Arch. Environ. Contam. Toxicol. 32, 42–49 (1997)

ARCHIVES OF
Environmental
Contamination
and Toxicology

Risk Assessment as a Management Tool Used to Assess the Effect of Pesticide Use in an Irrigation System, Situated in a Semi-Desert Region

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Received: April 1996/Revised: 21 July 1996

Abstract. A preliminary study undertaken by the CSIR in July 1993 on the health effects of aerial crop spraying of pesticides in the Vaalharts irrigation area in South Africa indicated that potential health risks could exist for the inhabitants of this area. An extensive scientific health risk assessment and epidemiological study to determine the actual health risks, is very expensive and requires medical and financial justification. The aim of this study was to develop a theoretical health risk model, which could be used as a predictive tool to determine as accurately as possible from the data available if a complete scientific health risk assessment study is justified. The actual amounts of pesticides sold in the Vaalharts area by two major pesticide manufacturers were used to perform a theoretical health risk assessment. The risks were assessed by making use of RISK*ASSISTANT, a computer modeling system and chemical database. The United States Environmental Protection Agency's (EPA) health risk model was applied to the data to identify the hazards, assess the exposures and dose response, and characterize the risks. Three exposure scenarios, namely, the ingestion of food and water and the inhalation of air were evaluated. The method used to calculate the risks varied according to the type of health hazard and the results were characterized accordingly. The acute health effects due to exposure to pesticides are well known and the risks are easy to determine. However, the risks associated with chronic health hazards were more difficult to calculate. For this reason a ranking model was developed which made use of a point scoring system. This model highlights those pesticides which have the greatest possibility of causing chronic health effects. From the results it can be concluded that very large amounts of pesticides are used in the Vaalharts area and that the community might be at risk to chronic health effects. Although the theoretical health risk assessment model was successfully used in this study, its effectiveness as a predictive tool still has to be proven by a complete scientific study.

Due to an increase in the incidence of neurological and respiratory ailments in the Vaalharts irrigation area, in South Africa, and concern by the local medical practitioners that it may be caused by aerial crop spraying of pesticides, it was decided to use a theoretical risk assessment model as a decision making tool to determine if a full environmental impact study should be done in the area. The aim of this study was to develop a risk assessment model as a quick cost effective tool to predict the possible risks the Vaalharts population groups face when being exposed to the health hazards of aerial crop spraying. It must, however, be understood that such a study can only use the data which is available and that in certain cases, assumptions would have to be made. In cases where data was unavailable or too expensive to obtain the worst case scenario was used. This study is a preliminary measure of uncertainty and probability, and a more accurate health risk assessment can only be done if an in-depth scientific study is undertaken.

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Approach

Due to the fact that no application statistics were available, the predictive model was based on the actual sales figures of pesticides in the area (Appendix A) and catalyzed the selection of a theoretical model over a more accurate and complex modeling system. Three exposure pathways were evaluated, each of which corresponds to a different environmental medium (air, water, and food).

The Environmental Protection Agency (EPA) RISK*-ASSISTANT modelling system and database was used on the modelled scenarios to calculate the potential health risks for each pesticide. RISK*ASSISTANT incorporates an easy-to-use database, which includes information on toxic hazards of chemicals from the U.S. Environmental Protection Agency's database of risk assessment and risk management information, the Integrated Risk Information System (IRIS) and, for chemicals not yet covered by the IRIS, from the Health Effects Assessment Summary Tables (HEAST) published quarterly by the EPA.

Each scenario was evaluated, using conservative assumptions and may, therefore, overestimate risks for some individuals. The calculated risk estimates should be viewed as crude approximations.

The United States Environmental Protection Agency's (USEPA) health risk assessment model was used to provide the structure of the study and includes:

1. hazard identification,
2. exposure assessment,
3. dose-response assessment,
4. risk characterization.

Health Risk Assessment Methodology

Hazard Identification: Both the concentration of a pesticide and its formulation determine whether it is a hazard or a remedy (Appendix A). The higher the concentration of active ingredient the more hazardous it becomes. A pesticide formulated as a solution or as an emulsifiable concentrate is, as a rule, more hazardous than when formulated as a dust or as a wettable powder. The classification of a pesticides toxicity is based on the dermal, oral and inhalation toxicity of the active ingredient(s) in the formulation with due observance of additional information regarding systematic accumulation, chronic poisoning, carcinogenicity, teratogenicity, mutagenicity etc., (Vermeulen *et al.* 1990).

Information about the acute health effects of specific pesticides on mammals in laboratories under controlled conditions is widely available and relatively well understood. However, the state of knowledge regarding the acute, subchronic, and chronic effects of many pesticides on humans is not all clear, especially where the pesticides are used in varying temperatures and other weather conditions or when used with a range of other chemicals, possibly interacting with medicines that workers and the community might be taking (Watterson 1988).

The Vaalharts irrigation area is a very intense farming community with about 29,000 inhabitants who could be exposed to pesticides when spray drift and pesticide residues in food and water are considered. What effect ''low levels'' of pesticide have on individuals is unclear, but pesticide residues are commonly found in human tissue, and in the United States virtually everyone has some pesticide residue, averaging 6 mg per kg fatty tissue (Watterson 1988).

Pesticides can cause various neurological changes in humans and have been linked to parkinsonism, have been correlated with hypertension and cardiovascular disease and can affect blood cholesterol and serum vitamin A levels. Some pesticides can reduce fertility and may cause sterility. Other effects relate to blood conditions, allergies, possible liver disease and links with teratogenicity, mutagenicity and cancer. Household spraying of pesticides has been linked to leukaemia in young children around Los Angeles. Skin problems are a particular hazard for pesticide users. Some researchers have found that the signs and symptoms of neurological damage after exposure to pesticides were not solely linked to acute and chronic poisoning by organophosphorous chemicals, but followed exposure to organochlorine pesticides, carbamates, various fungicides and other pesticide groups too. The precise effects of pesticides on the immunological system are also not known (Watterson 1988).

Pesticides are used on a large scale in the Vaalharts area, ±120,000 kg of formulated pesticides a year, and this is directly related to the large number of organophosphate poisoning cases reported annually. Acute organophosphate poisoning is easy to identify but to link the chronic and subchronic diseases to pesticide use is a much more complex task (Raschke *et al.* 1993).

Exposure and Dose-Response Assessment: The potential health hazards that exist in the Vaalharts irrigation area include the pesticides (insecticides, fungicides, herbicides, etc.) listed in Appendix A. This list includes the quantities of the pesticides sold by the two major suppliers of pesticides in the area. The representatives of these companies sell directly to the farmers who make up their own mixtures for application.

This model describes the following exposure pathways:

1. inhalation,
2. ingestion of water,
3. ingestion of food.

The most important exposure mediums or sources include:

1. food (fruit, vegetables and cereals),
2. outdoor air,
3. surface water.

Due to the fact that application data was unknown, the use of a theoretical health risk assessment model required that assumptions had to be made in certain cases. An attempt was made to ensure that all assumptions made were as realistic as possible and in a case where little or no data was available, a worst-case scenario was used. The following list includes a few of the major assumptions made:

1. All of the pesticides listed in Appendix A that may legally or practically be applied by aerial spraying and they constitute the total amount of pesticides sprayed in the area.
2. Each pesticide is evenly sprayed over the entire area (over each farm) and the quantity is, therefore, divided over an area of 32,000 ha.
3. Pesticides were applied individually and no mixtures were used.
4. Health risks associated with adjuncts, carriers or wetting agents were perceived to be negligible.
5. To determine the concentration of pesticide in a specific crop the following calculations were used:

$$M_a = M_r * A_a$$

$$P_c = M_a/(\text{area} * \text{crop yield}),$$

where M_a = total mass of active ingredient, M_r = total mass of formulation used, A_a = concentration of active ingredient in formulation, and P_c = concentration of pesticide in a crop.

To determine the concentration of pesticide per hectare, it is divided by 32,000 (assumed area which is sprayed). It is also divided by 3,000 (assumed average mass of a crop produced per hectare—obtained from the average yields published by Viljoen *et al.* 1992) to obtain the concentration per kilogram of crop. It is assumed that all the pesticide sprayed reaches the crop.

6. To determine the actual concentration of pesticide consumed, it is assumed that a 70-kg man ingests 100 g (taken from the generic amount—see below) of the food. From this

value a comparison can be made with the ADI (Acceptable daily intake) for a specific pesticide.

The 100 g of food is the total amount of contaminated food consumed. For the sake of this study, it is assumed that the food is homogenous and contains the same concentration of pesticides.

In reality, the total dietary exposure, E_t, that results from eating a combination of contaminated food is calculated as follows (USEPA 1986 in USEPA 1989):

$$E_t = \sum_{i=1}^{n} (C_f)_i (L)_i,$$

where C_f = the concentration (mg/kg) of the pollutant in the food at the time of consumption, L = the amount (kg/day) of contaminated food consumed, and I = the number of different food types consumed.

In order to perform this calculation, C_f, or the contaminant concentration in the food, i, must be known. $(L)_i$ is selected from tables in the literature. If specific contaminated foods are not known, the generic amounts are considered (*i.e.,* 50 g/day for vegetables, 28 g/day for fruits and 22 g/day for cereals).

7. Due to the large variety of pesticides and the wide differences in the manner in which various compounds are used any generalization about the impact of pesticide chemicals on the atmosphere is made impossible when they are considered as a generic group. The problem of assessment is also further compounded by the lack of any general data on the concentrations actually to be found in the air. The lack of data does not, however reflect any lack of concern, but rather the technical difficulties of measuring the concentrations and the difficulty of sampling the atmosphere on the scale necessary to obtain meaningful data.
8. The volume of air was calculated by multiplying the total area of the plots (32,000 ha) with the chosen calculated maximum and minimum mixing heights respectively, ignoring the irregular shape of the area (see Figure 1).

Below is an example of how the concentration of parathion in air was determined for a worst-case scenario.

Example: Calculated minimum mixing height for the year = 49 m

$$\text{Area} = 320{,}000{,}000 \text{ m}^2$$

$$\text{Volume} = 49 * 320{,}000{,}000$$

$$= 15 * 168{,}000{,}000 \text{ m}^3$$

$$\text{Total amount of active ingredient used} = 2979.7 \text{ kg}$$

$$\text{Concentration of pesticide in air} = 2979.7/15 * 168{,}000{,}000 = 196.5\ \mu\text{g/m}^3$$

The population of the Vaalharts area is 29,140 individuals (Population Census 1991). Most of the people living in this area are actively involved in either primary or secondary activities derived from intense farming. The majority of the people are black and the various lifestyles of each population group should be taken into account when doing a scientifically based, in-depth health risk assessment. For a theoretical risk assessment focusing on a hypothetical worst case scenario we can, however, disregard such a heterogenous population group and consider that the population is homogenous. Thus, every person is presumed to eat the food grown in the area, drink the water from the local river (Harts River) and inhale the air in the area for 365 days a year for 70 years.

Certain individuals are more susceptible to risks due to pesticide poisoning than others because of certain external factors such as occupation, age, sex, and residential location. People who work with the pesticides are regarded as the high risk groups, followed by children and the aged and infirmed, due to their physiological susceptibility. Risks will vary due the location of certain people, *i.e.,* the farmers are more susceptible to aerial spraying than those living in the towns, and people who live in the area their whole lives are at greater risk than those who stay only a short while. The accuracy of the exposure assessment is a primary determinant of the soundness of the risk assessment, and it is therefore advisable to use environmental data and actual population counts in preference to literature values or estimates. The upper limits of exposure and population size should be used to provide maximum protection of public health.

Risk Characterization: The method used to calculate risk varies according to the type of health hazard. In this health risk assessment, the risks are posed by chemicals having a threshold mode of action.

The sources of pesticide exposure taken into consideration in this study were via air, water, and food, and only those pesticide formulations that are legally allowed to be sprayed aerially were considered. The risks associated with these exposures were characterized by:

- Comparing the ADI and ingested concentrations for each pesticide and highlighting those pesticides which surpass those limits. When comparing the pesticide concentrations in food with the ADI as a measure of the potential risk the following pesticides sprayed in the Vaalharts area are characterized as being potentially dangerous: Chlorothalonil, 2,4,5,6-tetrachloro-1,3-benzenedicarbonitrile, and Methamidophos, *O,S*-dimethyl phosphoramidothiate (2 × the ADI), Paraquat, 1,1′-dimethyl-4,4′-bipridinium (3 × the ADI), Parathion, *O,O*-diethyl *O*-(4-nitrophenyl) phosphorothioate (8 × the ADI), Monocrotrophos, (*E*)-dimethyl 1-methyl-3-(methylamino)-3-oxo-1-propenyl phosphate (50 × the ADI), and Fenamiphos, ethyl 4-(methythio)phenyl (1-methylethyl)phosphoramidate (60 × the ADI).
- For agents that cause noncancer toxic effects when ingested a hazard index (HI) is calculated, which compares the predicted dose of the agent (Average Daily Dose) to a dose that is assumed not to be associated with toxic effects (Reference Dose). Hazard Indices of <1.0 are generally considered by the EPA to be associated with low risks on noncancer toxic effects, but extreme caution must be used in interpreting the Hazard Indices. The following pesticides, having a HI > 1.0, are considered as being hazardous to human health when consumed in water and food according to the assumptions made:

Dimethoate, *O*,*O*-dimethyl *S*-[2-(methylamino)-2-oxoethyl]phosphorodithoate, Parathion and MCPA, (4-chloro-2-methylphenoxy) acetic acid ($1 < HI < 10$), Methamidophos, Fenamiphos, and Endosulfan, 6,7,8,9,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3- benzodioxathiepin 3-oxide ($HI > 10$).

- The pesticides exceeding the concentration limits (AALGs) for air, based on Calabrese and Kenyon (1991) were: Mancozeb, [[1,2-ethanediylbis[carbamodithioato]](2-)] manganese mixture with [1,2-ethanediylbis[carbamodithioato]]-2-)]zinc, Demeton-*S*-methyl, s-[2-(ethylthio)ethyl]*O*,*O*-dimethylphosphorthioate, Parathion, Monocrotrophos, Fenamiphos, and Endosulfan.
- Certain chemicals may cause cancer if ingested and/or inhaled, and this risk can also be calculated by RISK*ASSISTANT. If the calculated risk is 1×10^{-6} (or 1E-006), this would literally suggest that a person would have a one-in-a-million chance of getting cancer because of a specific chemical exposure, in addition to their chance of getting cancer from other causes. The EPA generally considers risks below 1×10^{-6} to be low, but extreme caution must be used when interpreting the results of the analyses. The following chemicals could have an inherent cancer risk if ingested via food and water and are characterized according to the weights of evidence and carcinogen risk factors: Alachlor, 2-chloro-*N*-(2,6-diethylphenyl)-*N*-(methoxymethyl)acetamide, Atrazine, 6-chloro-*N*—ethyl-*N′*-(1-methylethyl)1,3,5-triazine-2,4-diamine, Chlorothalonil, Dichlorvos, 2,2-dichloroethenyl dimethyl phosphate.

The sum of the exposure pathways for air, water, and food determines the total exposure. This can be reported by taking into account each pesticide individually or by calculating the sum of all the pesticides. To investigate the impact a specific exposure pathway contributes to health risks, the total exposures for two pesticides, used extensively in the Vaalharts area, was determined and represented in Table 1.

The exposure to pesticide residues of parathion via inhalation is approximately 56% of the total exposure, the intake of food accounts for 30% and drinking water about 14%.

Considering the large amounts of pesticides (120,000 kg) sprayed in such a small area (32,000 ha), it is very difficult to determine to what extent these pesticides contribute to human health risks. This is due to the fact that interaction and synergistic effects occur between pesticides and their metabolites which could increase the potential health risks. The pesticides indicated in Table 1, pose a potential health risk, due to the fact that they are used in such large quantities. Every substance is either a remedy or a poison—it is only the concentration that separates the two. This risk assessment has taken into account each pesticide, its exposure pathway and its health hazards individually.

It must be clearly understood that these indices of hazards and representations of risk are for pesticides that do not biologically degrade to components which are less hazardous, or in some cases to metabolites which are even more toxic than the active ingredient. To determine whether the risks have been over- or underestimated due to this assumption, the half-life and environmental effects of each pesticide characterized above, will be discussed. The shorter the half-life of the pesticide and the less that is absorbed by the body, the smaller the health risks.

The pesticides used in the Vaalharts irrigation have been characterized according to certain criteria and a few have been highlighted as being a greater hazard and more of a risk to human health than others. If handled incorrectly or carelessly, most pesticides provide a high degree of risk to acute health diseases. Pesticides can be ranked fairly easily according to their acute health risks due to the large amount of data available on acute hazard effects. An effort has been made to develop a scoring system for chronic health risks. The potentially hazardous pesticides were ranked so as to determine which individually contribute to greater chronic health risks. The scoring system was set up according to the classification of each

Table 1. The total exposure levels for certain pesticides in the Vaalharts area

Active Ingredient	From Food (mg/kg)	From Air (mg/m^3)	From Water (mg/L)	Total Exposure[a] (mg/day)
Monocrotrophos	21.315	0.111	0.213	6.443
Parathion	31.040	0.160	0.621	10.124

[a] If 100 g of contaminated food is consumed per day
If 2 l of river water is consumed per day
If 35 m^3 of air is inhaled per day
Thus, total exposure to pesticides by the community of Vaalharts = (X mg/kg food $*$ 0.1) + (Y mg/m^3 air $*$ 35 m^3) + (Z mg/L $*$ 2l)
Example. For parathion the total exposure per day was

$$= (31.04 * 0.1) + (0.160 * 35) + (0.621 * 2)$$
$$= 3.104 + 5.6 + 1.42$$
$$= 10.124 \text{ mg/day}$$

Table 2. Method of points scoring for the system of ranking pesticides according to their chronic health risks

Category	0 Points	1 Point	2 Points
1. Hazard class	Class O, III & II	Class Ia & Ib	
2. Pesticide class		Organochlorines	
3. Conc. of pesticide inhaled vs AALG		>AALG	
4. HI in food & water	HI <1	HI = 1–10	HI = 10–100
5. Concentration of pesticide found in food, air and water after application	food—<10 mg/kg water—<0.1 mg/kg air—<0.1 mg/m^3	food—>10 mg/kg water—>0.1 mg/kg air—>0.1 mg/m^3	
6. Biodegradation half-life in the environment	0–1 months	1–3 months	>3 months
7. Conc. of pesticide consumed in food vs ADI	<ADI	>ADI by 1–10×	>ADI by 10–100×

Table 3. Risk scores of pesticides used in the Vaalharts area, ranked in descending order

Active Ingredient	Risk Score
Parathion	9
Fenamiphos	9
Monocrotophos	7
Endosulfan	6
Methamidophos	5
Chlordane	5
Chlorothalonil	4
MCPA	4
Demeton-S-methyl	4
Dimethoate	3
Mancozeb	3
Dichlorvos	2
Bromoxynil	2
Alachlor	1

pesticide and the concentration at which it was used in the Vaalharts area. The points were allocated as shown in Table 2. Table 3 ranks the pesticides used in the Vaalharts area in descending order according to their chronic health risks. The maximum possible score is 12 and indicates a very high level of concern. Low scores indicate a low level of concern, but still a potential risk. This scoring system succeeds in highlighting out of all the pesticides used in the area, those that may be the cause of concern. This allows for integrated scientific studies which are focused on the potential source of the alleged problems.

Conclusions

Over 70 different chemicals (active ingredients) are used in more than 140 pesticide products sold in the Vaalharts irrigation area. This amounts to over 120,000 kg of pesticides which may be released annually in an area no larger than 32,000 ha.

Due to the large amounts of pesticides used in the area, farm workers, laborers, and aerial crop spraying pilots and co-workers may be at high risk of acute pesticide poisoning if safety and preventative measures are not correctly implemented.

The community of Vaalharts may be at risk for chronic pesticide poisoning resulting in respiratory and neurological diseases, and liver, kidney, and blood disorders. Active ingredients in certain pesticides which rate high on the list of chronic health risks include: parathion, fenamiphos, monocrotophos, chlordane, methamidophos, and endosulfan.

The most significant exposure pathway is via the inhalation of air, which contributes ca. 50–70% of the total exposure. This may explain the increase in the incidence of respiratory and neurological ailments in Hartswater. Food and water contribute ca. 25–40 and 5–15%, respectively. This can however, vary due to the fact that not all the food and water consumed is obtained directly from the environment. Food is washed, peeled, cooked, or processed and the water is mainly obtained from municipal water.

Under normal conditions the total amount of pesticide residues available for exposure to humans will be much lower. This assessment highlights a worst possible case, and only gives an indication of the outer limits that could be achieved.

The aerial crop spraying and use of pesticides in the Vaalharts area may pose realistic acute and chronic health problems for the community and the environment. An integrated, scientifically based environmental risk assessment and epidemiological study is essential to assess the risks more thoroughly, so as to determine more accurately to what extent pesticides have an effect on human health in the Vaalharts area.

The health risk model described in this study may be used as a decision making tool to predict those pesticides that may pose a problem in the area. The identification of a large group of pesticides may provide justification for an integrated scientific and epidemiological study.

Discussion

Risk assessment is very subjective and is only as accurate as the information that is available. Risks are likely to change when more information on a specific situation is obtained. If a risk assessment has been determined subjectively, one must always seek to find additional information to improve the assessment. As technology increases and more experience is gained in the field of risk assessment, the closer one will come to determining the absolute risks. The methodology used to determine the risks associated with the aerial crop spraying of pesticides in the Vaalharts area is very simplistic and based on educated assumptions. In spite of this a solid risk assessment foundation has been created for further studies in this field.

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Appendix A

Pesticides Supplied by Company A for the 92/93 Season

Trade Name	Active Ingredient	Amount Sold
Afalon 450 Sc	Linuron	20 L
Antracol 70 WP	Propineb	167 kg
Baytan	Triadimenol	40 kg
Basagran	Bentazone	265 L
Bayfidan 250 EC	Triadimenol	106 L
Baygon EC	C + D + P	70 L
Baygon Green	C + D + P	3.75 kg
Baygon Yellow	C + D + P	8.75 kg
Baygon Fly Bait	C + D + P	22 kg
Bayleton A	Triadimefon	1.2 kg
Bayleton EC	Triadimefon	468 L
Baytan	Triadimefon	1,250 L
Baythion ant killer	Phoxim	6 L
Baythroid H WP	Cyfluthrin	8.24 kg
Baythroid Oso EC	Cyfluthrin	1 L
Bestox	Cypermethrin	221 L
Buminal	Protein hydrolysate	40 L
Bulldock		59 L
Buctril	Bromoxynil	892.5 L
Combi 6	Dimethylamine	200 L
Cupravit 85 WP	Copper oxychloride	987 kg
Dacthal	Chlorthal-dimethyl	290 kg
Decis	Dentamethrin	671 L
Demildex 85 WP	Mancozeb	191 kg
Dithane M45	Trichlorfon	7 kg
Dipterex	Diuron (urea)	48 kg
Diuron 800 SC		230 L
Eptam Super	EPTC	1,090 L
Focus Ultra	Cycloxydim	170 L
Folicur 125 EW	Terbuconasol	353 L
Folicur 250 EW	Terbuconasol	204.5 L
Folicur 250 EC	Terbuconasol	368 L
Folithion 250 EC	Fenitrothion	100 ml
Gaucho	Imidacloprid	220 kg
Gramoxone	Paraquat	630 L
Guardian	Acetochlor	1,272.5 L
Harness	Acetochlor	1,931 L
Lasso	Acetochlor	230 L
Lebaycid 500 EC	Fenthion	16 L

Appendix A. *Continued*

Trade Name	Active Ingredient	Amount Sold
Magsol	Magnesium chlorate	2,022 kg
MCPS	MCPA Potassium	578.65 L
Metasystox R	Demeton-S-methyl	4.7 L
Monceren	Pencycuron	35 L
Morestan	Quinomethionate	4 kg
Nimrod EC	Bupirimate	6 L
Pree	Metazachlor	70 L
Racumin	Coumatetralyl	2.88kg
Raxil	Terbuconasol	300 L
Recoil	Mancozeb & Oxadixyl	125 kg
Ridder EC	Glyphosate	8.6 L
Ridder Ready to use		500 ml
Ronstar	Oxadiazon	40 L
Roundup	Glyphosate	240 L
Sancoz EB		350 kg
Sencor	Metribuzin	10 L
Sencor	Metribuzin	2 kg
Sting	Glyphosate	370 L
Thiulin	Thiram	15.36kg
Terbo	Bromoxynil &	705 L
Totril	Terbuthylazine	20 L
Treffer	Ioxynil octanoate	518 L
	Trifluralin	
Ustilan 10 GR	Ethidimuron	150 kg
Ustilan 70 WP	Etidimuron	250 kg
Azodrin	Monocrotophos	8 L
Curaterr	Carbofuran	13,925 kg
Dedevap 1000 EC	Dichlorvos	12.5 kg
Folimat 800 SL	Omethoate	192.45 L
Gusathion	Azinphos-ethyl	75 L
Metasystox	Demeton-S-methyl	873.83 L
Nemacur	Fenamiphos	1,325 L
Nemacur	Fenamiphos	6,925 kg
Nuvacron	Monocrotophos	5 L
Parathion	Parathion	1,388 L
Tamaron	Methamidophos	169 L
Thiodan	Endosulfan	370.75 L

Plant and Pest Control Agents Supplied by Company B during 92/93 Season

Trade Name	Active Ingredient	Quantity
Acarol	Bromopropylate	27 × 2 L
Chlordasol	Chlordane	11 × 5 L
Counter	Terbufos	195 × 15 kg
Curaterr	Carbofuran	785 × 25 kg
Cypermethrin	Cypermethrin	264 × 1 L
Cypermethrin	Cypermethrin	284 × 100 L/ml
Demeton-S-methyl	Demeton-S-methyl	43 × 25 L
Demeton-S-methyl	Demeton-S-methyl	4 × 5 L
Demeton-S-methyl	Demeton-S-methyl	2,423 × 100 L/ml
		26 × 5 L
Dimethoate	Dimethoate	53 × 100 L/ml
Dimethoate	Dimethoate	
Endosulfan	Endosulfan	11 × 25 L
Endosulfan	Endosulfan	1 × 1 L/L
Fenvalerate	Esfenvalerate	826 × 1 L
Carbadust	Carbaryl	75 × 25 kg
Lannate	Methomyl	8 × 5 L
Lannate	Methomyl	2,006 × 100 L/ml
Lebaycid	Fenthion	7 × 2 L
Lebaycid	Fenthion	22 × 2 L/L
Meothrin	Fenpropathrin	8 × 5 L
Meothrin	Fenpropathrin	8 × 1 L
Meothrin	Fenpropathrin	4 × 1 L/L
Mevinphos	Mevinphos	4 × 5 L
Mevinphos	Mevinphos	2 × 5 L/L
Monostem	Monocrotophos	76 × 5 L
Monostem	Monocrotophos	106 × 25 L
Monostem	Monocrotophos	20,726 × 100 L/ml
Nasiman	Protein hydrolysate	1 × 25 L
Nemesis	Pyriproxyfen	82 × 2 L
Oncol 200	Benfuracarb	17 × 25 L
Parathion	Parathion	14 × 5 L
Parathion	Parathion	102 × 25 L
Parathion	Parathion	19,514 × 100 L/ml
Samurai	Esfenvalerate	2 × 1 L
Samurai	Esfenvalerate	289 × 100 L/ml
Sumicidin	Fenvalerate	10,222 × 100 L/ml
Sumicidin	Fenvalerate	69 × 1 L
Sumicidin	Fenvalerate	55 × 5 L
Trichlorfon	Trichlorfon	25 × 2 kg
Trichlorfon	Trichlorfon	4 × 20 kg
Clortosip	Chlorothalonil	19 × 5 L
Clortosip	Chlorothalonil	2 × 5 L/L
Calirus	Benodanil	23 × 1 kg
Dimeldex	Copper Oxychloride	8 × 25 kg
Ifax	Mancozeb	4 × 5 kg
Olymp	Flusilazole	4 × 1 L
Punch C	Flusilazole Carbendasim	361 × 2 L

Appendix A. *(continued)*

Trade Name	Active Ingredient	Quantity
Punch C	Flusilazole Carbendasim	22,194 × 25 L/ml
Punch Extra	Flusilazole Carbendasim	28 × 2 L
Punch Extra	Flusilazole Carbendasim	7 × 2 L/L
Sancozeb	Mancozeb	53 × 25 kg
Sancozeb	Mancozeb	92 × 1 L/kg
Sumisclex	Procymidone	64 × 5 L
Thiram	Thiram	14,945 × 60 g
Vydate	Oxamyl	393 × 5 L
Ethephon	Ethephon	16 × 5 L
Harvade	Dimethipin	4 × 5 L
Harvade	Dimethipin	238 × 1 L/L
Kelpak	Cytoquinine	783 × 1 L/L
Kelpak	Cytoquinine	132 × 25 L/kg
Magnisal	Magnesium nitrate	36 × 25 kg
Magnisal	Magnesium nitrate	132 × 25 L/kg
Magsol	Magnesium chlorate	7 × 32 kg
Magsol	Magnesium chlorate	203 × 1 L/kg
Sodium molibdate	Sodium molibdene	28 × 2 kg
Sodium molibdate	Sodium molibdene	51 × 2 L/kg
Sodium molibdate	Sodium molibdene	31 × 1 kg
Sodium molibdate	Sodium molibdene	78 × 1 L/kg
Sodium molibdate	Sodium molibdene	5 × 500 g
Sodium molibdate	Sodium molibdene	82 × 500 L/g
Sodium borate	Sodium borate	15 × 25 kg
Assert	Imazamethabenzmethyl	3 × 25 L
Atrazine	Atrazine	19 × 20 L
Basagran	Bentazone	3 × 5 L
Basagran	Bentazone	29 × 25 L
Bladex Plus	Atrazine/Cyanazine	4 × 25 L
Bromoxynil	Bromoxynil	35 × 25 L
Bromoxynil	Bromoxynil	4 × 5 L
Bromoxynil	Bromoxynil	1,329 × 100 L/ml
Diuron	Diuron	2 × 20 L
Eptam Super	EPTC	82 × 20 L
Gallant	Haloxyfop	56 × 5 L
	Tibenuronmethyl	70 × 500 g
Granstar	Tibenuronmethyl	10,668 × 1 L/g
Granstar		27 × 25 L
Gramoxone	Paraquat	53 × 5 L
Gramoxone	Paraquat	16 × 25 L
Guardian	Acetochlor	16 × 5 L
Guardian	Acetochlor	
Harness	Acetochlor	140 × 25 L
Harness	Acetochlor	203 × 5 L
Harness	Acetochlor	4 × 5 L/L
Hammer	Imazethapyr	64 × 10 L

Appendix A. *(continued)*

Trade Name	Active Ingredient	Quantity
Hammer	Imazethapyr	214 × 5 L
Hyvar X	Bromacil	14 × 2 kg
Lasso	Alachlor	3 × 25 L
Linex	Linuron	2 × 5 kg
MCPA	MCPA	24 × 25 L
MCPA	MCPA	297 × 1 L/L
Roundup	Glyphosate	18 × 25 L
Roundup	Glyphosate	39 × 5 L
Roundup	Glyphosate	14 × 1 L
Simazine	Simazine	6 × 5 L
Sting	Glyphosate	17 × 25 L
Sting	Glyphosate	22 × 5 L
Treffer	Trifluralin	105 × 20 L
Treffer	Trifluralin	19 × 5 L
Treffer	Trifluralin	40 × 2 L
Totril	Ioxynil	3 × 5 L