/kg/day, at which 16% and 22% increases were reported in absolute and relative weights, respectively. There was not a significant reduction in body weight or body weight gain at this dosage. Because an increase in liver weight alone is not considered to be an adverse effect, a NOEL 0.9

mg/kg/day was considered appropriate for this study.

There was no evidence of oncogenicity in studies conducted with the rat, mouse or dog and fenoxaprop-ethyl was not genotoxic in any of the standard battery of *in vitro* and *in vivo* tests. Reproductive toxicity was measured in two multi-generation studies in rats. In both studies, a NOEL for developmental and maternal effects was established at a dietary concentration of 30 ppm, equivalent to 1.7 mg/kg/day, based on increased liver and kidney weights, nephrocalcinosis and decreased thymus weight at 180 ppm.

The NOEL of 10 mg/kg/day, from the rat and Cynomolgus monkey developmental toxicity studies, was used to determine margins of safety for potential acute occupational exposure. The value of 1.9 mg/kg/day was used to calculate the margins of safety from seasonal occupational exposure.

Occupational exposure was estimated using surrogate data: for the M/L/A on golf courses, sod farms and landscape, PHED was used; for mowing, a 2,4-D turfgrass study was used; for recreational activities on treated turfgrass, a chlorpyrifos study was used. The mean Absorbed Daily Dosages (ADDs), estimated using PHED, at the maximum label rate, ranged from 5.72 to 56.4 μg/kg/day. For mowers, the mean ADD value was insignificant. For recreational turfgrass users, the anticipated ADD was 3.94 μg/kg/day. The Seasonal Average Daily Dosage (SADD), for M/L/As, ranged from 0.12 to 18.4 μg/kg/day.

For combined occupational and acute dietary exposure, assuming the highest theoretical dietary exposure to fenoxaprop-ethyl (Whip®) in rice for workers (0.051 μg/kg/day), the estimated level of exposure for M/L/As would result in <0.2% to 2.6% additional exposure above the calculated occupational ADD values. For combined seasonal exposure, using chronic dietary intake (0.002 μg/kg/day), the total anticipated exposure would be <0.1% higher than for occupational exposure, alone. The only exception would be the least exposed worker (golf course manager) applying the lowest label rate, where the combined (theoretical) dietary and occupational exposure combined would be 4.6% greater than the occupational exposure alone.

The MOS values for potential acute, occupational exposure, based on mean ADD values at the maximum label application rate, were 177, 266 and 1750 for landscaping PCOs, sod farm managers and golf course managers. The mean MOS value for individuals engaged in recreational activities on treated turfgrass was 2,540. The range of MOS values for M/L/As based on mean estimated seasonal exposures, at the maximum label application rate, were from 103 (landscaping PCO) to 15,800 (golf course manager).

The equivalent MOS values for combined exposure *i.e.* occupational plus dietary, were 177, 265 and 1,730 for landscaping PCOs, sod farm managers and golf course managers. The mean MOS value for individuals engaged in recreational activities on treated turfgrass, combined with chronic dietary exposure, was 2,510. The range of MOS values for M/L/As based on mean estimated seasonal exposures, at the maximum label application rate, combined with chronic dietary exposure, as above, were not significantly different from MOS values for occupational exposure alone.

A margin of safety of at least 100 is generally considered to be protective of human health when the toxicology endpoints are derived from animal studies. Based on toxicology studies indicating fetal anomalies, maternal mortality and liver toxicity, MOS values have been derived for potential occupational exposure. For the application of Acclaim® to turfgrass, MOS values were above 100 for acute (short-term) worker exposure. For recreational activities in treated turfgrass and worker re-entry for mowing, MOS values were also over 100. For seasonal occupational exposure, based on maximum loads and applications per season, MOS values for mean seasonal exposure were above 100 for M/L/As applying Acclaim® to turfgrass.

II INTRODUCTION

A. CHEMICAL IDENTIFICATION

Fenoxaprop-ethyl is a selective post-emergence herbicide which is used against a range of perennial and annual grass weeds in a variety of crops. It is a member of the aryloxy phenoxy-propionate class of herbicides *e.g.* diclofop-methyl, haloxyfop-methyl, fluazifop-butyl. The latter is the only other member of this class registered in California (since July, 1994), for weed control in a range of vegetable, fruit, nut and non-crop situations.

It has long been recognized that members of this class interfered with normal lipid metabolism in sensitive plant and animal species. The effects of fenoxaprop-ethyl, plus the 3 herbicides mentioned above, were studied using enzymes in isolated, intact chloroplasts (Kobek *et al.*, 1988) from sensitive grasses *(Poaceae)* and tolerant plants *(Pisum; Spinacia)*. All 4 compounds, as the free acid form, inhibited the *de novo* biosynthesis of fatty acids. The I_{50} values (for 50% inhibition of [^{14}C]-acetate incorporation into fatty acids) were in the range 10^{-7} to 2.10^{-6}M. The parent esters either did not inhibit or did so only at very high concentrations ($\sim 10^{-4}$M). Chloroplasts from herbicide-tolerant (dicotyledonous) species were insensitive. It was shown that the target for all 4 compounds was acetyl-CoA-carboxylase, the rate-limiting enzyme in fatty acid biosynthesis. This enzyme is also found in mammals, principally in liver, but also in adipose tissue.

B. REGULATORY HISTORY

The herbicidal properties of fenoxaprop were first described in 1982 (Bieringer *et al.*, 1982). The ethyl ester, fenoxaprop-ethyl, was introduced by Hoechst AG as code number HOE 33171 and registered by U.S. EPA in 1987 (U.S. EPA, 1988). A Section 3 registration on rice in California was issued in 1994, after a risk assessment was conducted. The present registration is for use against grass weeds in ornamentals, sod farms, landscape and rights of way, under the name Acclaim® 1EC.

C. TECHNICAL AND PRODUCT FORMULATIONS

Fenoxaprop-ethyl is sold as an emulsifiable concentrate (EC). Acclaim® 1EC contains 1 pound of active ingredient per gallon *i.e.* 12.5% fenoxaprop-ethyl, 87.5% inerts.

D. USAGE

In the USA, fenoxaprop-ethyl is a selective post-emergence herbicide used against annual and perennial grass weeds in cotton, peanuts, rice, soybeans (Whip®), rights of way, [24(c) for] turfgrass seed production (Horizon®), spring and winter wheat (Tiller®) and ornamentals and turf (Acclaim®). Outside the USA, fenoxaprop-ethyl is also registered for grass control on beets, beans and potatoes.

E. ILLNESS REPORTS

No worker illness data from actual work-related activities in California are available. The incidence of worker illnesses from the use of fenoxaprop-ethyl in other states is not known.

F. PHYSICAL AND CHEMICAL PROPERTIES

The physical and chemical properties of fenoxaprop-ethyl are described in *Risk Assessment of Fenoxaprop-ethyl (WHIP®) Volume I, Risk Characterization Document* (Gammon *et al.*, 1994). This was prepared in response to the registration application for the use of fenoxaprop-ethyl on rice.

G. ENVIRONMENTAL FATE

Field and laboratory studies describing the photolysis, soil metabolism and leaching potential have been reviewed in two installments. The first (Papathakis, 1993) was summarized in the initial risk characterization document for fenoxaprop-ethyl, Whip® (Gammon *et al.*, 1994). Since the completion of the RCD for Whip,® further studies have been accepted by DPR (Papathakis, 1994) and are summarised, as follows:

Leaching potential

Partitioning of a pesticide between soil and water gives some indication of its potential to leach through soil into groundwater. The determination of the adsorption and desorption dissociation constants, adjusted for percentage organic carbon in the soil, are referred to as the K_{oc} constants. The parent, fenoxaprop-ethyl has been shown to be immobile in 4 types of soil: clay, silty clay loam, sandy loam and clay loam; K_{oc} values for adsorption were >5,000. Because of the rapid degradation of fenoxaprop-ethyl in soil to the free acid, K_{oc} values were also determined for the acid. These ranged from 193 (medium mobility) in clay loam to 1,245 (low mobility) in silty clay loam. The soil mobility of total ^{14}C from fenoxaprop-ethyl *i.e.* parent plus all soil degradates, was similar to the free acid, the K_{oc} ranging from 223 (moderate mobility) in clay loam to 1,767 (low mobility) in clay.

Field Dissipation

The registrant has not submitted a dissipation study for turfgrass. However, two terrestrial dissipation studies, on soybeans in Iowa and peanuts in North Carolina, indicate that fenoxaprop-ethyl is rapidly converted to the free acid ($t_{1/2} < 1$ h). Furthermore, the total combined residue of parent, free acid plus benzoxazolone degrades at a moderate rate in soil, with a $t_{1/2} = 14.3$ days (IA) and 9.4 days (NC).

III TOXICOLOGY PROFILE

The full toxicology profile of fenoxaprop-ethyl, including pharmacokinetics, is described in *Risk Assessment of Fenoxaprop-ethyl (WHIP®) Volume I, Risk Characterization Document* (Gammon *et al.*, 1994). This was prepared in response to the registration application for the use of fenoxaprop-ethyl on rice.

IV RISK ASSESSMENT

A. HAZARD IDENTIFICATION

Potential adverse effects, primarily reflecting hepatotoxicity, have been identified in acute, subchronic and chronic studies, using various animal species. In acute and sub-chronic studies, hepatomegaly was consistently observed, usually without an effect on body weight. Hepatomegaly following subchronic administration invariably reversed, whenever treatment was discontinued. However, effects on liver biochemistry and histology were sometimes also reported. There were no remarkable effects on liver enzymes which are commonly induced by xenobiotics but alkaline phosphatase increased significantly in subchronic studies in rat, mouse and dog. No studies were completed which investigated the effects of fenoxaprop-ethyl on enzymes involved in lipid metabolism. Inhibitors of acetyl CoA carboxylase, the target enzyme of fenoxaprop, have the capacity, in mammals, to alter blood lipid levels. In the male rat, a reduction ($p < 0.05$) in blood cholesterol and total lipids in a chronic study (Kramer *et al.*, 1985a) may be a reflection of inhibition of this enzyme. However, in the female mouse, there was an increase in blood cholesterol at the HDT, in a subchronic study (Leist *et al.*, 1981). Male mice in this study showed an increase in total lipids at the two highest doses. It is therefore possible that many of the effects reported in acute, subchronic and chronic studies are manifestations of a compromise of normal liver function. Atrophy of the splenic capsule and thymus in the dog (Brunk *et al.*, 1980) and of the thymus in the rat (Tesh *et al.*, 1985) could reflect toxicity to the immune system. However, there are insufficient data available from these studies to evaluate the immunocompetence of the animals.

Acute Toxicity

Toxic effects following short-term exposure were identified mainly in developmental toxicity studies. Nine such studies were submitted, using four different animal species. In general, the NOEL values for developmental and maternal toxicity were similar, indicating a lack of a specific developmental effect. In one study, however, (James *et al.*, 1983) fetal effects were observed at lower dosages than were maternal effects. These took the form of increased frequencies of skeletal and visceral anomalies, with a LOEL of 32 mg/kg/day and a NOEL of 10 mg/kg/day. The NOEL for maternal toxicity was ≥100 mg/kg/day, the HDT. This NOEL was based on the lack of significant toxicological effects at this dosage.

In a developmental toxicity study using the Cynomolgus monkey, a developmental NOEL of ≥50 mg/kg/day was determined, along with a maternal NOEL of 10 mg/kg/day (Osterburg, 1984). A high rate of abortions was reported, at both doses, and 45% maternal mortality at 50 mg/kg/day (0% at 10 mg/kg/day). There was no concurrent control, but the rates of abortions, although high, were within the range of historical controls. Because the first mortality was observed after only eight doses, this can be considered an acute, treatment-related effect with a maternal LOEL of 50 mg/kg/day and a NOEL of 10 mg/kg/day. In addition, U.S. EPA considered the rabbit NOEL also to be 10 mg/kg/day (Baeder *et al.*, 1983), based on fetal mortality at 50 mg/kg/day. However, in reviewing this study, together with Baeder *et al.*, 1982b, a NOEL of 50 mg/kg/day was determined for maternal and developmental toxicity in the rabbit, on the basis of significantly increased abortions and fetal anomalies/growth retardation occurring only at 200 mg/kg/day, the HDT.

The NOEL of 10 mg/kg/day, based on increased rat fetal anomalies and mortality in pregnant Cynomolgus monkeys was, therefore, used to calculate margins of safety for acute short-term occupational exposures to fenoxaprop-ethyl.

Subchronic

Subchronic toxicity by dietary exposure to fenoxaprop-ethyl was expressed in a 30-day mouse study as liver toxicity *i.e.* increased absolute and relative weight with abnormal histopathology, with a LOEL of 3.5 mg/kg/day and a NOEL of 1.9 mg/kg/day in females (Leist *et al.*, 1981). This NOEL was used in the calculation of MOS values for seasonal worker exposure as well as combined worker and dietary exposure.

The season of use for Acclaim® is closer to 3 months, and a 3-month sub-chronic dietary study in the beagle dog is available (Brunk *et al.*, 1981) with a lower NOEL of 1.0 mg/kg/day (F) and 1.2 mg/kg/day (M). However, a NOEL from this study has not been used for risk assessment, for the following reason. Although chronic interstitial pyelonephritis was reported in both sexes, it was not reported in two chronic studies in beagle dogs in either sex, dosed for 1-year (Brunk *et al.*, 1984) or 2-years (Brunk & Kramer, 1985), even at doses up to 5.0 mg/kg/day. Therefore, pyelonephritis in the sub-chronic studies must be considered of doubtful toxicological significance.

Chronic Toxicity

Because of the strictly seasonal use of Acclaim® on turfgrass and because of the recovery from and/or adaptation to the toxic effects observed in sub-chronic and chronic animal feeding studies with fenoxaprop-ethyl, the chronic toxicity of fenoxaprop-ethyl has not been addressed in this RCD.

Oncogenicity

There was no evidence of oncogenicity in chronic studies in rat, mouse and dog (Kramer *et al.*, 1984; Kramer *et al.*, 1985 a,b; Brunk & Kramer, 1985).

B. EXPOSURE ASSESSMENT

Occupational Exposure

An Absorbed daily dosage (ADD) and a seasonal average daily dosage (SADD) were estimated for ground application of Acclaim® to turf using U.S. EPA's computer database, PHED (Pesticide Handlers' Exposure Database). The absorbed daily dosage for individuals conducting recreational activities on treated grass lawns was also calculated, using a surrogate study with Lorsban.® To estimate re-entry exposure, the dislodgeable foliar residue (DFR) was calculated during mowing treated grass from a study using 2,4-D (Volume IIa). Acclaim® is likely to be used on a seasonal basis (3 months) in California, from May to July (Volume IIa). Because of this seasonality, the reversal of sub-chronic toxicity following a recovery period (Section IV-A), and the lack of oncogenicity in the long-term studies, calculations of annual (AADD) and lifetime (LADD) worker exposure were considered inappropriate.

Mixer/Loader/Applicator

The exposure of a mixer-loader-applicator involved in application, at the maximum label rate, of Acclaim® on golf courses, sod farms and landscape resulted in estimated mean Absorbed Daily Dosages (ADDs) of fenoxaprop-ethyl of 5.72, 37.6 and 56.4 μg/kg/day, respectively. Corresponding Seasonal Average Daily Dosages (SADDs), at the maximum label rate, were 0.12, 2.04 and 18.4 μg/kg/day, respectively (Table 1). It was concluded that the DFR, after application of Acclaim® at the maximum label rate, would be insignificant (~0.27 g/1000 ft^2). Therefore, exposure during mowing was not estimated.

Recreational

The exposure of a recreational user of turfgrass, treated at the maximum label rate for crabgrass (0.008 lb. a.i./1000 $ft.^2$), resulted in an estimated mean ADD of 3.94 μg/kg/day and SADD of 1.20 μg/kg/day (Table 1).

Table 1. Occupational or recreational exposure estimates to fenoxaprop-ethyl from the use of Acclaim® 1EC on turfgrass.[a]

TYPE OF EXPOSURE	ADD[b] μg/kg/day	SADD[c,d] μg/kg/day
Mixer-Loader-Applicator		
Golf course	1.94 - 5.72	0.042 - 0.12
Sod farm manager	8.23 - 37.6	0.45 - 2.04
Landscaping PCO	19.3 - 56.4	6.29 - 18.4
Recreational[e]	3.94	1.20[f]

a/ see Volume IIa for calculations of worker exposure, using PHED.

b/ ADD = Absorbed Daily Dosage (mean) following Acclaim® use at a range of label application rates.

c/ SADD = Seasonal Average Daily Dosage following Acclaim® use at a range of label application rates.

d/ Application days/season = 2 (golf course); 5 (sod farm manager); 30 PCO (landscaping)/92 day season.

e/ Estimated from a Lorsban® (chlorpyrifos) exposure study on lawns (Volume IIa).

f/ Based on 28 days of exposure per season (92 days).

Combined occupational/recreational and dietary exposure

Acute

The combined ADD values were obtained by summing the values for occupational/recreational exposure (Table 1) with the theoretical residues estimated for acute dietary exposure. The latter was determined for males 13-19 yrs. old, consuming rice containing residues at the limit of detection, LOD (0.02 ppm), $95^{th.}$ percentile of exposure (Gammon *et al.*, 1994). This dietary component was 0.051 μg/kg-day. Combined exposure is given in Table 2.

Seasonal

The combined SADD values were obtained by summing the values for occupational/recreational exposure (Table 1) with the theoretical residue estimated for chronic dietary exposure. The latter was determined for males 20+ yrs. old, consuming rice containing residues at 0.01 ppm, 50% LOD (Gammon *et al.*, 1994). This dietary component was 0.002 μg/kg-day. Combined exposure is given in Table 2.

Table 2. Combined exposure estimates to fenoxaprop-ethyl from the use of Acclaim® 1EC on turfgrass and Whip® 1EC on rice: occupational/recreational plus dietary.

TYPE OF EXPOSURE	ADD[b] μg/kg/day	SADD[c] μg/kg/day
Mixer-Loader-Applicator		
Golf course	1.99 - 5.77	0.044 - 0.12
Sod farm manager	8.28 - 37.7	0.45 - 2.04
Landscaping PCO	19.4 - 56.5	6.29 - 18.4
Recreational	3.99	1.20[d]

a/ see Volume IIa for calculations of worker exposure, using PHED, and Gammon *et al.*,1994 for dietary exposure.

b/ ADD = Absorbed Daily Dosage (mean) following Acclaim® use at a range of label application rates, combined with acute dietary exposure of 0.051 μg/kg-day.

c/ SADD = Seasonal Average Daily Dosage following Acclaim® use at a range of label application rates, combined with chronic dietary exposure of 0.002 μg/kg-day.

d/ Based on 28 days of exposure per season (92 days).

C. RISK CHARACTERIZATION

The risk characterization process consists of calculating a MOS by dividing the NOEL value for a specific toxicological endpoint (Section IV) by the estimated occupational exposure (Table 1) or combined occupational and dietary exposure (Table 2).

Occupational

Mixer/Loader/Applicator

The acute MOS values, based on the mean ADD, for mixer-loader-applicators for ground application on golf courses, sod farms and landscape, were 1,750, 266 and 177, respectively, at the maximum label rate (Table 3). The seasonal MOS values, based on the mean SADD for ground application on golf courses, sod farms and landscape, were 15,800, 931 and 103, respectively, at the maximum label rate.

Recreational

For a recreational user of treated turfgrass, acute and seasonal MOS values were 2,540 and 1,580 respectively, at the maximum label rate (Table 3).

Table 3 Margins of safety from occupational (M/L/A) or recreational exposure to fenoxaprop-ethyl from Acclaim® use on turfgrass.

TYPE OF EXPOSURE	ACUTE MOS[a,b]	SEASONAL MOS[b,c]
Mixer-Loader-Applicator		
Golf course	1750 - 5150	15,800 - 45,200
Sod farm manager	266 - 1220	931 - 4,220
Landscaping PCO	177 - 518	103 - 302
Recreational[d]	2,540	1,580

a/ MOS = $\frac{\text{NOEL (10 mg/kg/day)}}{\text{Exposure (ADD)}}$

NOEL (acute), from two developmental toxicity studies, based on increased fetal skeletal and visceral anomalies in rat (James *et al.*, 1983) and maternal mortality in Cynomolgus monkey (Osterburg, 1984).

b/ Based on exposure at a range of label application rates or the maximum (Table 1).

c/ MOS = $\frac{\text{NOEL (1.9 mg/kg/day)}}{\text{Exposure (SADD)}}$

NOEL (subchronic) based on liver toxicity in a 30-day mouse study (Leist *et al.*, 1981).

d/ Estimated from a Lorsban® (chlorpyrifos) exposure study on lawns (Volume IIa).

Combined occupational/recreational and dietary

The combined MOS values, based on the range of ADD and SADD values presented in Table 2, are given in Table 4. The MOS values for acute exposure ranged from 177 (landscaping PCO) to 1,730 (golf course manager), based on the maximum label rate. For seasonal exposure, MOS values ranged from 103 (landscaping PCO) to 15,800 (golf course manager), based on maximum label rate.

Recreational use of turfgrass gave corresponding estimated MOS values of 2,510 (acute) and 1,580 (seasonal), based on maximum label rate for crabgrass control.

Table 4 Margins of safety from occupational (M/L/A) or recreational exposure to fenoxaprop-ethyl from Acclaim® use on turfgrass combined with dietary exposure from Whip® use on rice.

TYPE OF EXPOSURE	ACUTE MOS[a,b]	SEASONAL MOS[c,d]
Mixer-Loader-Applicator		
Golf course	1,730 - 5,030	15,800 - 43,200
Sod farm manager	265 - 1,210	931 - 4,220
Landscaping PCO	177 - 515	103 - 302
Recreational[e]	2,510	1,580

a/ $MOS = \frac{\text{NOEL (10 mg/kg/day)}}{\text{Exposure (ADD)}}$

NOEL (acute), from two developmental toxicity studies, based on increased fetal skeletal and visceral anomalies in rat (James *et al.*, 1983) and maternal mortality in Cynomolgus monkey (Osterburg, 1984).

b/ Based on ADD from range of label rates, combined with acute dietary exposure on rice (Table 2).

c/ $MOS = \frac{\text{NOEL (1.9 mg/kg/day)}}{\text{Exposure (SADD)}}$

NOEL (subchronic) based on liver toxicity in a 30-day mouse study (Leist *et al.*, 1981).

d/ Based on SADD from range of label rates, combined with chronic dietary exposure on rice (Table 2).

e/ Mean exposure at maximum label rate; from a Lorsban® exposure study on lawns (Volume IIa).

V RISK APPRAISAL

Risk assessment is the process which is used to evaluate the potential for exposure and the likelihood that the toxic effects of a substance will occur in humans under specific exposure conditions. Every risk assessment has inherent limitations in the application of existing data to estimate the potential risk to human health. Therefore, certain *a priori* assumptions are incorporated into the hazard identification, dose-response assessment and exposure assessment processes. These, in turn, result in uncertainty in the risk characterization, which integrates all of the information in these three processes. Qualitatively, risk assessment for all chemicals has similar types of uncertainty. However, the degree or magnitude of the uncertainty varies depending on the availability and quality of the data and the exposure scenarios being assessed. Varying degrees of uncertainty are involved in the estimation of these two parameters, affecting the accuracy of the risk characterization. Specific areas of uncertainty associated with this risk assessment for fenoxaprop-ethyl are delineated in the following discussion.

Acute toxicity tests measure the effects of a chemical after a single or brief period of exposure. Developmental toxicity studies are a special case in the battery of such tests. Typically, daily dosages are administered to pregnant animals during the period of organogenesis of the fetus. In the absence of data to the contrary, it is assumed that a reported developmental effect can result from a single dose on a particular day during this time period (U.S. EPA, 1991a). Because fenoxaprop-ethyl is not completely eliminated from the rat or monkey body within 24 hours (Dorn *et al.*, 1984), it is therefore possible that an effect could take place late in the dosing sequence and be the result of an accumulation of chemical above a "threshold" *i.e.* a single daily dosage may be insufficient to cause the effect. In such a case, the NOEL value in terms of the daily dosage would underestimate the "true" NOEL. The NOEL value which was used to determine the acute MOS values for fenoxaprop-ethyl was derived from two such studies *i.e.* fetal anomalies (rat) and maternal mortality (Cynomolgus monkey) and may, therefore, be an underestimate of the acute NOEL. Thus, the MOS values calculated here for acute toxicity could be underestimates of the "true" MOS values *i.e.* MOS values in practice could be greater than those presented.

For subchronic toxicity, which has been used to assess the seasonal occupational exposure, another area of uncertainty exists. Liver toxicity appeared to reverse with the discontinuation of dosing in the rat and dog. Furthermore, in chronic studies, effects observed in animals at interim sacrifice *e.g.* enlarged liver, had disappeared or adapted at study conclusion, even with continued consumption of fenoxaprop-ethyl. It is therefore possible that the experimentally determined NOEL for subchronic effects could be an underestimate of the "true" NOEL. Thus, the "true" MOS values for seasonal exposure could also be higher than the estimates presented here.

Occupational Exposure

Occupational exposure studies for fenoxaprop-ethyl associated with the ground application of Acclaim® to turfgrass were not available to DPR. Therefore, estimates were obtained using the Pesticide Handlers' Exposure Database, PHED (Volume IIa). PHED is a generic database and thus includes pesticides with different physicochemical properties and formulations; therefore, it is possible that occupational exposure estimates from PHED may not be completely reflective of potential exposures obtained from pesticide-specific studies. Furthermore, PHED only enables the mean exposure to be calculated, and does not allow standard deviation of the mean or an upper end confidence interval of exposure to be estimated. The use of mean exposure data will result in higher

MOS values. Because PHED does not permit an estimate of a potential upper end exposure, it may therefore overestimate the MOS values for certain occupational activities. However, other factors may have exaggerated worker exposure. The use of the maximum label rate may overestimate actual use rates, in practice. In addition, human dermal penetration data which are specific to fenoxaprop-ethyl are lacking and absorption was assumed to be the same as for the rat, 73%. However, this value may be an overestimate of dermal penetration since rates in rodents, for a range of pesticides, are generally 5 to 10x greater than rates in humans (Feldmann & Maibach, 1974; Wester & Maibach, 1985). However, it is unclear to what extent these laboratory studies cited represent an accurate estimation of dermal absorption for a specific pesticide in the field. Other reasons for the possible over-estimation of occupational exposure using PHED are provided in Volume IIa, Exposure Appraisal.

<u>Daily (acute) Exposure</u>

For acute exposure, a margin of safety value of 100 or greater is generally considered to be protective of human health when the toxicology (*e.g.* NOEL) is based on animal studies. For application to turfgrass, the MOS values, based on mean ADD values at the maximum label application rate, were above 100 for the mixer-loader-applicator in golf course, sod farm and landscaping scenarios. Recreational and re-entry activities, *e.g.* mowing, on treated turfgrass also resulted in estimated MOS values above 100.

<u>Seasonal Exposure</u>

For seasonal exposure, a margin of safety value of 100 or greater is generally considered to be protective of human health when the toxicology (*e.g.* NOEL) is based on animal studies. Based on the mean SADD values at the maximum label application rate, the MOS values for mixer-loader-applicators were above 100.

<u>Chronic Exposure</u>

For the reasons discussed, the calculation of MOS values associated with annual and lifetime exposure to Acclaim® are considered inappropriate.

<u>Combined Exposure</u>

Dietary theoretical exposure from treated rice is considered negligible (Gammon *et al.*, 1994). For example, acute dietary exposure of males (13-19 yrs.), at the $95^{th.}$ percentile, following consumption of rice containing residues at the LOD, 0.02 ppm, would increase exposure by only 0.051 μg/kg-day (Gammon *et al.*, 1994). This represents an increase of <0.2% to 2.6% of the total potential acute exposure for landscaping PCOs and golf course personnel, respectively *i.e.* the most exposed and least exposed workers. Seasonal combined exposure resulted in an insignificant (<0.1%) increase above occupational exposure in all scenarios except for golf course personnel applying the lowest label rate, who could experience an increased level of exposure of ~4.6% with the addition of theoretical dietary residues from rice.

VI CONCLUSIONS

Occupational and Recreational

A margin of safety of at least 100, whenever it is based on animal toxicity data, is conventionally recommended to protect the population from the toxic effects of a pesticide. Using mean, acute occupational exposure, the estimated margins of safety for the mixer-loader-applicator applying fenoxaprop-ethyl to turfgrass were above 100. Re-entry (*e.g.* for mowing) and recreational activities on treated grass also resulted in estimated MOS values above 100. For seasonal exposure, and using subchronic toxicity data, margins of safety were above 100 for mixer-loader-applicators applying fenoxaprop-ethyl to turfgrass as well as for re-entry and recreational activities on treated grass.

Combined Occupational/ Recreational and Dietary

Occupational exposure, at the range of label application rates, was calculated in combination with both acute and seasonal dietary exposure scenarios. In no instance did the addition of hypothetical dietary exposure from rice consumption reduce the MOS values below 100.

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EXPOSURE ASSESSMENT FOR

FENOXAPROP-ETHYL

VOLUME IIa

EXPOSURE ASSESSMENT FOR ORNAMENTAL, RIGHTS-OF-WAY AND TURF USES

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Worker Health & Safety Branch
Department of Pesticide Regulation
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ESTIMATION OF EXPOSURE OF PERSONS IN CALIFORNIA TO FENOXAPROP-ETHYL FROM ORNAMENTAL AND TURF USES

BY

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ABSTRACT

Fenoxaprop-ethyl is currently registered for use in California as a selective post emergent rice herbicide. Anomalies in fetal rats and liver toxicity in adult laboratory animals dosed with this chemical prompted the risk assessment for fenoxaprop-ethyl. The Hoechst-Roussel Agri-Vet Company has submitted an application to register fenoxaprop-ethyl for use on turfgrass, ornamentals and rights-of-way. The Acclaim® 1EC Herbicide label permits applications to be made with a ground boom tractor, low or high volume spraygun or hand-held sprayer. Estimates of the occupational exposure to fenoxaprop-ethyl from applying Acclaim® 1EC Herbicide range from 0.20-5.85 mg per workday. Although human dermal absorption data are not available, results from a rat study indicate that 73% of a 2.3 ug/cm^2 dose was considered absorbed after a 10-hour exposure period. The estimated mean absorbed daily dosage for applications made at the maximum label rate were 5.72 ug/kg/day for a golf course maintenance applicator and 56.4 ug/kg/day for a residential pest control operator making applications with a hand-held spray gun. Adults performing various recreational activites (picnicing, sun bathing, touch football, weeding) on treated turf experienced an estimated 3.94 ug/kg/day dose of fenoxaprop-ethyl. The incidental exposure incurred from mowing a treated lawn or turf is expected to be insignificant.

INTRODUCTION

The exposure assessment for the use of fenoxaprop-ethyl in rice has been completed and fenoxaprop-ethyl is currently registered for use in California as Whip® 1EC Herbicide for the control of grassy weeds in rice (Wang and Haskell, 1994). The manufacturer of fenoxaprop-ethyl, the Hoechst-Roussel Agri-Vet Company, has submitted an application to register fenoxaprop-ethyl for use on ornamental plantings, rights-of-way and turfgrass, including sodfarms. As the physical and chemical properties of a pesticide can impact the dermal absorption rate and *in vivo* metabolism, a summary of these properties is present in the exposure assessment (Wang and Haskell, 1994). The label permits applications to be made with a hand-held spray wand or gun which are known to cause higher rates of occupational exposure. In the report by Rutz and Krieger (1992), exposure rates (ug of exposure per lb of a.i. applied) for hand-held spray gun or wand applications were reported to be several orders of magnitude greater than applications with a boom equipped tractor. The use of Acclaim® by pest control operators to control grassy weeds in residential lawns has the potential to cause exposure to the occupants.

PRODUCT FORMULATIONS

Acclaim® 1EC Herbicide has been formulated as an emulsifiable concentrate with one pound of fenoxaprop-ethyl per gallon equivalent to 12.5% of the product by weight. The request is to register its use for the selective post-emergent control of grassy weeds in turf, ornamental landscaping and along rights-of-way.

USAGE

The supplemental label for the proposed registration of Acclaim® 1EC Herbicide in California allows the selective post-emergent control of annual and perennial grasses in residential and commercial turfgrass, sodfarms, ornamental plantings and in rights-of-way. The label permits applications to be made with a ground boom tractor, low or high volume spraygun or with a hand-held sprayer. Label rates range from 0.031-0.35 lb a.i. per acre depending on the site and the stage of growth of the weed species. For small turf areas and ornamental plantings, the rates are 0.0007-0.008 lb a.i. per 1,000 ft^2. The recommended dilution rates are 30-100 gallons of water per acre or 0.7-1.4 gallons of mixture per 1,000 ft^2, depending on the application method. Thorough spray coverage is essential for optimum control of the target species. A minimum interval of 14 days should be observed between successive applications. A maximum of 1.08 lbs of a.i. can be applied per acre to turf, ornamental plantings and rights-of-way during one growing season. Application to sod is not permitted within four weeks of cutting for transplanting.

Acclaim® may not be applied with any type of irrigation system. Treated areas should not be mowed for at least 24 hours to allow sufficient time for the active ingredient to penetrate and translocate in the target species.

LABEL PRECAUTIONS

The Acclaim® 1EC Herbicide label carries the signal word, "WARNING" and the precautionary statements indicate the category II toxicity classification is due to temporary eye injury that is reversible within 7 days. The statements for oral, inhalation and dermal exposure indicate these routes have a toxicity category III classification. The following protective clothing must be worn by applicators and other workers handling Acclaim®: long pants and long-sleeved shirt, chemical resistant gloves, protective eyewear, shoes and socks. For sodfarm uses only, the federal Worker Protection Standard (WPS) lists a restricted-entry interval (REI) of 24 hours for unprotected workers.

WORKER ILLNESSES/INJURIES

Since the active ingredient of Acclaim®, fenoxaprop-ethyl, was recently registered for use on rice in 1994, data regarding exposure-related illnesses in California are not available.

DERMAL IRRITATION/SENSITIZATION

Fenoxaprop-ethyl has a low acute mammalian toxicity. It is classified as a category II eye irritant. The label requires eye protection and impermeable rubber gloves to be worn by applicators and other handlers. A dermal sensitization test conducted with guinea pigs did not indicate this product is an animal dermal sensitizer (Jung and Weigand, 1982).

DERMAL ABSORPTION

Dermal absorption data from a human study were not available. However, the rate of absorption of fenoxaprop-ethyl through the skin of rats has been studied and submitted (Laveglia *et al.*, 1986). Four groups of 20 animals each were exposed to a dermal dose of 2.3, 23, 231, or 2315 ug/cm^2 for 10 hours. The excreta was collected for up to 72 hours after the dose was washed off. Researchers observed that a high percentage of the dose was bound to the treatment site with an average of only 24% of the dose for all dose groups removed during wash-off. The presence of fenoxaprop-ethyl equivalents in the urine and feces up to 72 hours after the exposure indicates that a large portion of the bound skin residues is bioavailable. For the low dose rats, 73% of the dermal dose was considered absorbed and bioavailable after a 10-hour exposure period (Wang and Haskell, 1994).

ANIMAL METABOLISM

The metabolism of fenoxaprop-ethyl has been studied extensively in rats and the following results were summarized from the indicated studies. With an oral dose of 2 mg/kg, the percent of the dose excreted as ^{14}C equivalents of fenoxaprop-ethyl after 96 hours was 42.1-53.9% in the urine and 33.8-40.4% in the feces (Dorn *et al.*, 1985). The observed lack of detectable parent material in the urine indicates the metabolism is complete when absorbed from the gastrointestinal tract. Two primary metabolites, that may be suitable for use as biological markers for urinary monitoring, were observed in the urine: benzoxazol mercapturic acid and hydroxyphenoxy propionic acid (Dorn *et al.*, 1985; Burkle et al., 1985). The elimination of fenoxaprop-ethyl and/or its metabolites in the urine and feces is biphasic with an initial excretion half-life of 8.5-12.5 hours followed by a slower second phase of 27-73 hours for urine and 27-34 hours for feces (Kellner and Eckert, 1984). With an oral dose of 2 or 10 mg/kg, 2.2 to 5.1% of the dose was detected in the tissues seven days after administration, indicating a long tissue half- life (Kellner and Eckert, 1982; Kellner and Eckert, 1984). The residual metabolites were detected in the adipose tissue and excretory organs such as the kidneys. With respect to the effect of sex and dosage rate on metabolism, there were no qualitative differences discerned in the excreted metabolites. However, there may be quantitative differences with respect to certain chemical species of metabolites being transformed and excreted (Dorn *et al.*, 1985).

OCCUPATIONAL EXPOSURE

I. Application

The Acclaim® 1EC Herbicide product label permits applications to be made with a variety of equipment to residential and commercial turf grass, ornamental plantings and rights-of-way. The use of Acclaim® is projected to occur primarily on golf course turf and residential lawns. The application equipment used on ornamental plantings and rights-of-way are similar to those used on golf courses and by residential pest control operators. And because the application rates and timing of the applications are the same, the occupational exposure estimates from the golf course and residential turf treatments will represent the exposure estimates for all uses on the Acclaim® 1EC Herbicide.

Occupational exposure data to support these uses were not submitted by the manufacturer. The Pesticide Handlers Exposure Database (PHED, 1995) was used to derive estimates of the exposure to fenoxaprop-ethyl for the various application methods. As a database composed of the results from studies which did not follow a standardized protocol, PHED has limitations to it's use as a surrogate database. The PHED database was constructed as a summary of the exposure data from many studies, each with a different minimum detection level (MDL) for the analytical method used to detect residues in the sampling media. And since the detection of dermal exposure to the body regions was not standardized, some studies observed exposure to only selected body regions such as the hands, arms and face, with the other body regions considered 100% protected from exposure by work clothing. As a consequence the subsets derived from the database for dermal exposure have different number of observations (n) for each of the body regions. The calculation of a standard deviation for the mean dermal exposure rate for the whole body is therefore not appropriate because the mean rate was derived as the sum of the mean rates for each body region which were derived from various numbers of observations (replicates). Although confidence intervals were provided for the derived mean dermal and inhalation rates, they may not represent an accurate expression of their variability. The physical properties of each pesticide were not included in the selection criteria for the database. As a consequence, the surrogate data derived for a specific pesticide can not be subsetted on the basis of similar physical properties such as vapor pressure, etc. In recognition of these limitations, PHED was used to derive data subsets that estimate the occupational exposure to fenoxaprop-ethyl for work tasks related to the application of Acclaim® 1EC Herbicide.

The use of Acclaim® for the postemergent control of annual and perennial grasses in turf, ornamentals and rights-of-way is dependent on the site and weed species. Use rates at a specific site can range from 0.031-0.35 lb a.i./acre depending on the stage of growth of the weed species. The control of crabgrass on golf courses and commercial landscaping are projected to be the likely uses of this product in California (Hervardi, 1994). The use season would be approximately three months per year (late spring to early summer) depending on location with a maximum of two treatments per season. On golf courses, applications of Acclaim® would take place primarily on greens, practice greens and tees with only limited use on the fairways (Hernandez, 1995). For an 18 hole course, these areas constitute approximately 200,000 ft^2. Applications would take place early in the morning before the players arrive. If the golf course maintenance supervisor treated all the greens, practice greens and tees in one morning at the label rate for untillered crabgrass (0.0027 a.i./1,000 ft^2) or at the maximum label rate for crabgrass control (0.008 lb a.i./1,000 ft^2), he would handle 0.54 or 1.6 lbs of fenoxyprop-ethyl, respectively.

Acclaim® 1EC Herbicide does have some potential for use on sod farms. The production manager for a large sod farm in the Central Valley indicated that barnyardgrass and sprangletop infestations can become a problem. Weed control in sod production is generally accomplished with preplant fumigation, use of weed-free seed for planting and pre and post emergent herbicides. The use of herbicides on growing sod entails some risk because of the potential for phytotoxicity with some active ingredients. However, the post emergent use of Acclaim® may be needed to control these grassy weeds.

Sod farms typically make several plantings a season to insure a supply of sod for most of the year. Each planting can range from 10-30 acres, depending on the time of year and take about 6-9 months to mature. On a large ranch, three-four hundred acres could be planted during one growing season. Sod can become infested with grassy weeds like barnyardgrass from planting contaminated seed. Herbicide applications are typically made with tractors equipped with boom sprayers that can drive over the growing sod. To prevent the loss of the planting, an emergency application of Acclaim® might be made when the turf is old enough to tolerate the temporary phytotoxicity that can occur with some turf species. At the maximum label rate for seedling Kentucky bluegrass (0.078 lb a.i./acre), the production manager could handle 2.3 lbs of fenoxaprop-ethyl during a 30 acre application. Since older turf could be treated at the maximum rate of 0.35 lb a.i. per acre, an applicator could handle 10.5 lbs of a.i. per 30 acre treatment. Assuming the production manager treated five plantings per season, he might treat 150 acres in a year.

The PHED database was used to derive an estimate of the exposure when an applicator mixes, loads and applies a pesticide with a tractor equipped with a boom sprayer. A subset was generated from the MLAP file in PHED with the following selection criteria:

Parameter	Comments
Dermal grade-uncovered	All grades of studies A-E to maximize the number of replicates
Dermal grade-covered	All grades of studies A-E to maximize the number of replicates
Hand grade	All grades of studies A-E to maximize the number of replicates
Formulation	Emulsifiable concentrate or aqueous suspension or solution
Study location	Outdoor
Application method	Ground boom tractor
Total lbs a.i. applied	Greater than 5.0
Exposure units	ug/pound of a.i. sprayed
Inhalation rate	25 L/min (PHED default)
Exposure	Combined dermal/inhalation
Head patches	Used actual and estimated head patches
Normal work clothing	Long pants, long-sleeved shirt, rubber gloves

The following mean (arithmetic) rates of exposure per pound of a.i. applied were computed from the subset: 0.37 mg of dermal exposure and 0.0035 mg of inhalation exposure (Appendix A). A golf course maintenance supervisor wearing the label required work clothing or coveralls, face shield or goggles, and gloves could experience the following estimated rates of exposure: (a) 0.54 lb a.i. handled-0.20 mg of dermal exposure and 0.0019 mg of inhalation exposure per workday or (b) 1.6 lbs a.i. handled-0.59 mg of dermal exposure and 0.0056 mg of inhalation exposure per workday. The production manager on a sod farm could experience: (a) 2.3 lbs a.i. handled-0.85 mg of dermal exposure and 0.0081 mg of inhalation exposure or (b) 10.5 lbs a.i. handled-3.89 mg of dermal exposure and 0.020 mg of inhalation exposure.

A pest control advisor specializing in golf courses projects residential pest control operators (PCOs) and landscape maintenance personnel will be the greatest users of Acclaim® (Eckert, 1994). The ChemLawn® Company is a nationwide company that specializes in residential and commercial lawn care. Dr. Law, the Regional Technical Manager for ChemLawn® in California, indicated that tank sizes on their trucks can range from 100-400 gallons (Law, 1995). This tank is used to apply liquid fertilizers, sometimes in combination with 2,4-D and MCPA as a total lawn treatment. A second 30 gallon tank is used exclusively to mix and apply pesticides. The spray system on the trucks is calibrated to apply fertilizer and pesticide mixtures at a rate of 2 gallons of mix per 1,000 ft^2 of lawn equivalent to a dilution rate of 87 gallons per acre. Dr. Law indicated Acclaim® 1EC Herbicide will probably be used as a "spot" treatment to control crabgrass infestations in lawns and landscaping strips. Although the growing season for crabgrass is several months, efficacious control will occur early in the season before the plants become too large and start seed production. The average residental customer has 3,000 ft^2 of lawn and one PCO can treat 15-45 customers per day. Most accounts are on a monthly basis for fertilizer and weed control treatments. If a third of the customers request the crabgrass treatment on an annual basis, the PCO could treat 30 days during the 92 day use season (May-July). On a daily basis, if one operator treated 33% of the accounts for crabgrass, a maximum of 15 accounts per day or one acre of lawn would be treated. The 30-gallon tank will be used to mix and load the Acclaim® and it can be applied separately as needed from the fertilizer. If the PCO applies three tankloads of Acclaim® per workday at the 87-gallon per acre dilution rate with a hand-held spraygun, he can treat approximately one acre per day. At the label rate for untillered crabgrass (0.0027 a.i./1,000 ft^2) in turf and landscaping, the residential PCO could handle 0.12 lbs of fenoxprop-ethyl per workday. At the maximum label rate (0.008 lb a.i./1,000 ft^2) for crabgrass control, the residential PCO may handle 0.35 lb a.i. per workday.

A second subset was generated with PHED using the MLAP file for a worker that mixes, loads and applies a pesticide with a hand-held wand with the following criteria:

Parameter	Comments
Dermal grade-uncovered	All grades of studies A-E to maximize the number of replicates
Dermal grade-covered	All grades of studies A-E to maximize the number of replicates
Hand grade	All grades of studies A-E to maximize the number of replicates
Formulation	Emulsifiable concentrate or aqueous suspension or solution
Study location	Outdoor
Application method	Low or high pressure hand wand
Total lbs a.i. applied	Greater than 5.0
Exposure units	ug/pound of a.i. sprayed
Inhalation rate	25 L/min (PHED default)
Exposure	Combined dermal/inhalation
Head patches	Used actual and estimated head patches
No clothing-total deposition	Generated more observations for each body region

When the subset was querried for workers wearing long pants, long-sleeved shirt and chemical resistant gloves, only observations of exposure to the head, neck and hands were listed for the hand-held wand application method. However, if the workers potential dermal exposure was querried (total deposition to clothing and skin), observations of exposure were included for all body regions. The following mean (arithmetic) exposure rates were computed from the subset for workers not wearing clothing: 167 mg of dermal exposure and 0.049 mg of inhalation exposure per lb of a.i. applied (Appendix B). The residential pest control operator handling 0.12 lb of fenoxaprop-ethyl per workday could experience an estimated 20 mg of potential dermal exposure and 0.0059 mg of inhalation exposure. At the maximum label rate he could experience 58.5 mg via the dermal route and 0.017 mg via inhalation. The dermal values can be reduced by 90% to account for the protection provided by wearing long pants and a long-sleeved shirt or coveralls, face shield or goggles, and chemical resistant gloves (Thongsinthusak *et al.*, 1993a). At the typical and maximum label rates, the rate of dermal exposure per workday for the residential PCO was 2.0 mg and 5.85 mg, respectively.

The following table summarizes the estimated occupational exposure expected from utilizing the application methods available on the Acclaim® 1EC Herbicide label to make treatments to various sites. For the exposure assessment, the absorbed daily dose (ADD) and the seasonal absorbed daily dose (SADD) need to be calculated to determine if the margin of safety (MOS) is adequate for a acute or subchronic adverse health effect.

TABLE I. PHED Estimate of Occupational Exposure for Workers Mixing, Loading and Applying Fenoxaprop-Ethyl to Turf and Landscaping

Tasks (Mixing/Loading Application)	PHED Exposure Per Lb A.I. Handled (mg) Dermal	PHED Exposure Per Lb A.I. Handled (mg) Inhalation	Dermal Exposure[a,b] (mg/person/day)	Inhalation Exposure[b] (mg/person/day)	Absorbed Daily Dosage[c] (ug/kg/day)	Seasonal Average Daily Dosage[c,d] (ug/kg/day)
Ground Boom on Golf Course Turf*						
untillered label rate	0.37	0.0035	0.20	0.0019	1.94	0.042
maximum label rate	0.37	0.0035	0.59	0.0056	5.72	0.12
PHED database N=91						
Ground Boom on Sod Farm**						
low rate for Kentucky bluegrass	0.37	0.0035	0.85	0.0081	8.23	0.45
maximum label rate	0.37	0.0035	3.89	0.037	37.7	2.05
PHED database N=91						
Hand-Held Boom on Landscaping***						
untillered label rate	16.7	0.049	2.0	0.0059	19.3	6.29
maximum label rate	16.7	0.049	5.85	0.017	56.4	18.4
PHED database N=44						

Haskell, WH&S Branch, 1996

* Worker handled 0.54 or 1.6 lbs a.i.
** Worker handled 2.3 or 10.5 lbs a.i.
***Worker handled 0.12 or 0.35 lb a.i.

[a] The PHED dermal exposure rate for the hand-held wand application was derived from the database with the worker wearing no clothing. Since the Acclaim® label does require the worker to wear long pants and long-sleeved shirt, chemical resistant gloves, protective eyewear, shoes and socks, the dermal exposure rate was reduced by 90% (Thongsinthusak *et al.*, 1993a).

[b] Values expressed as the arithmetic mean and represent the product of the appropriate PHED exposure rate and the lbs a.i. handled as indicated by the asterisks.

[c] The exposure assessment utilized a 73% dermal absorption rate for fenoxaprop-ethyl (Wang and Haskell, 1994) and a 50% inhalation uptake (Raabe, 1988) to calculate the ADD and SADD for a 75.9 kg man (Thongsinthusak *et al.*, 1993a).

[d] The SADD was calculated with a 92-day annual use season (May-July) and two application days per season for the golf course operator (Hervardi, 1994), five days for the sod farm manager and 30 days per year for the residential PCO. Although the growing season for crabgrass in California is several months, control of this grass with fenoxyprop-ethyl becomes increasely difficult as the plants become larger. Applications should also be made early enough in the growing season to prevent seed production.

II. Occupational Exposure from Treated Sites

Routine tasks may require workers to enter treated areas or handle treated turf which have the potential to cause exposure to residues of fenoxaprop-ethyl. The federal Worker Protection Standards do not apply to workers entering areas where pesticide use has occurred on turf, ornamental plantings and right-of-way sites with the exception of sod farms. For treatments on sod farms, a minimum restricted entry interval of 24 hours is mandated for unprotected workers. The Acclaim® 1 EC Herbicide label does recommend that treated turf should not be cut for sod within four weeks of treatment.

Turf grown for sod is harvested by a machine that cuts the sod into strips approximately 18 inches wide and 6 feet in length. The cut sod is then rolled up with the soil side out and loaded onto pallets. Workers rolling and stacking the sod may come in contact with treated foliage. Workers laying sod that has been treated with Acclaim® may also come in contact with foliar residues.

A photodegradation study of ^{14}C-labeled fenoxaprop-ethyl on a loamy sand soil surface observed this compound is photochemically labile (Gildemeister and Jordan, 1984). At zero hours after the application, 97.7% of the radioactivity was recovered and associated with the parent compound. Forty-six percent of the initial radioactivity associated with the parent material was detected after 4 hours of irradiation time and 3.8 % of the radioactivity after 45 hours of irradiation. The parent compound was observed to readily degrade into the acid form which accounted for 50% of the radioactivity after 4 hours of irradiation. This metabolite was observed to be less photochemically labile than the parent and accounted for 24% of the radioactivity after 45 hours of irradiation. The 28-day preharvest interval will permit the residues of the parent material and its primary metabolite to degrade through many half-lives. If the degradation is estimated at three half-lives per day, assuming 12 hours of light per day, then the residue levels after the application will degrade through approximately 80 half-lives in 28 days. An estimated 4×10^{-27} % of the initial deposition of the parent material will be present after 28 days which is below any analytical detection limit. The exposure to fenoxaprop-ethyl incurred from workers harvesting or laying treated sod is expected to be insignificant.

Maintenance workers on golf courses and landscapers could experience exposure to fenoxaprop-ethyl from mowing treated turf. The Acclaim® 1 EC Herbicide label recommends a minimum interval of 24 hours between treatment and mowing. The maximum label rate for the control of crabgrass in turf is 0.008 lb a.i. per 1,000 ft^2 or 0.35 lb a.i. per acre. This maximum application rate is equivalent to 3.6 g of a.i. per 1,000 ft^2. The amount of foliar residues that could be considered dislodgeable and potentially available for exposure was estimated from a study that observed the residues of 2,4-D present after a lawn application. In the study by Harris and Solomon (1992), a liquid mixture of 2,4-D amine/mecoprop/dicamba was applied by a professional lawn care company at a rate equivalent to 10 g of 2,4-D per 1,000 ft^2 of lawn. As 2,4-D has a low vapor pressure and the application rate and technique were similar to those permitted by the Acclaim® 1EC Herbicide , the study was considered a suitable surrogate for fenoxyprop-ethyl. One hour after the application, the dislodgeable residues were measured by rubbing moistened cheesecloth attached to a pair of shoes on the treated lawn. A mean value of 8.45 ± 0.927 mg/m^2 of a.i. was detected from the five plots that were sampled which represented 7.6% of the initial application. If the same percentage of fenoxyprop-ethyl foliar residues are present and dislodgeable after the 3.6 g/1,000 ft^2 application, then 0.27 g/1,000 ft^2 (0.29 $\mu g/cm^2$) could be considered available for exposure. The incidental exposure incurred from mowing treated turf or lawn is expected to be insignificant, due in part to a low level of DFR present and the low probability of the DFR becoming airborne during mowing and available for inhalation.

III. Non-Occupational Exposure from Treated Sites

The Acclaim® 1 EC Herbicide label does not provide a "reentry interval" for persons entering treated areas for recreational purposes. Adults or children playing on a lawn that has been treated a few hours earlier with fenoxaprop-ethyl could be subject to some incidental exposure to foliar residues. A study by Vaccaro *et al.* (1993) observed the exposure to chlorpyrifos via biomonitoring for adults performing various recreational activities on lawns treated with Dursban®. From the biomonitoring data, an estimate of the dermal and inhalation exposure to chlorpyrifos was extrapolated for adults. A mean absorbed dermal dose of 458 ug was derived for the eight adults participating in the study. With an estimated dermal absorption rate of 9.6% for chlorpyrifos, the calculated dermal exposure from the biomonitoring data was 4.77 mg (Thongsinthusak *et al.*, 1993b). Since chlorpyrifos has a low vapor pressure and the application rate and technique were similar to those permitted by the Acclaim® 1EC Herbicide, the study was considered a suitable surrogate for fenoxyprop-ethyl. To utilize the data, the exposure rates have to be reduced to reflect the difference in application rates between the chlorpyrifos and fenoxaprop-ethyl labels. The rate of Dursban® applied in the Vaccaro study (0.094 lb a.i./1,000 ft^2) was 11.75 times greater than the maximum rate (0.008 lb a.i./1,000 ft^2) allowed for crabgrass control on the Acclaim® 1EC Herbicide label. The 0.41 mg dermal dose of fenoxaprop-ethyl per day for adults was derived by reducing the dermal dose from the chlorpyrifos study by a factor of 11.75. This translates into an ADD (dermal absorption 73%) of 3.94 ug/kg/day for a 75.9 kg adult.

EXPOSURE APPRAISAL

There are factors used to estimate occupational exposure and to calculate the Absorbed Daily Dosage that are conservative (tendency to overestimate the value of concern) in nature. These factors are real, but are typically buried in the methods of estimating exposure and are not acknowledged. This section is an attempt to put these experimental factors in perspective with what will actually happen in the work place.

A. Occupational exposure assessment

The PHED data base was used to derive the occupational exposure estimates when fenoxaprop-ethyl is applied with a handgun or ground boom tractor. The data base is comprised of data from exposure studies that utilize patch dosimetry almost exclusively. This dosimetry method was introduced by Durham and Wolfe (1962) as a means of estimating dermal exposure for pesticide workers. For those studies that utilized patch dosimetry to measure dermal exposure, approximately half of the data points in PHED are reported as non-detectable. Because a majority of the studies in the database are more than 10 years old, many of the detection limits are >0.1 ug/cm^2. For data reported as non detected, we use, by default, 1/2 of the limit of detection (LOD). Thus, the net effect is that an unmeasured residue below the detection limit becames a major component of the exposure. For example, assuming a body surface of 20,000 cm^2 and a 0.1 ug/cm^2 detection limit, the estimated exposure if all patches were non detects would be 2000 ug.

B. Dermal Absorption Rate

Skin is the primary route of worker exposure (Wolfe, 1976), accounting on average for 99% of the potential pesticide exposure for pesticide handlers. The 73% dermal absorption rate used to calculate the ADD was derived from a rat study in which most of the dermal dose of fenoxyprop-ethyl remained bound to the skin after wash off. Only 24% of the dose was recovered from the wash water. This high level of bound material could be due to the lipophilicity of fenoxyprop-ethyl or to covalent or hydrogen bonding with the skin. Less than 10% of the dose was detected in the tissues and carcass. However, for the rats held 72 hours after washing the dose, 12% of the dose was detected as fenoxaprop-ethyl equivalents in the excreta. Without additional excretion data that could identify the fate of the bound skin residues over time and the observation that fenoxaprop-ethyl equivalents continue to be excreted after 24 hours, the assumption has to be made that the bound skin residues will ultimately be bioavailable (Zendzian, 1994). Although the excretion data does indicate some of the bound skin residues were ultimately bioavailable, the total percentage of the dose detected in the carcass and tissues or excreta was only 22%. In light of the study data, the 73% absorption rate is a conservative value for use in estimating the ADD.

Another factor that may contribute to an overestimation of dose is the difference between absorption rates derived from animal studies and the rates observed in human studies. The rat is the most commonly used model to estimate dermal absorption. This is because rats are relatively cheap and most of the toxicological testing is done on rats. Also, many companies have an aversion to using humans for the determination of dermal absorption, even though they are the species for which risk assessment is intended. However, the rat typically overestimates human dermal absorption by two to ten fold. This has been demonstrated in approximately a dozen different compounds tested in both rats and man (Wester and Maibach, 1977; Shah and Guthrie, 1983; Wester and Maibach, 1993; Feldmann and Maibach, 1974; Sanborn, 1994; Thongsinthusak, 1994). Rabbits typically have even higher absorption than rats (Wester and Maibach, 1977).

The mean rat dermal absorption for 26 pesticides from several different chemical classes was 19%±16% (Thongsinthusak *et al.*, 1993c). Thus at the 95th percentile, dermal absorption for pesticides in general would be 51%. The 73% dermal absorption rate which was derived with the assumption that all bound skin residues are ultimately bioavailable, is very conservative in comparsion to pesticides in general.

C. Estimating the Absorbed Daily Dose

Dosage is expressed as a single static value both in worker exposure and animal toxicology studies. The rate of dermal absorption is always lower than the rate of oral absorption in animals used for toxicology testing. Adverse effects occur only when plasma levels in the target organ exceed a critical level. However, dermal acquisition occurs over the entire work day, and because dermal absorption is slower than oral, plasma levels for the same total absorbed dosage will not be nearly as high for a dermal dose aquired over an entire day versus an oral bolus dose. A dermal dose acquired over the entire workday produces peak plasma levels much lower than the bolus oral feeding dosage acquired by animals in seconds to minutes. Because effect is highly dependent on plasma level, treating an eight hour dermal acquisition as though it were a bolus (i.e., summing the entire dermal dose) is extremely conservative. The net effect of assuming instantaneous dermal dose acquisition and absorption is an overestimate of peak plasma concentration compared to the oral route by several fold for the same absorbed dose (Auton *et al.*,1993). Lower urinary metabolite concentrations (an indication of lower peak plasma concentrations) are also seen with dermally applied pesticides when compared with the urinary metabolite concentration observed following oral dosing (Krieger et al., 1991).

D. Conclusion About Exposure Estimates

These factors are operating in the exposure assessment for fenoxaprop-ethyl and because they are multiplicative, result in overestimates of the ADD of eight or more fold. The concern that the maximally exposed individual is not adequately represented by mean estimates of exposure is not well founded when considering all the "hidden" conservatism built into all estimates of exposure resulting from the dermal route.

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APPENDIX A

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

Exposure Scenario: long pants, long-sleeved shirt, gloves

PATCH	DISTRIBUTION	MICROGRAMS PER LB AI SPRAYED				
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs
Head (all)	Other	22.88	187.2329	531.1695	18.1824	91
Neck-front	Lognormal	2.61	26.0784	462.7439	2.5186	91
Neck-back	Lognormal	1.199	15.9613	541.3663	1.1274	86
Upper arms	Lognormal	1.164	6.2942	248.9768	1.4616	27
Chest	Lognormal	3.55	7.9105	129.7427	3.312	53
Back	Lognormal	1.42	3.8849	126.3199	1.8184	53
Forearms	Lognormal	2.178	18.0492	261.5905	1.7621	24
Thighs	Other	0.764	19.901	361.9954	2.0552	31
Lower legs	Other	0.476	16.2554	386.1751	0.9961	30
Feet	Other	0.131	0.131	0.00	0.131	8
Hands	Lognormal	24.6312	72.512	195.5505	9.7794	42
TOTAL DERMAL	46.0305	61.0032	374.2108		43.1442	
INHALATION	Other	1.1089	3.5353	162.0259	0.8374	76
COMBINED	47.1394	62.1121	377.7461		43.9816	

95% Confidence Interval on Mean: DERMAL: (-6414.8033, 7163.2249)

95% Confidence Interval on Mean: INHALATION : (0.0135, 51.7886)

Inhalation rate: 25 Liters/minute

Number of Records: 91

Data file: MIXER\LOADER\APPLICATOR Subset Name: TEMP.NAME.MLAP

APPENDIX B

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

Exposure Scenario: No Clothing (total deposition)

PATCH	DISTRIBUTION	MICROGRAMS PER LB AI SPRAYED				
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs
Head (all)	Lognormal	470.665	947.5139	113.9537	530.0539	44
Neck-front	Lognormal	25.6725	109.5777	151.2877	27.4268	44
Neck-back	Other	33.924	68.6788	134.7671	27.6195	44
Upper arms	Other	1407.4215	2270.6267	117.3649	1265.6316	44
Chest	Lognormal	607.5825	2593.3395	151.2877	649.1001	44
Back	Other	1094.82	2216.4506	134.7671	891.3559	44
Forearms	Lognormal	418.902	811.2881	104.3574	421.356	43
Thighs	Lognormal	1982.389	3979.6065	135.3001	1719.1109	44
Lower legs	Other	2128.315	2999.0326	124.3333	1372.4011	44
Feet	------	------	------	------	------	------
Hands	Lognormal	116538.4615	151272.6081	87.4742	108766.0523	44
TOTAL DERM:	116777.5805	124708.153	167268.7225		115670.1081	
INHALATION:	Normal	32.3077	49.0192	100.0518	24.6859	44
COMBINED:	116826.5997	124740.4607	167317.7417		115694.794	

95% Confidence Interval on Mean: DERMAL: (-1071852.452, 1406389.8977)
95% Confidence Interval on Mean: INHALATION : (-47.1082, 145.1466)

Inhalation rate: 25 Liters/minute
Number of Records: 44
Data file: MIXER\LOADER\APPLICATOR Subset Name: NALED4.MLAP