Shaughnessy Number: ___080803___
Date Out of EAB: ___1/6/88___

To: R. Taylor
Product Manager #25
Registration Division (TS-767C)

From: Michael P. Firestone, Chief   *Michael P. Firestone*
Special Review Section #2
Exposure Assessment Branch/HED (TS-769C)

Thru: Paul F. Schuda, Chief
Exposure Assessment Branch/HED (TS-769C) *Paul F. Schuda*

Attached, please find EAB review of:

Reg./File No.:   _____206273_____

Chemical: _____Atrazine_____

Type Product: _____Herbicide_____

Product Name: _____

Company Name: _____

Submission Purpose: ___Exposure Assessment for Policy Group___

Date In: ___10/24/87___   Action Code: ___350___

Date Completed: ___01/06/88___   EAB #: ___80077___

Monitoring Study Requested: ____   Total Reviewing Time: ___6 days___

Monitoring Study Volunteered: ___

Deferrals to: _____   Ecological Effects Branch

              _____   Residue Chemistry Branch

              _____   Toxicology Branch

1.0 INTRODUCTION

The Fungicide-Herbicide Branch, Registration Division, has requested an exposure assessment for the uses of atrazine. Ciba-Geigy has submitted a 2-year rat study in which atrazine produced mammary tumors in female rats. The exposure assessment will be utilized to estimate nondietary risk to mixer-loaders and applicators for presentation to the OPP Policy Group.

Atrazine is a triazine herbicide used to control broadleaf and grassy weeds in corn, sorghum, rangeland, sugarcane, macadamia orchards, guava, pineapple, turfgrass farms, conifer reforestation, Christmas tree plantations, proso millet, wheat, grass seed fields, and for nonselective vegetation control in fallow and noncropland. Atrazine is formulated as an emulsifiable concentrate, wettable powder, pellet, granule, tablet, or flow concentrate.

2.0 ATRAZINE USE DATA

Richard Petrie, Science Support Branch, Benefits and Use Division, provided use information to Exposure Assessment Branch (EAB) on December 11, 1987 (Use Related Exposure Data for Atrazine Exposure Assessment). Use data were provided for row crops and sugarcane to represent the major atrazine use sites. Macadamia nut orchards were selected to represent handheld spray gun applications. Turf uses were selected to represent homeowner uses.

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2.1 CORN

Atrazine is applied to corn primarily as a preemergent broadcast herbicide. It is commonly tank mixed with other preemergent herbicides such as alachlor, metolachlor, and simazine. Approximately 70 percent is applied by growers and 28 percent by commercial ground boom applicators. An additional 2 percent is applied aerially. The liquid formulation is used and is applied at an average application rate of 2.0 lb ai/A. One application per site is made annually.

The grower will treat 195 acres of corn on the average, which will require the use of 390 lb ai. Ground-boom application of 195 acres will occur over a 2-day period and require a total of 8.9 hours of actual application time. A commercial ground applicator is expected to treat 6000 acres during the treatment year. This would necessitate the handling of 12,000 lb ai/yr and require 80 hours of actual spray time. Unlike the grower, the commercial applicator and mixer/loader may be separate individuals. Aerial applicators can treat 385 acres daily over a 15-day period for a total of 5775 acres annually. A total of 11,550 lb ai would be handled by the mixer/loader. The pilot would require 6.3 hours of actual spray time to treat the 5775 acres. The pilot and mixer/loader would be different individuals.

2.2 SUGARCANE

Atrazine is primarily applied to sugarcane in Florida. Current practice in Florida is to apply atrazine to sugarcane with two postemergent applications. The farm size consists of small farms of 1000 acres or less and corporate farms of 15,000 to 20,000 acres. The average farm size is 3000 acres and the corporate farms are frequently subdivided into smaller management units. Aerial application accounts for 60 to 80 percent of the atrazine applied to sugarcane with commercial and grower ground application accounting for the remainder. The average application rate to sugarcane is 1.0 lb ai/A.

One aerial mixer/loader and pilot team is expected to average 13,200 acres treated annually based on treating 440 acres daily for 30 days during the year. The mixer/loader would handle 13,200 lb ai and the pilot would require 14.2 hours spray time to treat 13,200 acres. The ground-boom applicators treating 3000 acres twice per year will treat 6000 acres annually. This will require handling 6000 lb ai annually. The actual spray time to treat 6000 acres is estimated to be 79.2 hours. The mixer/loader and applicator are expected to be separate individuals.

2.3 MACADAMIA NUTS

Atrazine is applied as a weed control in macadamia orchards in Hawaii. The label application rate is recommended to be 2 to 4

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lb ai/A with applications repeated as necessary. Atrazine cannot be applied in the orchards by air or when the nuts are on the ground. In 1986 the orchard size averaged 30 acres with some plantations being over 1000 acres. In 1986, atrazine application averaged one application per year at 2 lb ai/A.

Typically, atrazine is applied by the grower and his crew by handheld spray gun. The application team consists of one vehicle driver and one or two sprayers hand spraying underneath the trees. A 30-acre farm will have 20.5 acres that are treated, which would require 41 lb ai. One applicator would require 35 hours of actual spray time and two applicators 17.5 hours to treat 20.5 acres.

2.4 TURF - HOME LAWNS

Atrazine is applied to warm-season turfgrass to control weeds. Two applications per year are permitted on home lawns. For homeowner use, atrazine is impregnated into granular fertilizer. A homeowner with a typical lawn of 7000 ft^2 would require 30 minutes to treat the lawn with a 36-inch hand push drop spreader. Using Scotts Bonus S Weed Control Plus Lawn Fertilizer, which contains 0.99 percent atrazine as an example, it would require three 11.5 lb bags of the fertilizer to treat 7000 sq ft. Two annual treatments would require 69 lb of the fertilizer, which would contain 0.68 lb atrazine and require 1 hour to apply and 12 minutes to load.

Commercial lawn applicators would apply atrazine by a
handheld spray gun. Five to ten minutes are required to spray a
7000 ft^2 lawn and an applicator can treat 30 lawns per day.
Assuming the applicator applies atrazine 5 days a week during 4
weeks in the year, a total of 600 lawns annually can be treated.
At 8 minutes a lawn, an applicator would spend 80 hours annually
spraying atrazine. Atrazine is applied to home lawns at 7 oz
atrazine/7000 ft^2. Seven oz of a 4 L liquid formulation is
equivalent to 0.22 lb ai/7000 ft^2 lawn or 1.36 lb ai/A. The
mixer/loader is a different individual from the applicator. The
mixer/loader would mix and load the truck tanks at a base of
operations. The ratio of mixer/loaders to applicators is assumed
to be one but may vary from operation to operation.

3.0 NONDIETARY OCCUPATIONAL EXPOSURE

3.1 MIXER/LOADER EXPOSURE

To estimate the dermal exposure to mixer/loaders, EAB reviewed
four studies available in the published literature. To the extent
possible, exposure was estimated in which mixer/loaders wore long
pants and long-sleeved shirts. The use of protective gloves was
also assumed. The exposure to mixer/loaders using closed loading
systems or open pouring the concentrated pesticide were calculated
separately. A summary of the exposure estimates are provided below:

I. OPEN POUR

Study	Replicates	Exposure (mg/lb ai)	Clothing
Abbott	18	0.93	Long-sleeved shirt, long pants, protective gloves

II. CLOSED LOADING

Study	Replicates	Exposure (mg/lb ai)	Clothing
Dubelman	9	0.0041	Long-sleeved shirt, long pants, protective gloves
Peoples	9	0.025	Long-sleeved shirt, long pants, protective gloves

The 18 Abbott replicates estimate dermal exposure to mixer/loaders open pouring the concentrated pesticide to be 0.93 mg/lb ai handled. The use of closed loading systems reduces the exposure received to 0.015 mg/lb ai handled.

3.2 GROUND-BOOM APPLICATOR EXPOSURE

To estimate the dermal exposure to ground-boom applicators, six studies available in the published literature were evaluated. The estimated dermal exposure for ground-boom applicators applying 1.0 lb ai/A while wearing the long-sleeved shirt and long pants is presented below. Any deviations from this clothing scenario are also identified.

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Study	Replicates	Exposure (mg/hr)	Clothing
Abbott	18	40	Long-sleeved shirt, long pants
Maitlen	21	0.7	Short-sleeved shirt, long pants
Dubelman	12	0.93	Long-sleeved shirt, long pants
Wojeck	23	72	Long-sleeved shirt, long pants
Staiff	20	0.4	Short-sleeved shirt, long pants
Wolfe	7	9.4	Short-sleeved shirt, long pants

The total of 101 replicates yields a weighted geometric mean exposure of 4.6 mg/hr. The large range of 0.4 to 72 mg/hr around this geometric mean reflects the wide range of exposure that can occur to applicators during ground-boom application. Tractor type and boom equipment can greatly affect exposure. Enclosed cabs provide a physical barrier between the applicator and spray. Wojeck found that shielding the boom yielded lower exposures. Wind can blow spray drift across the applicator and increase exposure. It is reasonable to assume that depending on equipment used, weather conditions, and the personal habits of the applicator, the exposure received during any given application can fall anywhere within this range of 0.4 to 72 mg/hr.

3.3 PILOT AND FLAGGER EXPOSURE

To estimate the dermal exposure to pilots and flaggers, EAB reviewed six studies available in the published literature. To the extent possible it was assumed that the pilots and flaggers wore long-sleeved shirts and long pants. In the Maddy, Peoples, and Mumma studies the actual residue measured under the clothing was used to estimate dermal exposure. Atallah presented his data as calculated dermal exposures that assumed long pants and short-sleeved shirts that completely eliminated exposure to the covered areas of the body. The pilot exposure from the Lavy-82 study was calculated assuming the pilots wore long-sleeved shirts and long pants that completely eliminated exposure to the covered body areas. The Lavy-82 study had an insufficient number of patches to estimate exposure to the legs.

The estimated pilot exposures adjusted to an application rate of 1.0 lb ai/A are presented below.

Study	Replicates	Exposure (mg/hr)
Lavy-82	3	0.10
Maddy	4	0.021
Peoples	11	0.86
Mumma	6	0.80
Atallah	4	0.38

The exposures ranged from 0.021 to 0.86 mg/hr with a weighted
mean exposure of 0.58 mg/hr.

The estimated flagger exposures adjusted to an application
rate of 1.0 lb ai/A are presented below.

Study	Replicates	Exposure (mg/hr)
Maddy	8	0.36
Peoples	9	1.1
Atallah	3	17.2

The flagger exposure ranged from 0.36 to 17.2 mg/hr with a
weighted mean of 3.2 mg/hr. The flagger estimates are for
flaggers standing in the open and attempting to remain upwind of
the spraying. Wind shifts can, and in the studies did, produce
higher exposures.

3.4 HAND SPRAYER EXPOSURE

Hand spray applicator exposure data available to EAB is
limited. One study by K.T. Maddy and H.R. Fong (Monitoring
Worker Exposure to Dinoseb, California Department of Food and
Agriculture, Worker Health and Safety Unit, April 28, 1983,
Report No. HS-1079) monitored worker exposure in which dinoseb
was spot sprayed in orchards. The application method is similar

to the use of atrazine in that one or two individuals walk behind a truck-mounted spray tank spot spraying by handheld wand. Although the application scenario is an excellent surrogate for atrazine use in orchards, the number of replicates (one mixer/loader/ boom applicator and two applicators) is extremely limited.

The study monitored the dermal exposure to a mixer/loader handling 25 lb ai and then boom spraying from a truck in the orchard. The exposure was measured for an individual wearing a long-sleeved shirt, long pants, and protective gloves. The dermal exposure for the mixer/loader was 5.4 mg/lb ai. The first hand spray applicator had a dermal exposure of 195 mg/lb ai. The second applicator had a dermal exposure of 35 mg/lb ai while hand spraying. The mean hand spray exposure was 115 mg/lb ai. Both applicators wore long-sleeved shirts, long pants, and protective gloves. Dinoseb was reported to penetrate the gloves and therefore the exposures may mimic an unprotected hand scenario for the mixer/ loader and applicators. The hand spray applicators were observed to walk through the spray and this was evidenced by the leg exposures accounting for 87 and 76 percent of the total dermal exposure.

The Maddy study may also be used as a surrogate for home lawn application of atrazine by commercial applicators. Data on home lawn application of pesticides is extremely sparse and a more in-depth exposure assessment would necessitate a Data Call-

In (DCI) Notice.

3.5 HOME LAWN GRANULAR APPLICATION EXPOSURE

Homeowner exposure from use of granular fertilizers containing
atrazine can be estimated from one replicate reported by
R.P. Freeburg; W.H. Daniel; and V.J. Konopinski (Applicator
Exposure to Pesticides Applied to Turfgrass, Dermal Exposure
Related to Pesticide Use, American Chemical Society, Symposium
Series 273, 1985, pp. 287 to 295). In this study, an applicator
loaded granular diazinon and applied it by rotary spreader to a
lawn in a manner similar to how atrazine would be applied. The
total dermal exposure to the unprotected individual was 33.5 mg/hr
at an application rate of 5.5 lb ai/A. Atrazine is applied to
lawns at an application rate of 2.1 lb ai/A (34.5 lb Scotts Bonus
S Weed Control Plus Lawn Fertilizer per 7000 ft^2 x 0.99% atrazine
x 1/7000^2 x 43,560 ft^2/A). Adjusting for the application
rate of 2.1 lb ai/A would yield an exposure estimate of 12.8 mg/hr
(33.5 mg/hr x 2.1/5.5). Because the Freeburg study had only one
granular application replicate and hand exposure had to be
estimated by extrapolating from wrist exposure, the exposure
estimate should be considered a "ball-park" estimate. A more
definitive granular exposure estimate would require a DCI Notice.

4.0 ANNUAL NONDIETARY EXPOSURE TO ATRAZINE

4.1 CORN

As previously discussed, atrazine is applied to corn at 2.0 lb ai/A. A grower will handle 390 lb ai in treating 195 acres annually. The required spray time is 8.9 hours. The annual grower exposure when atrazine is applied to corn is as follows:

Mixer/loader - open pour - 0.93 mg/lb ai x 390 lb ai/yr x
1/70 kg = 5.2 mg/kg/yr

Ground boom applicator - 4.6 mg/hr x 2 x 8.9 hr/yr x
1/70 kg = 1.2 mg/kg/yr

Combined - 5.2 mg/kg/yr + 1.2 mg/kg/yr = 6.4 mg/kg/yr

The commercial applicator will treat 6000 acres annually over an 80-hour period. The mixer/loader will handle 12,000 lb of atrazine. If the mixer/loader open pours atrazine, the annual exposure is estimated to be 160 mg/kg/yr (0.93 mg/lb ai x 12,000 lb ai/yr x 1/70 kg). If the mixer/loader uses a closed loading system, the annual exposure would be reduced to 2.6 mg/kg/yr (0.015 mg/lb ai x 12,000 lb ai/yr x 1/70 kg). The applicator would average an annual exposure of 11 mg/kg/yr (4.6 mg/hr x 2 x 80 hr/yr x 1/70 kg). Commercial ground applicators may or may not mix and load the pesticide. If the applicator also mixes and loads, the combined annual exposure would be 170 mg/kg/yr for open pour and 14 mg/kg/yr with use of a closed system.

4.0 ANNUAL NONDIETARY EXPOSURE TO ATRAZINE

4.1 CORN

As previously discussed, atrazine is applied to corn at 2.0 lb ai/A. A grower will handle 390 lb ai in treating 195 acres annually. The required spray time is 8.9 hours. The annual grower exposure when atrazine is applied to corn is as follows:

Mixer/loader - open pour - 0.93 mg/lb ai x 390 lb ai/yr x 1/70 kg = 5.2 mg/kg/yr

Ground boom applicator - 4.6 mg/hr x 2 x 8.9 hr/yr x 1/70 kg = 1.2 mg/kg/yr

Combined - 5.2 mg/kg/yr + 1.2 mg/kg/yr = 6.4 mg/kg/yr

The commercial applicator will treat 6000 acres annually over an 80-hour period. The mixer/loader will handle 12,000 lb of atrazine. If the mixer/loader open pours atrazine, the annual exposure is estimated to be 160 mg/kg/yr (0.93 mg/lb ai x 12,000 lb ai/yr x 1/70 kg). If the mixer/loader uses a closed loading system, the annual exposure would be reduced to 2.6 mg/kg/yr (0.015 mg/lb ai x 12,000 lb ai/yr x 1/70 kg). The applicator would average an annual exposure of 11 mg/kg/yr (4.6 mg/hr x 2 x 80 hr/yr x 1/70 kg). Commercial ground applicators may or may not mix and load the pesticide. If the applicator also mixes and loads, the combined annual exposure would be 170 mg/kg/yr for open pour and 14 mg/kg/yr with use of a closed system.

Aerial mixer/loaders are commonly different individuals from the pilot or flagger. Closed loading systems are more common with aerial operations. Therefore, the annual exposure for an aerial mixer/loader handling 11,150 lb ai/yr is 2.4 mg/kg/yr (0.015 mg/lb ai x 11,150 lb/yr x 1/70 kg). The pilot would treat 5775 A/yr over a 6.3-hour duration of actual spraying. The pilot exposure during atrazine application to corn would average 0.10 mg/kg/yr (0.58 mg/hr x 2 x 6.3 hr/yr x 1/70 kg). Assuming a flagger is exposed for the same period as the pilot, annual flagger exposure is estimated to average 0.58 mg/kg/yr (3.2 mg/hr x 2 x 6.3 hr/ yr x 1/70 kg).

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4.2 SUGARCANE

A ground application team would consist of two individuals, the mixer/loader and the ground applicator. The mixer/loader would handle 6000 lb ai/yr. The annual exposure for the mixer/loader is as follows:

Open pour mixer/loader: 0.93 mg/lb ai x 6000 lb/yr x 1/70 kg
                                  = 80 mg/kg/yr
Closed system mixer/loader: 0.015 mg/lb ai x 6000 lb
                                  ai/yr x 1/70 kg = 1.3 mg/kg/yr

The ground applicator will require 79.2 hours of actual spray time to treat 3000 acres twice annually. At a mean exposure of 4.6 mg/hr at 1.0 lb ai/A, the annual ground applicator exposure will average 5.2 mg/kg/yr.

An aerial mixer/loader using a closed loading system will receive an average exposure of 2.8 mg/kg/yr when handling 13,200 lb ai/yr (0.015 mg/lb ai x 13,200 lb ai/yr x 1/70 kg). The pilot would require 14.2 hours of spray time to treat 13,200 acres at 1.0 lb ai/A. The annual pilot and flagger exposures are as follows:

Pilot: 0.58 mg/hr x 14.2 hr/yr x 1/70 kg = 0.12 mg/kg/yr
Flagger: 3.2 mg/hr x 14.2 hr/yr x 1/70 kg = 0.65 mg/kg/yr.

4.3 MACADAMIA NUT ORCHARDS

The use information indicated that 41 lb atrazine would be required annually to treat a macadamia orchard. A mixer/loader would receive an exposure of 3.2 mg/kg/yr (5.4 mg/lb ai x 41 lb ai/yr x 1/70 kg). The hand applicator would receive an exposure of 67 mg/kg/yr (115 mg/lb ai x 41 lb ai/yr x 1/70 kg) based on one applicator. The exposure would be halved if the spraying were evenly split between two applicators. Based on various scenarios the annual exposures are estimated as follows:

Mixer/loader/driver: 3.2 mg/kg/yr

Mixer/loader/single applicator: 3.2 mg/kg/yr + 67 mg/kg/yr
                                   = 70 mg/kg/yr

Mixer/loader/split application: 3.2 mg/kg/yr + 33.5 mg/kg/yr
                                   = 37 mg/kg/yr

Single applicator: 67 mg/kg/yr
Split application: 34 mg/kg/yr

4.4 TURF-HOME LAWNS

A homeowner is expected to treat a 7000 ft^2 lawn twice annually with granular atrazine-containing lawn products. The two applications would require 1 hour and 12 minutes for loading and application. The estimated exposure for loading and application was 12.8 mg/hr at the atrazine application rate of 2.1 lb ai/A. The annual homeowner exposure is estimated to be 0.22 mg/kg/yr (12.8 mg/hr x 1.2 hr/yr x 1/70 kg).

The commercial mixer/loader would handle 132 lb ai/yr (0.22 lb ai/lawn x 600 lawns/yr), assuming one mixer/loader per applicator. At an exposure rate of 5.4 mg/lb ai the annual mixer/loader

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exposure is estimated to be 10 mg/kg/yr (5.4 mg/lb ai x 132 lb ai/yr x 1/70 kg). The handspray commercial applicator was estimated to receive a dermal exposure averaging 115 mg/lb ai. An applicator spraying 132 lb ai/yr would receive an annual exposure of 220 mg/kg/yr.

5.0 CONCLUSIONS

EAB estimated the annual exposure to mixer/loaders and applicators handling atrazine at representative use sites. The estimates, based on a 70 kg individual wearing a long-sleeved shirt and long pants at all times and protective gloves during mixer loading, are as follows:

Corn - Grower: Open pour M/L - 5.2 mg/kg/yr
                  Applicator - 1.2 mg/kg/yr
                  Combined - 6.4 mg/kg/yr

Corn - Commercial: Open pour M/L - 160 mg/kg/yr

                      Applicator - 11 mg/kg/yr
                      If combined - 170 mg/kg/yr

Corn - Commercial: Closed system M/L - 2.6 mg/kg/yr
                      Applicator - 11 mg/kg/yr
                      If combined - 14 mg/kg/yr

Corn - Aerial: Closed system M/L - 2.4 mg/kg/yr
                  Pilot - 0.10 mg/kg/yr

                  Flagger - 0.58 mg/kg/yr
Sugarcane - Ground: Open pour M/L - 80 mg/yr
                       Closed system M/L - 1.3 mg/kg/yr
                       Applicator - 5.2 mg/kg/yr

Sugarcane - Aerial: Closed system M/L - 2.8 mg/kg/yr
                       Pilot - 0.12 mg/kg/yr
                       Flagger - 0.65 mg/kg/yr

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Macadamia Nuts: M/L/driver - 3.2 mg/kg/yr

M/L/single applicator - 70 mg/kg/yr

M/L/split application - 37 mg/kg/yr

Single applicator - 67 mg/kg/yr

Split application - 34 mg/kg/yr

Commercial Lawn: M/L - 10 mg/kg/yr - No protective gloves

Applicator - 220 mg/kg/yr

Homeowner Lawn: 0.22 mg/kg/yr - No protective gloves

The above estimates have not been adjusted for the dermal absorption of atrazine. As previously stated, the exposure for macadamia nuts and lawn turf uses are based on an extremely weak data base and should be considered as rough estimates of exposure only.

Curt Lunchick 5 January 88

Curt Lunchick
Special Review Section II
Exposure Assessment Branch
Hazard Evaluation Division (TS-769C)

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