# Section 7

# AGRICULTURAL ASSESSMENT

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## 1. INTRODUCTION

### 1.1 Performance questionnaires

The NRA chose to gain information on the agricultural aspects of the use of atrazine by surveying various groups involved as advisers, users and registrants of the chemical. This was done by sending Performance Questionnaires to State co-ordinators, commodity and industry organisations, users and registrants. The purpose of the questionnaire was to gather information on use, performance, changed agricultural practices, adverse effects and trade and residues. The results form part of the efficacy report which appears in this section.

### 1.2 General use pattern and cropping systems

Atrazine is one of the most widely used herbicides in Australian agriculture. It has been extensively used in Australia since the late 1970s for the pre- and post-emergent control of annual grasses and broadleaf weeds in summer crops such as sorghum, maize, sweetcorn and millet and during the fallow phase before the planting of wheat and lupins. Atrazine is extensively used immediately after wheat harvest to provide weed control for the full length of the fallow before the sowing of sorghum (normally 10 - 12 months), replacing from five to eight cultivations (Bos *et al*). It is also used in sugarcane, in plantation forestry establishment and on lupins in WA. A relatively new major use is on triazine tolerant canola.

The introduction of herbicides such as atrazine and developments in machinery technology in the 1970s allowed the development of no-till and conservation tillage fallowing techniques. Conventional tillage totally disturbs the soil surface and buries crop residue but in the new systems, herbicides replace tillage for weed control. With no-till systems, the only soil disturbance is that required to sow the crop (Bos *et al*, 1995) and with conservation tillage, a minimum of 30% of the soil surface is left covered with crop residue after planting (Fawcett *et al*, 1994).

Another feature of these systems is the move away from continuous wheat cropping to crop rotations involving a range of winter and summer crops. These rotations are designed to maintain soil fertility, control disease, maximise the utilisation of rainfall, reduce run-off and reduce soil erosion (Bos *et al*, 1995; Fawcett *et al*, 1994).

According to Bos *et al* (1995), current cropping systems in Australia vary between regions but the general production systems are based on the ley farming system of a crop/pasture sequence, although the length of each sequence and crops sown may vary. In general, growers tend to rotate wheat cropping with legumes (peas, lupins, canola) or sorghum and a fallow and/or pasture period.

In the summer rainfall areas of northern NSW and southern and central Queensland, cropping involves the growth of both summer and winter crops with periods of fallow in between for the replenishment of soil moisture. The main crops grown in these areas are wheat and grain sorghum. Other winter crops include canola and lupins and summer crops include maize and millet. Livestock production is largely limited to the grazing of grain sorghum stubble and green oats. In the winter and uniform rainfall areas of NSW, canola and lupins are being introduced to replace one to two of the cereal crops.

In Victoria, in the Mallee region, the fallow period after harvesting wheat is often followed by a planting of oilseeds such as canola. In the North-East of the State, the crop-pasture sequence may extend up to eight or nine years with cereals, canola and lupins. Some farmers continuously crop with a rotation of wheat/wheat/lupins/lupins.

In Western Australia, the ley farming system is practised throughout the cereal cropping regions, except for some areas of the south-west where almost permanent annual pasture is grown, continuous cereal cropping in drier eastern areas and continuous cropping using grain lupins and cereals on light acidic soils.

A consequence of these systems of production is that atrazine is not usually used on the same area of land for two years running. Growers alternate atrazine tolerant crops with those that are not (such as wheat) so do not apply atrazine prior to planting these more sensitive crops. The label warns that crops, other than those recommended on the label, should not be planted for at least 18 months following treatment at rates of up to 3.25 kg ai/ha. Where rates above this are used, plantings may not be possible for very long periods.

## 2. EFFICACY ASSESSMENT

### 2.1 Introduction

One aspect of the contemporary assessment standards with which chemicals must comply in order to achieve and maintain registration is that use of products containing the chemical in accordance with the recommendations approved by the NRA for its use must be effective according to criteria determined by the NRA for the product.

Growers, commodity organisations, State departments of agriculture and the chemical industry have been surveyed for information on the performance of the chemical in the field, addressing aspects such as management strategies, methods of application and chemical failures. In particular, information has been sought on whether the way in which the chemical is presently used is the same as when it was first registered and whether the current label directions are still applicable.

These matters have been examined and the results presented in the following report.

## 2.2 Current usage

### 2.2.1 Registration status

Details of currently registered products and uses are available on pages 46 and 666, respectively.

### 2.2.2 Broadacre crops (sorghum, canola, broom millet, maize and sweetcorn) and sugarcane

Across Australia, in 1995-96, estimated total production and area planted of various crops, on which atrazine is registered for use, is shown in the following table:

| Crop | Total Production (Kt) | Area Planted (000 ha) |
|---|---|---|
| Sorghum | 1 725 | 652 |
| Lupins | 1 429 | 1 308 |
| Canola | 645 | 406 |
| Maize | 304 | 63 |
| Sugarcane (cut for crushing) | 36 759 | 385 |
| Sugar | 4 854 | - |

(source: ABARE, September 1996).

As an indication of the proportion of these crops treated with atrazine, NSW Agriculture advised in September 1995 that about 75% of its last sorghum crop (147,000 ha) and 90% of maize (22,000 ha) were treated with atrazine. Annual atrazine use on sugarcane has been estimated at 331 tonnes (Hamilton and Haydon, 1996).

Atrazine is applied to the summer cereals mostly pre-emergence, with some post-emergence application. Application tends to occur as follows:

- Lucerne - one application per year in spring/early summer;
- Maize/sweet corn - usually pre-emergence or very early post-emergence in late spring/early summer;
- Fallow - one application only. - one application per season;
- Sorghum - pre-plant and/or crop post-emergence. Combined with fallow application - max. of two applications; and

- Sugarcane - up to 3 applications per year over a 6 month period during spring/summer/autumn.

Atrazine is mainly used on maize and sorghum in New South Wales and Queensland. Its main use is for chemical fallow in Victoria, while in WA its main use is on lupins (Bos *et al*, 1995). Atrazine is increasingly used on triazine tolerant (TT) canola (not on the label) and a permit is currently in place to facilitate this. Estimated production of canola rose from 170 Kt in 1991/92 to 645 Kt in 1995/96 (ABARE, 1996).

Production of sorghum and the millets is largely concentrated in the uniform and summer rainfall areas between latitudes 17$^{o}$S and 33$^{o}$S and grown under dryland conditions, although some crops are irrigated. Most maize grown in Australia is concentrated in the eastern coasts and tablelands (Bos *et al*, 1995).

Sugarcane is grown in small areas of mainly alluvial soils along the Queensland coast, in northern New South Wales and increasingly in the Ord River irrigation area in WA.

Atrazine is used, as a mix with simazine, to control weeds in germinated lupins (not prior to sowing, as specified on the label).

Most growers use atrazine in conjunction with a knockdown chemical (such as glyphosate) which controls emerged weeds.

### 2.2.3 Plantation forestry

The States of Victoria, New South Wales, South Australia, Western Australia and Tasmania support over 1 million ha of plantation forest, of which about 88% is softwood. Plantation softwood is usually grown as monocultures to provide wood products for shelter, packaging, communication and personal care products on 30 - 35 year cycles, within which herbicides are used for the first 1 - 3 seasons. Three major regional concentrations (SE South Australia/SW Victoria, Softwood region of NSW and SE Queensland) account for 50% of the area established to softwood. Other smaller but economically significant softwood plantation regions are in each state or territory except the NT. (Clark, 1995).

About 136,000 ha of eucalypt plantations have been established in Australia, just over 10% of the total plantation area. Most eucalypt plantations are managed on short rotations of 10 - 20 years for pulp production (Clark, 1995).

Atrazine is used in the forestry industry as a pre-plant spray on new plantations of *P pineaster* and *Eucalyptus spp.* (under NRA permit) to give the 3 - 6 months of weed control required to obtain successful plantation establishment. It is applied in autumn to freshly cultivated sites prior to winter/spring planting and immediately after planting in areas not sprayed prior to planting. Where there is significant grass competition, atrazine is applied annually in plantations up to 3 years old. Glyphosate (or other knockdown herbicides) are often added to the mix if a small proportion of green weeds exist in pre-plant operations.

#### 2.2.3.1 Forest herbicide research management group.

The issue of water contamination by atrazine was raised by the State departments of agriculture and the NRA in August, 1993. Following investigations, a set of amendments to use patterns in Australia were proposed and submissions were sought from the plantation forestry industry on the technical and economic significance of atrazine in plantation forestry management. These new guidelines reflected ‘best farming practices’ and allowed two maximum application rates depending upon soil texture. These changes in labelling were approved provisionally by the NRA in April 1994 with the proviso that objective evidence would be available by 1997. The revised conditions for use for atrazine came into effect from December, 1995.

The plantation forestry users responded to this investigation with the formation of the Forest Herbicide Research Management Group (FHRMG) consisting of twelve members with a balance of forest industry and independent representatives. The FHRMG is to provide a nation-wide study in the form of a research and monitoring program to examine the impact of the provisional guidelines under Australian conditions. The project commenced in 1996, with completion in late 1988. The Group has undertaken to prepare interim requirements for best management practices needed to avoid off-site contamination of surface and ground water by 1997.

### 2.2.4 Home garden

Home garden products are available as mixtures of atrazine and amitrole. They are used to control weeds in areas in the home garden such as driveways, footpaths, fencelines, paved areas and tennis courts

### 2.2.5 Application methods and rates

#### 2.2.5.1 Broadacre crops and sugarcane

Atrazine is applied aerially and via boomsprays mounted on tractors. Between 5 and 20 ha/hr can be treated by boomspray and between 25 - 30 ha/hr aerially. Boomspray is preferred because of its low drift factor, accuracy and ease of cleaning out equipment. Aerial application is commonly used for fallow application and for sugar cane. Aerial application may also be used for sorghum. High clearance tractors are increasingly being used for sugar cane in lieu of aerial application.

Atrazine is applied pre- or post-emergence at rates of between 1.25 and 3.25 kg ai/ha on sorghum, broom millet and forage sorghum. The lower rate is recommended for sandy soils and medium textured soils, and the higher rate recommended where grasses are the major problem or on heavy soils. On maize and sweetcorn, it is applied at rates between 2.25 and 3.25 kg ai/ha with the lower rate recommended for broadleaf weeds and the higher rate for grasses. On established lucerne (more than 1 year old) it is applied at a rate of 0.55 kg ai/ha. On grasses and fallow areas, atrazine is applied pre-plant and pre-emergence at rates of between 1.8 and 3.25 kg ai/ha, with lower rates recommended if a wheat crop follows a sorghum rotation.

One grower in Queensland reported using atrazine at less than a quarter of the recommended rate. This was still found to produce the degree of protection he required. The lower rates gave control for three months and enabled crops other than sorghum or corn to be planted if rainfall were unsuitable for their planting. He reported that using the recommended rates tied up the area for too long.

One registrant has indicated the three applications may occur to sugarcane over a six month period, each at about 2 - 3 kg/ha of active ingredient. Such use would exceed the maximum annual rate of application of 3 kg/ha required by the NRA.

### 2.2.5.2 Plantation forestry

On difficult terrain, atrazine is applied aerially by helicopter and (less frequently) fixed-wing aircraft. On easy terrain, it is applied as strips by hand or tractor-mounted equipment, and by booms mounted on motorbikes and 4WD vehicles. Strips are approximately 1.5 m wide and 3 - 4 m apart. Atrazine is also hand-applied in a 1 m diameter circle around planted seedlings CP nozzles, capable of producing large droplets are preferred for all operations.

Areas treated vary between 40 -150 ha/hr (helicopter); 3 - 12 ha/hr (tractor); 1 ha (strip application by hand); 0.75 ha/hr (spot application by hand). Application may occur once, at establishment, or up to one application per year is up to 3 years.

Application generally occurs during May to July but, in Queensland, summer applications are also made to coincide with weed growth stimulated by summer rainfall. Rates of use vary between 4.5 l/ha ai on sandy soils and those defined as highly erodible to 8.0 l/ha on clay loams and heavier textured soils. Second rotation hoop pines are also treated in Queensland up to three times per season, each time at 5 kg/ha.

Agriculture WA report that the establishment of pine plantations in their state utilises pre-plant applications of atrazine at between 2.5 and 3.5 kg/sprayed ha (1.25 to 1.75 kg/plantation ha). This is applied using 1.5 m wide strips sprays to rows 3 m apart, usually with 5-sided shrouds. Approximately 2200 ha of pine plantation are established each year.

### 2.2.5.3 Home garden

Label application rates are given as product (g) per $m^2$ and correspond to 2.5 and 5.0 kg atrazine/ha. Working strength solutions range from 0.03 to 0.17% atrazine. The largest pack size for atrazine home garden use would enable treatment of 0.04 ha. Use would be by hand directed spraying, for instance from a knapsack or other pressure device, or watering can.

## 2.3 Registration trends

Over the past two decades, agricultural practices have changed markedly through the introduction of no-till and conservation tillage systems in Australia and around the world.

This change in farming practice is reflected in the responses obtained from growers via the PQs and review submissions. Many growers now report that they use atrazine as part of their reduced tillage or no-till programs and have observed reduced soil erosion and less water and nutrient runoff into waterways as a result of these. One grower reported that the introduction of atrazine and conservation tillage systems had made it possible to introduce lupins, canola, peas and faba beans into the wheat and pasture rotations. Another reported he was now able to grow sorghum in areas of weeds with less herbicide risk to the crop and experienced cleaner winter fallows which required less cultivation. Many reported a reduction in the amount of cultivation needed for weed control.

Growers very strongly support the use of atrazine in conservation tillage systems. Alternatives, such as simazine, do not have as wide a spectrum of control as atrazine and tend to be more expensive. As more farmers adopt these reduced cultivation methods, general demand for atrazine is expected to increase.

An increase in canola production is expected to increase atrazine demand in Victoria, and WA where the TT canola industry has the potential to expand into a large area of the WA wheatbelt. One manufacturer of atrazine reported that sales of atrazine had increased due to the introduction canola varieties resistant to atrazine, and planned to extend its registration to TT canola.

In Tasmania, use is expected to increase if sweetcorn cropping expands.

The NT Department of Primary Industries and Food expects increased demand for atrazine from several areas. An increase in the area sown to grain sorghum is expected after five years of drought. The continued spread of Parthenium weed into additional areas of the NT (and into NSW) is also likely to increase demand, at least in the short term. The Australian sugar industry is also likely to use more atrazine because of an increase in the area growing sugar cane; the industry is in an expansion phase. The rates of use are not expected to increase.

Promotion of the ‘Douglas-Daly and Katharine Development’ by the NT Department of Primary Industries and Food is also likely to increase demand for atrazine. This aims to make more agricultural land available for production which increases the likelihood of further crop production.

An increase in plantation forestry use is expected in two States as more plantations are established. AgricultureWA predicts an increase in the use of atrazine is likely if the proposed program to establish 10,000 ha/annum of *P pinaster* in the 400 to 650 mm rainfall zone of WA proceeds. This project is proposed as part of the National Landcare Program, specifically to ameliorate salt affected land. The Tasmanian Department of Industry and Fisheries also expects forestry plantation establishment in the State to increase. The forest industries are proposing to establish a large number of new eucalypt plantations, particularly in NW Tasmania over the next few years to ensure there is sufficient raw material for paper production. One manufacturer of atrazine products reported that sales of atrazine for plantation forestry use had remained constant over recent years, although there had been an increase in the sale of granular formulations for aerial application, to minimise drift potential.

Only one of the State departments of agriculture (NSW) expected the demand for atrazine to decrease in the future. This was because of the expectation that research will provide the option of other herbicides for some weeds.

Manufacturers report a general move away from wettable powders to dry flowable formulations and an interest in water-soluble packaging. They have not, in general, experienced recent movements in sales volume and do not expect sales to increase in the future.

## 2.4 Current use patterns

### 2.4.1 Broadacre crops

Most growers surveyed report they have been using atrazine for over five years and use it regularly (every season), although not usually on the same area of land. It is regarded as the most effective and cost-effective chemical to control specific weeds. It is also regarded as easy to use, and easy to mix and store.

The introduction of triazine tolerant (TT) canola two to three years ago has produced a rapid increase in canola cropping. In some districts TT canolas are the only varieties that can be grown because of the weed wild radish, with atrazine the only herbicide able to control this serious weed in the important rotation crop. TT canola is usually planted every 3rd or 4th year.

Canola is regarded by some growers as the only profitable break rotation crop for wheat since the demise of lupins caused by a build up of lupin root diseases which have caused lupin crop failures for the past 3 years. Atrazine has made it possible to grow canola in rotation with winter cereal. The important characteristic of canola is its ‘biofumigant’ action which controls cereal root diseases such as ‘take-all’, crown root and eye-spot lodging. This removes the need to use fungicides to control cereal diseases. A common mix is atrazine (2 l/ha) and simazine (2 l/ha) applied post-sowing, pre-emergent to the crop on bare soil.

Agriculture WA regard atrazine as essential in helping to develop TT canola into a new and viable industry. The department has developed IPM spray programs for pre-emergence weed control in lupins and pre-and post-emergence weed control in TT canola and is currently involved in trial work. However, they warn there may be the potential for resistance to arise to the triazines because simazine is already widely used in lupins.

Agriculture Victoria reports that atrazine is used on TT canola and lupins. It is regarded as essential on canola crops because simazine does not control all weed species. It is also widely used as a pre- and post-emergent spray in sweet corn and the plantation forestry industry. Atrazine is also recommended as part of a resistance management strategy to help remove chlorsulfuron-resistant ryegrass. The Victorian agriculture department has proclaimed an order requiring users to have gained a farm chemical users course certificate.

In Tasmania, the Department of Primary Industries and Fisheries has developed a spray program for the use of atrazine in sweet corn production in conjunction with metolachlor (where required). It is regarded as essential for sweet corn production and there is currently no equivalent in terms of control.

In the Northern Territory, sorghum and maize are the major grain crops and the weed, *Senna obtusifolia,* is a particular problem in crop and pasture production. The use of atrazine in sorghum provides a cost-effective method of controlling this and other weeds. The Department of Primary Industries and Food has developed spray programs using atrazine as a pre- and post-emergent on sorghum and maize for grass and broadleaf weed control With regards to IPM, the Department is currently evaluating a Ley Systems Strategy for sustainable and integrated crop and cattle production. Atrazine is recommended in the crop phase. The role of grazing management in the pasture phase, mulch management in no-till cropping and crop rotation on subsequent weed invasion is being assessed. It is intended that grazing and mulch management, crop rotation and chemical control methods be integrated for long-term weed management.

In Queensland, atrazine used alone or in mixtures is the main component in grass and broadleaf weed management in sorghum and maize. The Queensland Department of Primary Industries has developed roadside spray programs using mixtures of 2,4-D and atrazine to reduce the rate of spread of Parthenium weed through central Queensland. The program is carried out by local and state governments (Dept of Natural Resources and Dept of Transport). Atrazine is also used for Parthenium and broadleaf weed control on railway lines and ballast.

Agriculture NSW uses atrazine in a pre-emergent weed control program for commercial summer grain crops on Departmental stations and in many treated crops grown both on and off Departmental property. The selectivity of atrazine is regarded as necessary for economic returns of summer crops in many areas.

Atrazine is under consideration by the Department for inclusion in a resistance management program but its role in this program depends on future developments in herbicide resistance strategies in new farming systems in northern NSW. Atrazine is a group C herbicide with only a moderate risk of resistance occurring. It is, therefore, a useful rotation with other herbicide groups. It can be used in conjunction with post-emergent herbicides in an IPM program to eliminate crop competition by weeds.

Atrazine is widely used in the sugar industry as a pre-emergent herbicide, alone and in tank mixes, and as a post-emergent herbicide. The Australian sugar industry conservation tillage and residue retention farming systems are only considered possible with the use of atrazine for the control of broadleaf weeds. Without atrazine the farming system would return to intensive cultivation.

### 2.4.2 Plantation forestry

The plantation forestry industry prefers atrazine to other chemicals (such as simazine, sulfometuron methyl, oxyfluorfen and thiazopyr) because it is the most cost effective, works on the widest range of weeds, has less off site movement and long lasting residual activity. It is also documented as giving some stimulus to growth.

While plantation forestry is a minor use for atrazine across Australia; in Tasmania it is the dominant use. Atrazine is an integral part of the Tasmanian plantation forestry industry weed management program for softwood and hardwood plantation establishment. The industry is also developing new site preparation techniques to minimise the quantity of chemical needed for weed control in plantations. Trials undertaken by the Forest Herbicide Research Management Group are investigating leaching rates.

The plantation forestry industry in WA has integrated atrazine into IPM systems that utilise cultivation, grazing and pasture topping to reduce weed load prior to the establishment of plantations. All programs involve integrated weed management systems to some extent, either by conserving logging debris (mulch), minimising burning (maintains soil integrity and reduces weed load, particularly weeds stimulated by fire), cultivation (primarily to control perennial weeds), furrowing (removes seed-rich top soil from vicinity of tree), oversowing (encourages benign weeds at the expense of hazardous weeds) and spray topping (reduces seed set and focuses on problem weeds to achieve best control). A repeat treatment is applied between 8 and 12 months after planting. IPM systems enable low rates of atrazine to be applied. Atrazine is used under permit from the NRA in *P pineaster* and *Eucalyptus spp.*plantations.

Atrazine is also used as a post plant weed control mechanism in *Casuarina cunninghamiana* plantations from the Atherton Tablelands to the Brisbane Valley in Queensland.

## 2.5 Labelling, packaging and formulation type

The majority of PQ respondents found the labels clear and easy to understand. One respondent commented that there was variation in the labels from different manufacturers and that hezaxinone is not mentioned on the atrazine label but atrazine is mentioned on the hexazinone label.

Another grower commented that the only problem he had with the label was that the effect of atrazine in different soils had not been addressed sufficiently.

Some respondents found wettable granules were occasionally difficult to mix in the field and could leave a residue in the mixing tank. This can cause clogging of jets (usually only pressure jets on ground-based equipment). Growers also reported that some of the dry flowable formulations settle out if left for any length of time in a tank. This can cause blockages and reduces flexibility, especially when operating under variable weather conditions. For this reason, liquid formulations are preferred despite the handling advantages of the dry flowables. Labels recommend thorough mixing and agitation of the mixture while spraying.

Plantation forestry users tend to prefer granular formulations because they give better post planting control, if weeds are well established, due to the ability of the granules to penetrate foliage and disperse the chemical directly to the soil. Up to 18 months effective control of grasses and some broadleaf weeds is achieved when atrazine is applied as a pre-plant spray.

A sorghum grower reported he had changed to granules because this negated the need to wash out drums. Another grower found the bags the granules are packed in occasionally tear and are not completely waterproof.

Two growers reported trying soluble packs and had found these easier to handle.

## 2.6 Efficacy

Growers and commodity organisations, supported by State departments of agriculture, all agree that atrazine is still highly effective. Growers state they like its predictability and lower price when compared with other herbicides.

All respondents to the questionnaires agreed the recommended timing of application was still appropriate. They choose atrazine because, as a pre-emergence spray, it combines knockdown and residual functions which means less cultivation, better seeding timeliness and lower costs.

One spray contractor stated that weed kill had improved over the years. This was because the use of atrazine meant fewer cultivations prior to sowing which was less detrimental to the semi-water repellent soils in the area and the availability of newly released crop cultivars, tolerant of the triazines.

Some minor problems with atrazine were reported. The Department of Primary Industries and Food in the NT reported that trial work had been conducted with atrazine which indicated that re-cropping intervals may be changed in the future. Some changes have already been made to the labels - e.g. do not apply under hot, dry conditions. The Department also reported problems in applying this herbicide no-till, particularly on lighter soils. Problems include reliance on rainfall for incorporation, run-off into seed furrows and associated phytotoxicity to sorghum, and herbicide tie-up in the no-till mulch later.

The department also reported indications of variable performance of atrazine in 1995/96. It has been the major herbicide used in sorghum and maize in the NT for over 20 years. There is concern that the weed *Penniseteum peddicellatum* may be developing resistance. They propose to conduct pot trials to evaluate this possibility. This necessitates that atrazine be considered for future inclusion in resistance management programs.

The Victorian department of agriculture advises of a report by a reseller, in January 1996, that Johnson grass (*Sorghum halepense*) was resistant to atrazine.

The Tasmanian Department of Primary Industries and Fisheries advises the residual time in soil following forest application appears to be longer than indicated by the manufacturers.

Many growers reported they avoided spraying when conditions are very windy and several noted hot, dry windy conditions following application significantly decrease efficacy. Current labelling recommends application to moist soil and advises that the products require rainfall or irrigation to move them through the soil into the weed root zone to make them effective.

One grower noted that rainfall (i.e. wetting of crop foliage) is required as well as soil moisture for maximum efficacy. Another two noted that in very wet conditions, atrazine is not as effective in weed control.

Another grower from SA thought the application rates for *P radiata* too low to control the full spectrum of weeds and provide an adequate period of control.

One registrant reported an incidence of problems with plant back periods associated with alkaline soils and dry conditions in 1982.

Several respondents (crops and plantation forestry) specified they now obtained greater control than when they first used atrazine. They attributed this to a better knowledge of optimal application rates and timing of application.

No comments were reveived relating to home garden products.

## 2.7 Alternatives to atrazine

Atrazine is the chemical of choice for most growers and advisors, mainly because of its broad spectrum of activity against annual and broadleaf weeds, its residual nature and its cost-effectiveness. Chemical alternatives do exist for many current uses but are more expensive. Atrazine is generally considered to be the most cost-effective broadleaf weed control herbicide currently available.

State departments of agriculture view inter-row cultivation as a possible alternative to early weed control in row crop situations. However, this method does not control weeds directly in the rows nor can it be used where row spacings are inappropriate. Non-chemical options are not regarded as practical for broadacre cropping once a crop is established

There appear to be no alternative control options for annual grasses in grain sorghum unless specially treated seed and more expensive herbicides are used.

The use of atrazine in spray mixes (with 2,4-D) minimises regrowth from seed reserves of Parthenium in the soil for some months after application. Other herbicides are available to treat these but atrazine provides a low cost form of control for Parthenium weed and annual ragweed. Biological control of Parthenium weed is currently being investigated by the Department of Primary Industries and Food in the NT, with improved pasture management on grazing land (involving reduced stocking rates) representing a more effective long-term solution to the Parthenium problem

Other forms of control may be viable in cereal crops. *Penniseteum pedicellatum* is the major grass weed in NT cereal crops. It is intended that grazing management in a ley system pasture phase may reduce the incidence of this grass in the subsequent crop phase. The department proposes, in 1996/97, to assess the use of spray-topping in the pasture phase to reduce weed seed burden in the crop rotation. Metalochlor can be used with ‘Concep’ treated sorghum seed but is relatively expensive.

There appear to be very few effective substitutes for atrazine in the sugar industry. Atrazine is used widely because of its capacity to control a broad spectrum of weeds and its pre- and post-emergent activity. Cultural weed control is an alternative in young sugar cane without residue retention, but 50% of the sugar crop is now farmed with residues from the harvest being retained. Also, vines growing in the crop after canopy closure cannot be controlled mechanically.

Atrazine is regarded as essential for the economic management of pine plantations by growers and state departments of agriculture. Alternative chemicals or non-chemical strategies are either excessively expensive or ineffectual in achieving the desired outcome. Hexazinone is sometimes used as an alternative in the plantation forestry industry but is more mobile than atrazine and can be toxic to *P radiata*.

## 2.8 Phytotoxicity

The phytotoxicity of atrazine to non-target crops is well known and conveyed to users on the label. All labels advise that crops other than those recommended on the labels should not be planted for at least six months following treatment at rates of up to 1.25 kg ai/ha and for 18 months following treatments of between 1.25 and 3.25 kg ai/ha. When rates exceed 3,25 kg ai/ha plantings may not be possible for very long periods afterwards.

## 2.9 Summary of efficacy

Atrazine is one of the most widely used herbicides in Australian agriculture. Major agricultural uses in Australia include summer crops such as sorghum and maize and in grass seed crops. It is also used on sugercane and is widely used in Western Australia in lupins. Use on triazine tolerant canola is a relatively new, rapidly increasing use, allowed under permit but not registered on the label. Main non-agricultural uses are in the establishment of pine and eucalypt plantations and Parthenium weed control in Queensland, parts of the Northern Territory and northern NSW.

The past two decades has seen a major change in farming practices from intensive mechanical cultivation towards reduced till systems using herbicdes such as atrazine to control weeds. This has been accompanied by a change in crops grown, with a general move away from continuous wheat cropping to crop rotations involving a range of winter and summer crops.

Atrazine has made it possible for many growers to introduce crops such as lupins and peas into the wheat and pasture rotations. The recent introduction of triazine tolerant (TT) canola has produced a rapid increase in canola cropping. In some districts TT canolas are the only varieties that can be grown because of the weed, wild radish. Other growers find TT canola the only profitable break rotation crop for wheat since the demise of lupins due to lupin root diseases..

Atrazine is regarded as the chemical of choice for most growers and advisors, mainly because of its broad spectrum of activity, residual nature and cost-effectiveness. It is also regarded as easy to use with clear label instructions. Some growers found wettable granules were occasionally difficult to mix and could leave a residue in the mixing tank.

Growers and commodity organisations, supported by State departments of agriculture, all agree that atrazine is still highly effective. The recommended timing of application is still found to be appropriate and some users have experienced greater effectiveness over the years which they attribute to a better knowledge of optimal application rates and timing of application.

Minor issues concerning the efficacy of atrazine have been reported. There may be problems in applying this herbicide no-till, particularly on lighter soils, because of the reliance on rainfall for incorporation and run-off into seed furrows. Reports of variable perfromance in the Northern Territory over the 1995/96 season has raised concerns over the possible development of resistance to atrazine by a major weed of sorghum and maize, *Penniseteum peddicellatum*.

An unconfirmed report of resistance to Johnson grass (*Sorghum halepense*) has been reported in Victoria.

The issue of atrazine use and water contamination was investigated by the NRA in 1993 and resulted in a set of amendments to use patterns, including buffer zones from water courses, dams and wells, and maximum application rates. These restrictions were required by the end of December, 1995. Information from registrants and growers indicate these restirctions are not fully in effect. Another outcome of this investigation was the establishment of the Forest Herbicide Research Management Group to plan and review a water monitoring program and a series of trials on the impact of various use patterns on water quality. Interim recommendations from the Group are expected in 1997 with final recommendations by late 1988.

## 3. TRADE ASSESSMENT

Atrazine is not considered to present a risk to Australia's trade with other nations. Atrazine is used pre-plant or very soon after planting and, because of the long time interval between planting and harvest, there should not be any residues at harvest when used according to the label - a nil residue situation. For this reason, MRLs have been set at the limit of detection for approved crops.

Overseas, MRLs have been reported for at least one commodity in the following countries: Austria, Belgium, Brazil, France, Germany, Israel, Italy, Japan, Mexico, South Africa, Spain, Switzerland, The Netherlands, United States and Yugoslavia (for further details, see section 4.7 of this assessment). These MRLs are all equal to or above those set by Australia. Therefore, it is assumed that any relevant produce (ie produce for which the importing country has an MRL) reaching these countries, and containing atrazine at the Australian MRL, would be acceptable.

The National Residue Survey has not done any monitoring of atrazine, primarily because residues are not expected to be detected. However, in the 1992 Australian Market Basket Survey (published in 1994) the National Food Authority did look at atrazine and found no residues in crops. Their 1994 report (published in 1996) did not measure atrazine, presumably due to the negative result in the 1992 report.

## 4. RESIDUE ASSESSMENT

### 4.1 Metabolism and environmental fate

#### 4.1.1 Animal metabolism

Lactating goats

Approximately 150 mg of [$^{14}$C]-hydroxysimazine (a triazine structurally similar to atrazine except for the presence of two ethylamino groups instead of the one ethylamino and one isopropylamino groups in atrazine) was fed to goats for four consecutive days at an average daily dose of 3.83 and 3.34 mg/kg body weight. This was equivalent to approximate feeding levels of 89 and 67 ppm. Milk, urine and faeces were sampled throughout and the animals killed approximately 6 hours after the last dose (Fisher, G.D., 1993a) at which time selected tissues, gastro-intestinal tract content and bile were collected (Fisher, G.D., 1993b (as amended)).

The average recovery of the administered dose was 83.98% of which an average 54.36% was eliminated in the urine and 13.45% in the faeces. Gastrointestinal content, bile, edible tissues (fat, liver, kidney, muscle), and whole blood averaged 15.11%, 0.02%, 0.59%, and 0.12% respectively of the administered dose. The radioactivity in the milk averaged 0.34% of the total dose. Average concentrations and percentage dose distributions in tissues were:

| Tissue | Average concentration ppm (as [$^{14}$C]hydroxysimazine equivalents) | Average % of the administered dose |
|---|---|---|
| Whole blood | 0.23 | 0.12 |
| Muscle (leg, tenderloin) | 0.15 | 0.42 |
| Liver | 0.8 | 0.12 |
| Kidney | 1.9 | 0.045 |
| Fat (omental and perirenal) | 0.016 | 0.005 |
| Bile | 3.02 | 0.015 |
| Total % | (excluding bile values) | 0.71 |

In the milk, residue values were relatively constant and did not indicate any tendency to markedly increase over the dosing period. Mean daily milk residue concentrations were approximately 0.38 ppm for one goat and 0.25 ppm for the other. Maximum milk concentrations were in the evening milk with a maximum value of 0.596 ppm recorded.

Two lactating goats were given a dose of 50 mg of 14C-atrazine in the feed per day (1.25 mg/kg body weight) for 10 days (capsule, in the morning) and then killed 23 hours after the last dose for collection of muscle, liver, kidneys, omental and back fat and blood. Daily urine, faeces and milk were collected over the trial period. The animals were on a maintenance diet of 0.75 kg hay and 0.75 kg concentrate per day which was completely consumed (Merricks, 1986).

No results of the excretion or distribution of radiolabel were presented.

A study on metabolism of $\Delta^{14}$C-atrazine administered by capsule into the feed of lactating goats was presented (Posner et al., 1972a but details on the dose administered and distribution of radiolabel were not included in the report. Similarly a report on the metabolism of $\Delta^{14}$C-atrazine and $\Delta^{14}$C-simazine in milking goat was presented (Posner et al. 1972b) but again with no experimental detail.

### 4.1.2 Plant metabolism

Corn silage and grain

A study authored by Banzer and Cassidy (1971) on corn metabolism was presented with multiple pages missing and could not be reviewed.

Corn

Corn plants were grown in small scale field plots in three locations in the USA. At an approximate plant height of 12 inches, the immature plants were given a post-emergence foliar spray of a commercial atrazine formulation with $^{14}C$-atrazine (U-ring labelled) at a maximum use rate of 3 lb atrazine/acre (≈ 3.4 kg atrazine/ha) (Larson, 1992). The study was designed to determine if suitable hydroxy marker metabolites exist which could be used for future residue studies if ever deemed necessary. Such a marker metabolite would ideally represent 20% or more of the total radioactive residue and would increase accountability of total atrazine residues in plants compared to available residue data which only accounted for atrazine plus three of its chloro-metabolites. Corn leaves were sampled at day 0, corn forage at 30 days after treatment, at the silage stage (46, 75, or 72 days after treatment) and at harvest (approximately 85, 100, or 106 days after treatment). Corn grain was also sampled at harvest. Soil samples were taken at each sampling.

Most of the soil radioactivity was retained in the top 3 inches. Immediately after application the levels of total radioactivity in that layer ranged from 0.47 to 3.3 ppm, after 30 days 0.36 to 2.7 ppm, at silage 0.30 to 2.3 ppm, and at harvest 0.24 to 1.3 ppm atrazine equivalents. In the lower soil layers, total radioactivity never exceeded 0.18 ppm atrazine equivalents.

In corn leaves taken immediately after application, total radioactive residues were of the order of 200 to 560 ppm atrazine equivalents. Total radioactivity levels at the sampling times in the corn forage, silage, mature fodder and grain were:

| Harvest interval | Total Radioactive Residue (ppm atrazine equivalents) |
|---|---|
| 30 DAT forage | 0.47 - 2.8 |
| Silage stage forage | 0.5 - 0.71 |
| Mature fodder | 0.85 - 1.8 |
| Mature grain | 0.034- 0.071 |

In the fodder and forage extractability of the radiolabel ranged from 52.2% to 86.3% of the total radioactive residue and 38.2 to 41.9% in grain. Use of acidic extraction conditions could increase the extractability by up to almost 20%. Most of the extracted radioactivity was in the aqueous fractions - in forage and fodder 49.6% to 65.4% (except for one 30 day sample where the organic fraction accounted for 49.8% of the total radioactive residue) and in grain 36.7% to 41.4%. Non-extractable residues were highest in corn grain (52.4 to 60.2% of the total radioactive residue). The total recovery of radioactivity from the corn ranged from 90.1 to 106.9%.

The major metabolite identified in the aqueous extracts from corn forage and fodder was GS-17794 (called 2-amino-4-ethylamino-6-isopropyl-s-triazine but on the basis of the chemical structure presented, 2-amino-4-isopropylamino-6-hydroxy-s-triazine) (8.1% to 19.3% of the total radioactive residue). In grain this compound was present in lesser amounts (2.7% to 10.7%). Hydroxytriazines as a group could make up up to 36% of the total radioactive residue and atrazine and its 2-amino, 6-isopropyl or 2-amino-6-(ethylamino) and diaminochlorotriazine metabolites were minor constituents (< 5% of the total recovered radioactivity, <0.02 ppm), except in one 30 day forage sample where atrazine was measured at 1.2 ppm and made up 43.2% of the total radioactive residue. Quantitative results of the chlorotriazines identified were:

| Compound | 30 day forage | | Silage stage forage | | Mature fodder | |
|---|---|---|---|---|---|---|
| | % TRR | ppm | % TRR | ppm | % TRR | ppm |
| Atrazine | 0.4, 2.0, 43.2 | 0.003, 0.009, 1.23 | <0.1-1.3 | <0.001-0.009 | <0.1-0.8 | <0.001-0.013 |
| G-28273 | <0.1-0.2 | 0.001-0.003 | 0.1-0.2 | <0.001-0.001 | <0.1-0.1 | <0.002 |
| G-28279 | 0.2-0.3 | 0.001-0.006 | 0.1-0.2 | <0.001-0.001 | <0.1-0.2 | <0.001-0.003 |
| G-30033 | 0.3-0.4 | 0.001-0.011 | 0.1-0.2 | <0.001-0.001 | <0.1-0.5 | <0.001-0.007 |
| Unknown 1 | 1.1-2.3 | 0.008-0.045 | 0.8-2.6 | 0.005-0.015 | 1.0-4.1 | 0.009-0.064 |

G-28273 diaminochlorotriazine
G-28279 desisopropylatrazine
G-30033 desethylatrazine
ppm values determined from the TRR value in ppm and the individual compound's percentage of the TRR.

The organic fractions of corn grains were not analysed because of the low radioactivity levels (0.5 to 1.5% of the total radioactive residue).
Illustrative levels of GS-17794 present in the aqueous fraction after acid hydrolysis and neutral hydrolysis for the silage results are:

| Sample | Percent of recovered radioactivity | Percent of total $^{14}$C-residue | $^{14}$C-residue ppm |
|---|---|---|---|
| 30 day forage | 16.3-34.3 | 9.4-23.2 | 0.089-0.27 |
| Mature fodder | 26.5-33.0 | 17.0-19.4 | 0.14-0.33 |
| Mature grain | 29.6 | 14.0 | 0.005 |
| Silage stage forage | 29.5-32.8 | 18.1-19.3 | 0.09-0.14 |

Storage stability data presented indicated atrazine and its $^{14}$C-residues appeared stable in the corn tissues and tissue extracts stored under the conditions used in the study.

Sorghum
A study on sorghum was supplied (Larson, 1992) in which sorghum was grown in small scale field plots in three locations in the USA. The study was designed to determine if suitable hydroxy marker metabolites exist which could be used for future residue studies if ever deemed necessary. Such a marker metabolite would ideally represent 20% or more of the total radioactive residue and would increase accountability of total atrazine residues in plants compared to available residue data which only accounted for atrazine plus three of its chloro-metabolites. At an approximate plant height of 10-12 inches, the immature

plants were given a post-emergence foliar spray of a commercial atrazine formulation with $^{14}C$-atrazine (U-ring radiolabelled) at a maximum use rate of 3 lb atrazine/acre (≈ 3.4 kg atrazine/ha). Although two pages of the report's abstract were not supplied, the trial was reviewed on the basis of the remainder of the information submitted.

Sorghum leaves were sampled at day 0, sorghum forage at 30 days after treatment and at the silage stage (approximately 70-75 days after treatment), and sorghum fodder at harvest (approximately 103-130 days after treatment). Sorghum grain was also sampled at harvest. Soil samples were taken at each sampling.

Most of the soil radioactivity was retained in the top 3 inches. Immediately after application the levels of total radioactivity in that layer ranged from 0.47 to 3.3 ppm, after 30 days 0.36 to 2.7 ppm, at silage 0.30 to 2.3 ppm, and at harvest 0.24 to 1.3 ppm atrazine equivalents. In the lower soil layers, total radioactivity never exceeded 0.18 ppm atrazine equivalents.

In sorghum leaves taken immediately after application, total radioactive residues were of the order of 190 to 570 ppm atrazine equivalents. Total radioactivity levels at the sampling times in the sorghum forage, silage, mature fodder and grain were:

| Harvest interval | Total Radioactive Residue (ppm atrazine equivalents) |
|---|---|
| 30 DAT forage | 0.88 - 5.35 |
| Silage stage forage | 0.28 - 1.23 |
| Mature fodder | 0.42 - 1.04 |
| Mature grain | 0.03 - 0.39 |

In the fodder and forage extractability of the radiolabel ranged from 46.7% to 83.6% of the total radioactive residue and 18.6% to 32.6% in grain. Use of acidic extraction conditions could increase the extractability of the radioactive fractions. Most of the extracted radioactivity was in the aqueous fractions - in forage and fodder 28.7% to 55.2% (except for one 30 day sample where the organic fraction accounted for 54.9% of the total recovered radioactivity) and in grain 36.7% to 41.4%. The organo-soluble components made up a low percentage of the total radioactivity recovered (1 to 11.8%, except for one site where the 30 day levels were highest in the organic fraction). Non-extractable residues were highest in sorghum grain (68-85% of the total radioactive residue). The total recovery of radioactivity from the sorghum fractions by neutral extraction was 92.1-107.3%.

The major metabolite identified in the aqueous extracts from sorghum forage and fodder was GS-17794 (called 2-amino-4-ethylamino-6-isopropyl-s-triazine (page 73 of report) but on the basis of the chemical structure presented, 2-amino-4-isopropylamino-6-hydroxy-s-triazine) (2.3% to 7.7% of the total radioactive residue). In grain this compound was present in lesser amounts (0.4% to 3.5%). Hydroxytriazines as a group could make up 16-29% of the extracted radioactivity. Atrazine and its 2-amino, 6-isopropyl or 2-amino-6-(ethylamino) and diaminochlorotriazine metabolites were minor constituents (< 5% of the total recovered radioactivity, <0.05 ppm), except in one 30 day forage sample where atrazine was measured at 2.66 ppm and made up 49.8% of the total recovered radioactivity.

Quantitative results of the chlorotriazines identified were:

| Compound | 30 day forage | | Silage stage forage | | Mature fodder | |
|---|---|---|---|---|---|---|
| | % TRR | ppm | % TRR | ppm | % TRR | ppm |
| Atrazine | 0.7, 2.3, 49.8 | 0.02, 0.02, 2.66 | 0.1-4.7 | <0.001-0.05 | 0.1-5.8 | 0.001-0.06 |
| G-28273 | <0.1-0.2 | <0.001-0.007 | 0.2-0.3 | 0.001-0.002 | <0.1-0.1 | <0.001-0.001 |
| G-28279 | 0.3-0.6 | 0.003-0.018 | 0.2-0.7 | 0.002-0.003 | 0.2-0.3 | 0.001-0.003 |
| G-30033 | 0.7-1.2 | 0.021-0.035 | 0.2-1.4 | 0.001-0.015 | 0.1-0.7 | <0.001-0.007 |
| Unknowns | nd- 2.3 | nd -0.046 | nd-1.7 | nd-0.021 | nd-2.3 | nd-0.01 |

G-28273 diaminochlorotriazine
G-28279 desisopropylatrazine
G-30033 desethylatrazine
Unknowns 3 or 4 unknowns were identified.
nd not detected

Levels of atrazine and its chlorometabolites in sorghum grain were not reported on the basis of the low percentage of these compounds in the TRR of the grain (less than 5% and the total $^{14}$C residue in the grain being 0.019 ppm).

Illustrative levels of GS-17794 present in the aqueous fraction after acid hydrolysis and neutral hydrolysis for the silage results are:

| Sample | Percent of recovered radioactivity | Percent of total $^{14}$C-residue | $^{14}$C-residue ppm |
|---|---|---|---|
| 30 day forage | 21.4-30.2 | 9.0-13.9 | 0.11-0.48 |
| Mature fodder | 15.7-16.5 | 7.9-13.7 | 0.03-0.14 |
| Mature grain | 9.0 | 4.8 | 0.019 |
| Silage stage forage | 6.1-11.7 | 3.0-4.8 | 0.008-0.059 |

Storage stability data presented indicated atrazine and its $^{14}$C-residues appeared stable in the sorghum tissues and tissue extracts stored under the conditions used in the study.

Corn and Sorghum

In a follow-up study (Larson and Ash, 1995), corn and sorghum samples obtained after atrazine treatment at 3 lb/acre (Larson, 1992), were subjected to various extraction procedures to maximise the accountability of triazine residues. This was because the original study had shown there was no single hydroxytriazine that could adequately serve as a marker metabolite in all cases. Hydrolysis using 0.5N HCl and autoclave conditions were considered to be the most effective process. The extraction and fractionation results were:

| Harvest interval | Percent of total radioactivity (acid/autoclave extraction) | | | | | |
|---|---|---|---|---|---|---|
| | ppm | Organic | Aqueous | Extracted | Non-extracted | Total |
| **Corn** | | | | | | |
| 30 DAT | 2.84 | 1.1 | 85.3 | 86.4 | 7.1 | 93.5 |
| Silage stage forage | 0.499 | 0.9 | 77.8 | 78.7 | 11.2 | 89.9 |
| Fodder | 1.55 | 0.6 | 73.6 | 74.2 | 16.3 | 90.5 |
| Grain | 0.034 | 0.7 | 62.2 | 62.9 | 25.8 | 88.7 |
| **Sorghum** | | | | | | |
| 30 DAT | 5.35 | 1.1 | 77.2 | 78.3 | 14.6 | 92.2 |
| Silage stage forage | 1.07 | 1.1 | 82.2 | 83.3 | 14.8 | 98.1 |
| Fodder | 1.04 | 0.9 | 68.5 | 69.4 | 21.1 | 90.6 |
| Grain | 0.033 | 0.5 | 65.0 | 65.5 | 24.5 | 90.0 |

DAT days after treatment.

Analysis of the aqueous fractions extracted from the corn and sorghum gave the following accountability results:

| Compound characterised | Percent of total radioactivity | | | |
|---|---|---|---|---|
| | 30 DAT forage | Silage stage forage | Mature fodder | Mature grain |
| **Corn** | | | | |
| Cyanuric acid | 8.7 | 17.8 | 20.2 | 38.8 |
| GS-17791 | not available | not available | 0.4 | 1.2 |
| GS-17792 | 1.6 | 2.3 | 1.7 | 2.1 |
| GS-17794 | 6.6 | 13.5 | 13.0 | 8.4 |
| G-304048 | 59.5 | 32.7 | 28.3 | 2.2 |
| Unidentified and nonspecific | 8.9 | 11.5 | 10.0 | 9.5 |
| **Total** | 85.3 | 77.8 | 73.6 | 62.2 |
| **Sorghum** | | | | |
| Cyanuric acid | 4.9 | 16.7 | 13.0 | 38.9 |
| GS-17791 | 0.5 | 0.8 | 0.8 | 8.1 |
| GS-17792 | 1.6 | 1.7 | 1.0 | 0.9 |
| GS-17794 | 4.6 | 8.3 | 7.7 | 3.6 |
| G-304048 | 58.1 | 41.3 | 29.8 | 2.8 |
| Unidentified and nonspecific | 7.5 | 13.4 | 16.2 | 10.7 |
| **Total** | 77.2 | 82.2 | 68.5 | 65.0 |

Cyanuric acid 2,4,6-trihydroxy-s-triazine;
GS-17791 diaminohydroxyatriazine;
GS-17792 2-amino-4-ethylamino-6-hydroxy--s-triazine;
GS-17794 2-amino-4-isopropylamino-6-hydroxy-s-triazine;
GS-34048 hydroxyatrazine.

The acid/autoclave hydrolysis conditions resulted in high extraction and fractionation of radioactivity and identified cyanuric acid in grains and 2-(ethylamino)-4-hydroxy-6-(isopropyl-amino)-s-triazine in forage and fodder samples as the principal hydroxytriazine formed.

Sugarcane

A study on sugarcane was supplied (Larson, 1993) in which sugarcane was grown in small scale field plot in the USA. and given a total of four applications of a commercial atrazine formulation with U-ring labelled $^{14}$ C-atrazine. The first application was one day after planting at approximately 4 lb atrazine/acre (≈4.5 kg atrazine/ha), the second application, also as a pre-emergent treatment, was approximately 40 days later at the rate of 2lb of atrazine/acre (≈2.2 kg atrazine/ha). The third treatment was as a post-emergence broadcast spray at 207 days after sowing, again at the rate of 2 lb atrazine/acre (≈2 kg atrazine/ha). The fourth and last treatment was a "post-directed spray", applied at approximately 2 lb atrazine/acre, approximately 300 days after sowing. Cane was harvested 137 days later.

Sugarcane leaves were collected for analysis just before the fourth application and at final harvest. Cane was sampled at the final harvest. Soil samples were taken just before the first, third and fourth applications, and just after all applications and at harvest.

The highest radioactivity levels were found in the top 3 inches of soil. The initial (post-first application) level was 2.7 ppm (total radioactive residues). The final concentration at harvest was 0.88 ppm. In the lower soil layers, total radioactivity was between 0.003 and 0.99 ppm. A summary of analyses of the 0-3 inch soil layer showed the following results:

| | **Post-first application** | | | **Final harvest** | | |
|---|---|---|---|---|---|---|
| **Compound** | **% organic** | **% aqueous** | **ppm** | **% organic** | **% aqueous** | **ppm** |
| Atrazine | 79.4 | 7.7 | 2.38 | 0.9 | 0 | 0.008 |
| G-30033 | 0.3 | 0 | 0.007 | 0.2 | 0 | 0.002 |
| G-28279 | 0.1 | 0 | 0.004 | 0.1 | 0 | 0.001 |
| G-28273 | <0.1 | 0 | <0.001 | <0.1 | 1.4 | 0.012 |
| GS-12517 | <0.1 | 0 | 0.002 | 2.3 | 1.4 | 0.032 |
| CGA-101248 | 0 | 0 | 0.00 | <0.1 | 3.8 | 0.033 |
| GS-17794 | <0.1 | 0.1 | 0.004 | 0 | 1.5 | 0.013 |

G-30033 desethylatrazine
G-28279 desisopropylatrazine
G-28273 diaminochlorotriazine
GS-12517 2-amino-4-isopropylamino-6-ethylamino-*s*-triazine (amino-atrazine)
CGA-101248 2,4-diamino-6-isopropylamino-*s*-triazine
GS-17794 2-amino-4-isopropylamino-6-hydroxy-*s*-triazine.

In the pre-fourth application leaves there was 68.99 ppm of total radioactive residue with 3.86% organosoluble, 59.2% waterextractable and 34% non-extractable when using methanol/water as the extraction medium. In the final harvest leaves the corresponding values were 24.22 ppm, 3.1%, 47.9%, 39.5% and in the harvested cane, 2.09 ppm, 3.3%, 56.9%, 33.7%.

The accountability of atrazine levels found in the pre-fourth application and final harvest sugarcane leaves and the final harvest sugarcane were reported as:

| Compound characterised | Organic solubles % | Aqueous solubles % | ppm |
|---|---|---|---|
| **Pre-fourth application sugarcane leaves** | | | |
| Atrazine | 0.2 | - | 0.16 |
| G-30033 | 0.5 | - | 0.36 |
| G-28279 | 0.2 | - | 0.14 |
| G-28273 | <0.1 | 8.2 | 5.7 |
| GS-17794 | <0.1 | 8.5 | 5.9 |
| O-glucoside conjugate | - | 11.1 | 7.7 |
| **Final harvest sugarcane leaves** | | | |
| Atrazine | <0.1 | - | 0.017 |
| G-30033 | 0.1 | - | 0.027 |
| G-28279 | <0.1 | - | 0.015 |
| G-28273 | <0.1 | 1.7 | 0.426 |
| GS-17794 | <0.1 | 7.1 | 1.7 |
| O-glucoside conjugate | - | 11.8 | 2.8 |
| **Final harvest sugarcane** | | | |
| Atrazine | 0.3 | - | 0.007 |
| G-30033 | 1.4 | - | 0.029 |
| G-28279 | 0.4 | - | 0.009 |
| G-28273 | <0.1 | 3.0 | 0.063 |
| GS-17794 | <0.1 | 7.1 | 0.15 |
| O-glucoside conjugate | - | 6.6 | 0.14 |

- non-detectable
G-30033 desethylatrazine
G-28279 desisopropylatrazine
G-28273 diaminochlorotriazine
GS-17794 2-amino-4-isopropylamino-6-hydroxy-*s*-triazine.

In the non-extracted residue fraction from the sugarcane, atrazine and its chlorometabolites were not reported as present. Hydroxy and amino atrazines were reported as being present.

When more vigorous extraction methods were used (autoclave), cyanuric acid, GS-17794, and 2-(ethylamino)-4-hydroxy-6-(isopropylamino)-*s*-triazine were identified as the principal components of the total radioactivity (66.8% of the final harvest leaves and 66.2% of the final harvest cane's radioactivity could be extracted by this process).

Storage stability data presented indicated atrazine and its $^{14}C$-residues appeared stable in the sugarcane extracts stored under the conditions used in the study (storage at -10$^{o}$C or less).

In a supplement to the report on sugarcane (Larson and Ash, 1995), the nature of multiple low levels of metabolites isolated but not identified in the original study were further isolated and identified by mass spectroscopy. A total of 20 metabolites of atrazine and atrazine itself were identified from the residues extracted from the pre-fourth application sugarcane leaves sampled in the original study. These leaves were used for the study as they contained the highest $^{14}C$-residue (69 ppm) compared to final harvest leaves (24 ppm) and cane (2 ppm). The unidentified peaks in the pre-fourth application leaves contained 17.8 and 1.5% of the total radioactive residues (TRR). The leaves were extracted with methanol/water and using the results from this study and the original study, levels of identified residues were:

Atrazine, 0.2% of the TRR, 0.16 ppm; G-30033 0.2%, 0.36 ppm; G-28279 0.2%, 0.14 ppm; G-28273 8.2%, 5.7 ppm; GS-17791* 1.8%, 1.2 ppm; GS-17792* 0.9%, 0.6 ppm; GS-17794 8.5%, 5.9 ppm; CGA-1010248 2.2%, 1.5 ppm; G-34048* 0.7%, 0.48 ppm; GS-12517 1%, 0.7 ppm; conjugates of G-30033 and atrazine 20.9%, 0.05-7.7 ppm.

(*GS-17791 2,4-diamino-6-hydroxy-s-triazine; GS-17792 2-amino-4-ethylamino-6-hydroxy-s-triazine; G-34048 hydroxyatrazine. Other compounds previously identified in this evaluation report).

## 4.2 Methods of residue analysis

### 4.2.1 Analytical methods

Beef tissue To determine residues of atrazine and its metabolites in beef tissues (blood, muscle, liver, kidney, and fat), the tissue was extracted with acetone/water, the solid matrix centrifuged off and the supernatant decanted. After removal of the acetone under reduced pressure, the residue was cleaned-up by column chromatography and the residue obtained analysed by capillary GLC using a nitrogen phosphorus detector (Bade and Toth, 1985a).

The limit of detection was 0.01 mg/kg each for atrazine, desethylatrazine (G-30033), desisopropylatrazine (G-28279), and 2,6-diamino-4-chloro-*s*-triazine (G-28273). Average percentage recoveries at the 0.01 to 0.5 mg/kg fortification levels were:

| | Atrazine | G-30033 | G-28279 | G-28273 |
|---|---|---|---|---|
| **Blood** | 72 | 78 | 83 | 82 |
| **Muscle** | 78 | 80 | 82 | 71 |
| **Liver** | 73 | 87 | 86 | 84 |
| **Kidney** | 86 | 89 | 88 | 81 |
| **Fat** | 81 | 88 | 92 | 88 |

Beef and poultry tissues and poultry eggs In an updated version of analytical method AG-476 ((Bade and Toth, 1985a), residues of atrazine, simazine, G-30033, G-28279, and G-28273 in beef tissues (blood, tenderloin and round muscle, liver, kidney, and perirenal and omental fats), poultry tissues (lean meat, skin, liver, and fat) and poultry eggs were determined. Extraction was by homogenisation with water/acetonitrile (acetonitrile only for fat and skin samples), filtration, and the aqueous layer further cleaned-up by column chromatography and the residues determined by capillary GLC with a nitrogen/phosphorus detector. The limit of detection for each compound was 0.01 ppm. Using fortification levels of 0.01 to 0.25 ppm. The ranges of percentage recoveries for the individual tissues were:

| Tissue | Simazine | Atrazine | G-30033 | G-28279 | G-28723 |
|---|---|---|---|---|---|
| **Beef** | | | | | |
| Blood (1) | 69-113% | - | - | 67-117% | 68-101% |
| Muscle (2) | 72-126% | 89-109% | 90-115% | 78-125% | 71-105% |
| Liver (2) | 74-146% | 83-139% | 85-140% | 67-138% | 68-101% |
| Kidney (1) | 91-108% | - | - | 74-100% | 63-95% |
| Fat (2) | 68-143% | 82-104% | 85-102% | 82-139% | 77-104% |
| **Poultry** | | | | | |
| Lean meat (2) | 76-103% | 73-95% | 69-102% | 67-95% | 70-127% |
| Skin (1) | 71-86% | - | - | 76-109% | 76-112% |
| Fat (1) | 60-84% | - | - | 78-89% | 78-91% |
| Liver (3) | 69-101% | - | - | 67-91% | 78-91% |
| Eggs (3) | 71-100% | 74-94% | 69-95% | 69-103% | 61-89% |

(1) Fortification levels 0.01 to 0.20 ppm
(2) Fortification levels 0.01 to 0.25 ppm.
(3) Fortification levels 0.01 to 0.5 ppm.

Milk

To determine residues of atrazine and its metabolites in milk, milk protein was precipitated by acetone addition and the precipitate centrifuged down. The supernatant was decanted and the acetone removed under reduced pressure. The residue was further cleaned up by column chromatography and quantified by capillary GLC using a nitrogen phosphorus detector (Bade and Toth, 1985b).

The limits of detection were 0.01 mg/kg for each of the compounds. Average recoveries at the 0.01 to 0.5 mg/kg fortification levels were between 71 and 92% for all tissues.
Average recoveries were: atrazine 94%, G-30033 101%, G-28279 104%, and G-28273 109%. Fortification levels were 0.01, 0.1 and 0.5 ppm.

Forage, fodder, grain and grain fractions

Samples are extracted by refluxing with water/acetone for 2 hours. The extract is filtered and concentrated to the water layer. Oil fraction samples are extracted with water/acetonitrile and the oil layer discarded after centrifugation. The acetonitrile/water fraction is concentrated to the water layer. Soapstock is extracted with hexane/ethyl acetate. The organic phase is separated and brought to dryness. The residue is dissolved in hexane and extracted with water/acetonitrile. The water/acetonitrile fraction is concentrated to the water layer. The water layers from each extraction are cleaned-up by column chromatography. Atrazine and its metabolites are eluted and determined by capillary GLC using a nitrogen/phosphorus detector (Bade and Toth, 1987).

The method's limit of detection is 0.05 mg/kg. Average recoveries from millet forage, fodder and grain, sorghum forage, fodder, grain, and fractions, maize forage, silage, fodder, grain, ears, dry fractions, and oil fractions were all satisfactory (>70%) with fortification levels between 0.05 and 0.2 mg/kg. Average percentage recoveries were:

| | Recoveries (%) | | | | |
|---|---|---|---|---|---|
| | **Fortification level (ppm)** | **Atrazine** | **G-30033** | **G-28279** | **G-28273** |
| **Proso millet** | | | | | |
| Forage | 0.05-0.2 | 107.7 | 103.3 | 97.7 | 90.7 |
| Fodder | 0.05-0.2 | 102.7 | 107.7 | 98.7 | 103 |
| Grain | 0.05-0.1 | 86 | 96.5 | 88.5 | 89 |
| **Sorghum** | | | | | |
| Forage | 0.05-0.2 | 107 | 101 | 95.3 | 99.8 |
| Fodder | 0.05-0.2 | 101.8 | 103.7 | 97 | 112.3 |
| Grain | 0.05-0.1 | 96.2 | 97.2 | 90.2 | 86.7 |
| Fractions - | | | | | |
| Coarse grits | 0.05 | 132 | 127 | 132 | 96 |
| Fine grits | 0.05 | 125 | 120 | 128 | 100 |
| Flour | 0.05 | 95 | 124 | 117 | 89 |
| Feed stock | 0.1 | 72 | 70 | 63 | 94 |
| **Corn** | | | | | |
| Forage | 0.05-0.5 | 92.5 | 88.2 | 86.7 | 88.1 |
| Silage | 0.05-0.5 | 98.7 | 95.5 | 88.6 | 87.3 |
| Fodder | 0.05-0.5 | 90 | 89.3 | 86.8 | 78.1 |
| Grain | 0.05-0.5 | 93.6 | 95.1 | 91.3 | 70.3 |
| Ears SW corn | 0.05-0.1 | 97 | 91.3 | 83 | 94.7 |
| Dry fractions - | | | | | |
| Flour | 0.05 | 100 | 73 | 101 | 92 |
| Germ | 0.1 | 96 | 94 | 88 | 85 |
| Grits | 0.1 | 97 | 94 | 85 | 83 |
| Meal | 0.1 | 107 | 95 | 88 | 92 |
| Hulls | 0.2 | 107 | 106 | 102 | 84 |
| Oil fractions - | | | | | |
| Refined | 0.1 | 82 | 90 | 81 | 87 |
| Crude | 0.2 | 74.5 | 78 | 77 | 85.5 |
| Soapstock | 0.2 | 72 | 97 | 96 | 56 |

### 4.2.2 Stability of pesticide residues in stored analytical samples

No specific studies presented but evidence from metabolism studies indicate that frozen stored residues were generally stable.

### 4.2.3 Residue definition

The current residue definition in the MRL Standard defines atrazine as atrazine. This does not require that the chloro or other metabolites be measured.

## 4.3 Use pattern

The NRA in 1994 advised users of registered products containing atrazine that amendments to the atrazine use patterns were required to reduce the potential of atrazine to reach surface and groundwater.  Such changes were in line with situations overseas and would still allow the use of atrazine.

Atrazine uses considered to be no longer appropriate

On the basis of the NRA decision, specific uses of atrazine, now considered to have fallen under the restrictions are:

Agricultural buildings
Along creek banks
Aquatic areas
Continuous weed free conditions (e.g. industrial areas, cemeteries)
Couch Grass fairways, nature strips and median strips
Couch Grass turf, green couch, Kikuyu and Buffalo grass
Industrial uses and non-agricultural uses unless otherwise specified
Irrigation banks, channels and drains
Seasonal maintenance

### 4.3.1 Use patterns

These use patterns were taken from an interpretation of the product labels examined and the NRA decision to amend the atrazine use pattern. Ciba-Geigy products being given "pioneer" status and the labels for Ciba-Geigy Atrazine Granules 900 WG Herbicide and Flowable Gesaprim 500 SC were used as guides for the use patterns. Permit uses were not considered. NRA records indicate 34 products containing atrazine are registered, only 23 labels were available for evaluation.

#### 4.3.1.1 Number of applications, withholding periods

A single application has been presumed except where there was clear label indication that further applications were made. Similarly a nil withholding period has been assumed unless the label stated otherwise. In some cases treatment of native pastures was combined with a 14 day stock grazing restraint. Specific withholding period statements were:

| Product | Withholding period statement |
|---|---|
| FLOWABLE GESAPRIM 500 FW LIQUID HERBICIDE | When treating native pastures, keep stock off for 14 days while Flowable Gesaprim takes effect |
| ATRANEX 500 SC HERBICIDE | Do not graze stock for 14 days while product takes effect, when treating native grasses |
| CROP KING FLOWABLE ATRAZINE 500SC | When treating native pastures, keep stock off for 14 days while this product takes effect<br>Pinus radiata - Do not graze treated areas |
| MARKSMAN HERBICIDE (atrazine and dicamba) | Do not graze or cut for stock food for 7 days after application |
| ATRAZINE GRANULES 900 WG | When treating native pasture, keep stock off for 14 days while this product takes effect |
| FLOWABLE GESAPRIM 500 SC | When treating native pastures, keep stock off for 14 days while Flowable Gesaprim takes effect AND<br>Withholding period: NIL |
| MACSPRED FOREST MIX GRANULAR HERBICIDE (use in Pinus radiata plantations) | Keep stock away from treated areas |
| GESAPAX COMBI 800 WG HERBICIDE GRANULES (atrazine and ametryn) | Withholding period: NIL |
| GESAPAX COMBI 500 SC LIQUID HERBICIDE (atrazine and ametryn) | Withholding period: NIL |

### 4.3.1.2 Application rates

Ciba-Geigy rates were used where appropriate use patterns existed. Many of the product labels examined had reference to rates which were higher than the current Ciba-Geigy rates and were considered to reflect rates used before the decision to reduce the maximum rates for all crops was taken. When use rates significantly exceeded the 3 kg atrazine/ha/year (except plantation forestry uses), the use pattern was considered to be no longer valid. Small excesses (up to approximately 3.5 kg/ha/year) of the 3 kg/ha/year limit were treated as being 3 kg/ha/year.

In some instances, lower rates were used with the addition of other actives. As residues in such cases are expected to be lower than when the atrazine was used alone, these situations have been identified separately in the use patterns.

#### 4.3.1.3 Active constituent descriptions

Active constituent concentrations were originally described in terms of atrazine alone. Descriptions now refer to “atrazine and related triazines” or statements of that type. In the absence of information to the contrary, it has been assumed that the related triazines make up only a minor component and that they leave no measurable residues in agricultural commodities.

#### 4.3.1.4 Product specific requirements

A number of products had requirements for particular use patterns or use of the product which were not always required by other products for the same conditions. For example the ICI Crop Care product Atradex 900 WG Herbicide required that “Agral 600” be used when applying to emerged weeds as a foliar spray. Other product labels did not have a similar requirement in relation to spraying of emerged weeds. Wetting agents were also in the label requirements for some products for use on sorghum etc. These have been commented on in the Attachments “Label use patterns 1.” and “Label use patterns 2.” where considered appropriate.

Residue trials in support of registration of such products need to ensure that the adjuncts etc. are used so that the residue results are generated from trials conducted according to the label use pattern.

## 4.4 Residues resulting from supervised trials

### 4.4.1 Crop trials

No results from supervised crop trials using atrazine were presented. Ciba-Geigy had presented a list of available and previously submitted studies but had not presented the actual studies.

### 4.4.2 Animal transfer studies

Poultry

Mature leghorn hens were fed without restriction a diet containing atrazine at 0, 0.5, 1.5 and 5 ppm for 28 days. Skin plus attached fat, liver, fat and lean muscle were collected from three hens from each treatment group at 7, 14, 21 and 28 days. Eggs were collected from each treatment group on days 0, 1, 3, 7, 10, 14, 17, 21, 24 and 28. Combined chlorotriazine residues were calculated as the sum of the observed residues for atrazine, desethylatrazine (G-30033), desisopropylatrazine (G-28279), and diaminochlorotriazine (G-28273). Limits of detection were 0.01 mg/kg in all tissues except liver and 0.05 mg/kg in liver (Bade and Cheung, 1987a)

Analytical methods used were AG-476, “Determination of Atrazine, G-28279, G-300033, and G-28273 Residues in Beef Tissues (Blood, Muscle, Liver, Kidney, Fat) with modification to that analytical method. Samples were considered to be stable when stored under freezer conditions for at least 6 months. G-28273 in liver gave some indications of decline and this was to be further investigated.

No atrazine, G-30033 or G-28279 residues were determined in any samples.

Residues of diaminochlorotriazine (G-28273) in tissues were also less than the limits of quantitation for the 0.5 and 1.5 ppm feeding trials. At 5 ppm, residues of this metabolite were detected in skin (0.02 mg/kg) and breast and thigh tissue (0.02-0.03 mg/kg). In eggs, residues of this compound were between <0.01 and 0.01 mg/kg in the 1.5 ppm dosed birds and between <0.01 and 0.07 mg/kg in the birds fed at 5 ppm.

Dairy cattle

Lactating dairy cows were dosed once a day for 28 consecutive days with atrazine at levels equivalent to 0, 3.75, 11.25, and 37.5 ppm in their diet (Bade and Cheung, 1987b).

The dose was given in the morning mixed with a small amount of feed. There were two control cows and 3 cows per treatment group. One cow per treatment group was killed at days 14, 21, and 28 and liver, kidney, fat, blood and muscle collected for atrazine analysis. Milk was collected from each treatment group (pre-dose) on days 1, 4, 7, 12, 19, and 26. Evening milk samples were mixed with morning milk samples from the following day.

Samples were frozen until analysed by methods AG-463 (Determination of Atrazine, G-28279, G-30033, and G-28273 Residues in Milk) and AG-476 (Determination of Atrazine, G-28279, G-30033 and G-28273 Residues in Beef Tissues (Blood, Muscle, Liver, Kidney, Fat)) as modified by the analysing laboratory

No residues of atrazine (<0.01 mg/kg) were found in any of the tissues or milk analysed. A value of 0.04 mg/kg found in one milk sample after 2 days feeding was considered to be from contamination.

No residues of G-30033 or G-28279 were found in the tissues or blood at any of the feeding levels or in milk at the 3.75 and 11.25 ppm feeding levels. At the 37.5 ppm level milk results showed maxima of 0.03 mg/kg were reached followed by a return to non-measurable (<0.01 mg/kg) levels.

Metabolite G-28273 was present in tissues and milk from all feeding levels.
In tissues the maximum values were 0.02 mg/kg (3.75 ppm, loin muscle), 0.06 mg/kg (11.25 ppm, round muscle), and 0.115 mg/kg (37.5 ppm, liver). In milk, the maximum values at the three feeding levels were 0.03, 0.12, and 0.41 mg/kg respectively.

To investigate the rate of transfer and the nature of atrazine residues in milk, lactating Jersey cows (375 to 425 kg, 24 hours before slaughter) were given orally administered (UL)-$^{14}$C-atrazine for nine consecutive days, once per day at 0.0085, 0.0747, and 0.764 ppm of atrazine in the diet (one cow per feeding level, and one control cow). Milk was collected throughout the study. The animals were killed within 8 hours of the final milking. Average feed consumptions during the 9 days of treatment were 17.8, 17, and 14.7 kg/day (dry weights) for the low, medium and high dose animals. One urine sample was collected on day 6 from the high dose animal (Thalacker, 1996).

In the urine, the diaminochlorotriazine (G-28273) was the major radioactive metabolite, consisting of 22.1% (221 ppb) of the total radioactive residue (TRR).

Total radioactivity in the composite (pooled milk samples from 10 and 24 hours after the daily oral dose) milk samples indicated plateaux levels started from day 3. The levels averaged (days 3 through to 9), 0.161, 1.19, and 11.7 ppb respectively for the three feeding levels of 0.0085, 0.0747, and 0.764 ppm.

Transfer rates of total radioactivity to the milk for the three dose levels were (averages) 1.79, 0.91, and 1.52% (low, middle and high dose rates respectively).

Extraction methods recovered more than 90% of control milk fortified with G-28273 and approximately 20% of the radioactive dose could not be extracted from the milk at any of the three dose levels. On average, more than 80% of the milk radioactivity was present in the aqueous fraction after acetone extraction and hexane partitioning.

Averages of 66.6 to 70.5% of the total radioactive residues in milk were identified as G-28273. These corresponded to residue levels of 0.11, 0.77, and 8.04 ppb of G-28273. No other metabolite was present at more than 4% of the TRR.

**Residues of G-28273 in milk - Day 3-Day 9 averages**

| Dose (ppb) | TRR in milk (ppb) | G-28273 (ppb) | G-28273 (% TRR) |
|---|---|---|---|
| 8.6 | 0.16 | 0.11 | 67.2 |
| 74.7 | 1.19 | 0.8 | 66.7 |
| 753 | 11.7 | 8.27 | 70.2 |

G-28273 diaminochlorotriazine
TRR total radioactive residue

## 4.5 Fate of residues in storage and processing

Data were presented in various crops confirming the stability of atrazine residues during storage.

## 4.6 National maximum residue limits

The Australian MRLs for atrazine as listed by the MRL Standard are:

(Australian residue definition: atrazine)

| Atrazine | MRL (mg/kg) |
|---|---|
| Citrus fruits | *0.1 |
| Edible offal (mammalian) | *0.1 |
| Grapes | *0.1 |
| Lupin (dry) | *0.02 |
| Maize | *0.1 |
| Meat (mammalian) | *0.01 |
| Milks | *0.01 |
| Pineapple | *0.1 |
| Potato | *0.01 |
| Rape seed | T*0.01 |
| Sorghum | *0.1 |
| Sugarcane | *0.1 |
| Sweet corn (corn on the cob) | *0.1 |

T temporary

The United States of America has established the following atrazine residue limits:

**1. Residue definition: 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine**

| MRL ppm | Crop | MRL ppm | Crop | MRL ppm | Crop |
|---|---|---|---|---|---|
| 0.02 (N) | cattle, fat | 0.02 (N) | goats, meat | 0.02 (N) | poultry, MBYP |
| 0.02 (N) | cattle, MBYP | 0.05 | guava | 0.02 (N) | poultry, meat |
| 0.02 (N) | cattle, meat | 0.02 (N) | hogs, fat | 15 | rye grass, perennial |
| 15 | corn, fodder, field | 0.02 (N) | hogs, MBYP | 0.02 (N) | sheep, fat |
| 15 | corn, fodder, pop | 0.02 (N) | hogs, meat | 0.02 (N) | sheep, MBYP |
| 15 | corn, fodder, sweet | 0.02 (N) | horses, fat | 0.02 (N) | sheep, meat |
| 15 | corn, forage, field | 0.02 (N) | horses, MBYP | 15 | sorghum fodder |
| 15 | corn, forage, popcorn | 0.02 (N) | horses, meat | 15 | sorghum forage |
| 15 | corn, forage, sweet | 0.25 | macadamia nuts | 0.25 | sorghum grain |
| 0.25 | corn, fresh (include sweet K+CWHR) | 0.02 (N) | Milk | 0.25 | sugarcane |
| 0.25 | Corn, grain | 0.25 | pineapples | 0.25 | sugarcane, fodder |
| 0.02 (N) | eggs | 10 | pineapples, fodder | 0.25 | sugarcane, forage |
| 0.02 (N) | goats, fat | 10 | pineapple, forage | 5 | wheat, fodder |
| 0.02 (N) | goats, MBYP | 0.02 (N) | poultry, fat | 0.25 | wheat, grain |
| | | | | 5 | wheat, straw |

**2. Residue definition: Atrazine and metabolites; 2-amino-4-chloro-6-ethylamino-*s*-triazine, 2-amino-4-chloro-6-isopropylamino-*s*-triazine, and 2-chloro-4,6-diamino-*s*-triazine.**

| MRL ppm | Crop | MRL ppm | Crop | MRL ppm | Crop |
|---|---|---|---|---|---|
| 4 | grass, range | 5 | proso millet, fodder | 0.25 | proso millet, grain |
| 15 | orchardgrass | 5 | proso millet, forage | 5 | proso millet, straw |
| 15 | orchardgrass, hay | | | | |

Atrazine MRLs from other nations were reported by Ciba-Geigy as:

| Country | Crop | MRL mg/kg | Preharvest interval and comment |
|---|---|---|---|
| **Austria** | Asparagus | 1 | |
| | Maize | 0.5 | |
| **Belgium** | Fruit | 1 | |
| | Maize | 1 | |
| | Other plant products | 5 | |
| | Vegetables | 1 | |
| **Brazil** | Apples | 0.2 | All Brazilian MRLs are associated with a 45 day preharvest interval. |
| | Bananss | 0.2 | |
| | Citrus fruit | 0.2 | |
| | Cocoa | 0.2 | |
| | Coffee | 0.2 | |
| | Maize | 0.2 | |
| | Mango | 0.2 | |
| | Nuts | 0.2 | |
| | Peaches | 0.2 | |
| | Pepper (spice) | 0.1 | |
| | Pineapples | 0.2 | |
| | Sorghum | 0.2 | |
| | Sugar cane | 0.2 | |
| | Tea | 0.2 | |
| **France** | Fruit | 0.1 | |
| | Vegetables | 0.1 | |
| **Germany** | Other plant products | 0.05 | |
| **Israel** | Eggs | 0.02 | |
| | Maize (grain) | 0.25 | |
| | Maize (fodder) | 15 | |
| | Meat | 0.02 | |
| | Milk | 0.02 | |
| | Sorghum (grain) | 0.25 | |
| | Sorghum (fodder) | 15 | |
| | Sweet corn | 0.25 | |
| | Wheat | 10 | |
| **Italy** | Fruit | 0.1 | All Italian MRLs are associated with a 30 day preharvest interval. |
| | Maize | 0.1 | |
| | Sorghum | 0.5 | |
| | Vegetables | 0.1 | |
| **Japan** | Cereals | 0.02 | |
| | Fruit | 0.02 | |
| | Sugar cane | 0.02 | |
| | Vegetables | 0.02 | |
| **Mexico** | Maize (grain) | 0.25 | |
| | Maize (fodder) | 15 | |
| | Pineapples (fruit) | 0.25 | |
| | Pineapples (forage) | 10 | |
| | Sorghum (grain) | 0.25 | |
| | Sorghum (fodder) | 15 | |
| | Sugar cane | 0.02 | |
| | Sweet potatoes | 0.02 | |
| **South Africa** | Maize | 0.05 | |
| | Sorghum | 0.05 | |
| | Sugar cane | 0.05 | |
| **Spain** | Maize (grain) | 0.25 | |
| | Maize (forage) | 1 | |
| | Sorghum (grain) | 0.25 | |
| | Sorghum (forage) | 1 | |

| Country | Crop | MRL mg/kg | Preharvest interval and comment |
|---|---|---|---|
| **Switzerland** | Asparagus | 0.05 | |
| | Grapes | 0.05 | |
| | Maize | 0.1 | |
| **The Netherlands** | Fruit | 0.1 | |
| | Maize | 0.1 | |
| | Sugar cane | 0.1 | |
| **Yugoslavia** | Eggs | 0.02 | |
| | Fruit | 0.1 | |
| | Maize | 0.5 | |
| | Meat | 0.02 | |
| | Milk | 0.02 | |
| | Vegetables | 0.1 | |

## 4.7 Appraisal

### 4.7.1 Animal metabolism

Because the lactating goat metabolism studies presented either contained no experiment results or did not use atrazine as a test substance, the fate of atrazine in farm animals could not be reviewed. All further conclusions regarding animal commodities are based upon direct feeding studies.

### 4.7.2 Plant metabolism

In young corn plants treated with atrazine at a rate similar to those used commercially, atrazine residues were between 0.003 and 1.23 mg/kg in 30 day forage samples and less than 0.02 mg/kg in silage stage forage and mature fodder. Levels of chlorometabolites of atrazine were less than 0.02 mg/kg in the 30 day forage. In mature fodder, residues of these metabolites were less than 0.01 mg/kg. The major metabolite identified was 2-amino-4-isopropyl-6-hydroxy-*s*-triazine, present in amounts of up to 0.27, 0.33, 0.005, and 0.14 mg/kg in 30 day forage, mature fodder, mature grain, and silage stage forage respectively.

In a similar study, atrazine residues in young sorghum plants treated with atrazine at a rate similar to those used commercially, were between 0.02 and 2.66 mg/kg in 30 day forage samples and less than 0.1 mg/kg in silage stage forage and mature fodder. Levels of chlorometabolites of atrazine were less than 0.05 mg/kg in the 30 day forage. In mature fodder, residues of these metabolites were less than 0.01 mg/kg. The major metabolite identified was 2-amino-4-isopropyl-6-hydroxy-*s*-triazine, present in amounts of up to 0.48, 0.14, 0.019, and 0.06 mg/kg in 30 day forage, mature fodder, mature grain, and silage stage forage respectively.

When growing sugarcane was given 4 applications of atrazine at rates similar to those used commercially, the atrazine level in the leaves 207 days after sowing and approximately 90 days after the third treatment was 0.16 ppm. Chloroatrazine residue levels were between 0.15 and 5.7 mg/kg. At harvest (approximately 137 days after the fourth and last treatment), atrazine levels in the sugarcane and its leaves were 0.007 and 0.017 mg/kg respectively. Chlorometabolite residues were between 0.015 and 0.4 mg/kg in the leaves and 0.009 and 0.06 mg/kg in the cane.

The metabolism studies support the current atrazine MRLs for maize and sorghum grains. For sugar cane, inclusion of the chlorometabolites in the residue definition indicates consideration of the current MRL of *0.1 mg/kg could be desirable. The studies also demonstrate that forage and fodder could contain measurable residues of atrazine and its chlorometabolites and that establishment of fodder and forage MRLs also needs consideration.

### 4.7.3 Analytical methods

Analytical methods presented for determination of atrazine and its chlorometabolites in forage, fodder, grain, grain fractions, animal tissues, milk and eggs appeared satisfactory. The methods have sufficient sensitivity and recoveries at low residue levels (0.05 for grains, fodder and forage, and 0.01-0.05 mg/kg for animal commodities) and are based on extraction of the residues from the commodity and determination by gas liquid chromatography.

### 4.7.4 Residue definition

The animal transfer studies point to the need to consider amendment of the present residue definition for atrazine to include reference to its chlorometabolites. The USA has done this but has not applied the atrazine plus chlorometabolites residue definition to most commodities (including animal commodities) - there are very good practical reasons for such a course of action.

From a residue viewpoint determination of atrazine residues only appears practical and relevant in the light of the plant metabolism studies. However if there are toxicological reasons for it or if these metabolites are included in the residue definition of major trading partners, inclusion of the chlorometabolites in the residue definition may need to be considered further.

This issue was referred to the Advisory Committee on Pesticides and Health. The Committee appreciated the need to take into account toxicologically significant metabolites from an exposure risk assessment perspective. However, it was considered that the inclusion of the metabolites in the atrazine residue definition for food would be impractical for the following reasons:

- parent atrazine is likely to form a major component of the residues;
- some of the metabolites are common to other triazine herbicides which could present enforcement difficulties;
- it would unnecessarily complicate regulatory analyses which may compromise routine residue monitoring.

### 4.7.5 Animal transfer studies

When laying hens were fed atrazine for 28 days at levels of 0.5, 1.5 and 5 ppm in the feed, no residues of atrazine or its chlorometabolites except for DACT were detected in any tissues (<0.01 mg/kg or <0.05 mg/kg for liver). The diamine was present at levels of 0.02-0.03 mg/kg in muscle and skin at the 5 ppm feeding level and in eggs at ≤0.01 mg/kg at the 0.5 and 1.5 feeding levels and between <0.01 and 0.07 mg/kg at the 5 ppm feeding level.

In dairy cattle fed atrazine in the diet for 28 consecutive days at levels of 3.75, 11.25 and 37.5 ppm in the diet, no atrazine residues (<0.01 mg/kg) were found in any tissues or milk samples. Apart from DACT, residues of other chlorometabolites were less than 0.05 mg/kg. The diamine was present in tissues and milk at all feeding levels. In tissues the maximum values of the diamine were 0.02 mg/kg in loin muscle at the 3.75 ppm level, 0.06 mg/kg in round muscle at the 11.25 ppm level and 0.12 mg/kg in liver at the 37.5 ppm level. Maximum milk values were 0.03, 0.12 and 0.41 mg/kg respectively.

When dairy cattle were fed atrazine in the diet for 9 consecutive days at levels of 0.0085, 0.0747 and 0.764 ppm, average total residue concentrations in the milk were 0.00016, 0.0019, and 0.012 mg/kg respectively. DACT was the major metabolite identified with residue levels of 0.0001, 0008, 0.008 mg/kg found at the three feeding rates.

The animal transfer studies show that measurable residues of atrazine are unlikely to occur in animal commodities at atrazine levels in the feed of approximately 40 ppm.

### 4.7.6 Animal feed commodities

There are currently no Table 4 entries in the MRL Standard. Information on crop residues (specifically sorghum, lucerne and pasture) will be necessary in order to set animal feed commodity MRLs.

## 5. RECOMMENDATIONS

### 5.1 Efficacy

The NRA will obtain information from registrants, State departments of agriculture and CSIRO, on any reported incidents of atrazine resistance and follow-up investigations.

The interim recommendations of the Forest Herbicide Research Management Group should be incorporated into the conditions of use for atrazine products, where appropriate.

All current labels should be audited to ensure they comply with the restrictions introduced in December 1995, and these restrictions should be fully enforced.

Registration for use on canola, and the establishment of an appropriate MRL, should be made a priority by registrants, growers, state departments of agriculture and the NRA.

Registration for the use of atrazine on Parthenium weed should be extended to the Northern Territory and New South Wales.

## 5.2 Residues

No change to the current residue definition of atrazine parent for crops and animal commodities is warranted.

The following MRLs are recommended for amendment/deletion.

**(i) deletion due to no current Australian use pattern:**

| | |
|---|---|
| Citrus Fruits | *0.1 mg/kg |
| Grapes | *0.1 mg/kg |
| Pineapple | *0.1 mg/kg |

**(ii) modification (for new MRL see below):**

| | |
|---|---|
| Edible offal (mammalian) | *0.1 mg/kg |
| Meat (mammalian) | *0.01 mg/kg |
| Milks | *0.01 mg/kg |

**(iii) The following new MRLs to be introduced:**

| | |
|---|---|
| Primary Animal Feed Commodities | T40 mg/kg |
| Edible offal (mammalian) | T*0.1 mg/kg |
| Meat (mammalian) | T*0.01 mg/kg |
| Milks | T*0.01 mg/kg |

T refers to MRLs that will expire in three years after the review is finalised.

Applicants are required to provide forage and fodder residue data for sorghum, pastures and lucerne in order to confirm the primary animal feed commodity MRL and those of animal commodities. In addition, these data should permit confirmation or appropriate change to withholding periods for grazing of these crops. This trial data must be consistent with the Australian use patterns for atrazine-containing agricultural products.

### 5.2.1 Further work or information

It is desirable for applicants to provide the following:

- Complete farm animal metabolism studies
- A complete copy of the corn metabolism study of Banzer and Cassidy (1971).

# REFERENCES


Australian Bureau of Agricultural Resource Economics (ABARE). Australian commodities, vol. 3 no 3, September 1996.

**P** Bade, T.R. and Cheung, M.W. 1987a, Residues of atrazine and its chloro-metabolites in poultry tissues and eggs from laying hens following administration of atrazine, Ciba-Geigy Corp., USA, Rep. Nr. ABR-87059, 06/11/1987

**P** Bade, T.R. and Cheung, M.W. 1987b, Residues of atrazine and its chloro-metabolites in dairy tissues and milk following administration of atrazine, Ciba-Geigy Corp., USA, Rep. Nr. ABR-87060, 06/11/1987

**P** Bade, T.R. and Toth, J. 1985a, Determination of atrazine, G-28279, G-30033 and G-28273 residues in beef tissues (blood, muscle, liver, kidney, fat), Ciba-Geigy Corp., USA, Method No. AG-476, 17/09/1985

**P** Bade, T.R. and Toth, J. 1985b, Determination of atrazine, G-28279, G-30033 and G-28273 residues in milk, Ciba-Geigy Corp., USA, Method No. AG-463, 17/09/1985

**P** Bade, T.R. and Toth, J.C. 1987, Determination of atrazine, G-30033, G-28279 and G-28273 residues in forage, fodder, grain and grain fractions from grain crops using capillary gas chromatography, Ciba-Geigy Corp, USA, Method No. AG-484, 05/11/87

**P** Banzer, C. and Cassidy, J, 1971, Metabolites of $^{14}$C-Atrazine in mature corn silage, grain, and soil, Ciba-Geigy Corp, USA, Rep. Nr. GAAC-71022, 22/07/1971

Bos J, Jolley A and Johnstone P. Herbicide Persistence in Australian Winter Cereal Cropping Systems. Grains Research and Development Corporation, 1995.

Clark, J. Australia's Plantations. A report to the State Conservation Councils. Environment Victoria Inc., July 1995.

Fawcett R, Christensen, B and Tierney, D. The impact of conservation tillage on pesticide runoff into surface water: a review and analysis. Journal of Soil and Water Conservation, March-April 1994, pp 126 -135.

**P** Fisher, G.D (Study director), 1993a, Biological report for the metabolism of [$^{14}$C]-hydroxysimazine in lactating goats, Ciba-Geigy Corp., USA, Rep. Nr. BIOL-93003, 16/07/93

**P** Fisher, G.D. (Study director), 1993b, Analytical (Mass balance) phase report for the distribution of [$^{14}$C]-hydroxysimazine in lactating goats, Ciba-Geigy Corp., USA, Rep. Nr. ANPHI-93004, 16/11/93

**P** Gold, B. 1988a, Determination of simazine, atrazine, G-3033, G-28279 and G-28273 residues in beef tissues, poultry tissues, and poultry eggs using capillary gas chromatography, Ciba-Geigy Corp. USA, Method No. AG-540, 15/04/1988

Hamilton D and Haydon G. Pesticides and fertilisers in the Queensland sugar industry - estimates of usage and likely environmental fate. Project: ICM-R&D.94.01. Resource Management Institute, Department of Primary Industries, Indooroopilly, Queensland, January, 1996.

**P** Larson, J.D., 1992, $^{14}$C-Atrazine: Nature of the residue in corn and sorghum, Hazleton Laboratories, USA, Rep. Nr. HWA 6117-178, 26/10/1992

**P** Larson, J.D., 1993, $^{14}$C-Atrazine: Nature of the residue in sugarcane Final Report Amendment No. 1, Hazleton Wisconsin. Inc., USA, Rep. Nr. HWI 6117-181, 18/10/1993

**P** Larson, J.D. and Ash, S.G., $^{14}$C-atrazine: Nature of the residue in corn and sorghum, (MRID 42547116) Amendment No. 2 to the final report, Hazleton Wisconsin, Inc., USA, Rep. Nr. HWI 6117-178, Study completed October 26, 1992. Certificate of authenticity signed 9 March 1995.

**P** Larson, J.D. and Ash, S.G., $^{14}$C-atrazine: Nature of the residue in sugarcane (MRID 43016503) Supplement No.1 to the final report, Hazleton Wisconsin, Inc., USA, Rep. Nr. HWI 6117-181, Study completed October 18, 1992. Certificate of authenticity signed 9 March 1995.

**P** Merricks, D.L., 1986, Final Report Metabolism of atrazine in a goat, Agrisearch Incorporated, USA, Rep. Nr. 1227, 28/8/1986

**P** Posner S., Goldhamer, R.E., Epstein, B., and Klimek, J., 1972a Metabolism of $\Delta^{14}$C-atrazine administered in capsules and in feed to milking goats, Biometric, USA, Rep. Nr. A-647a, 25/10/1972

**P** Posner S., Goldhamer, R.E., Epstein, B., and Klimek, J., 1972b, Metabolism of $\Delta^{14}$C-atrazine and $\Delta^{14}$C-simazine administered in capsules to a milking goat, Biometric, USA, Rep. Nr. A-647b, 25/10/1972

**P** Thalacker, F.W., 1996, Determination of transfer rate and nature of the residue(s) in milk from $^{14}$C-atrazine treated cows, Corning Hazleton Inc, Madison, Wisconsin, USA, Rep. Nr. CHW 6117-325, 16/1/1996

# ATTACHMENTS

## ATTACHMENT 1

**Label use patterns 1 (as at commencement of review). Atrazine as the single active** (on some occasions, the label allows for mixing with another active). CIBA-GEIGY ATRAZINE GRANULES 900 WG HERBICIDE AND CIBA-GEIGY FLOWABLE GESAPRIM 500 SC LIQUID HERBICIDE USE PATTERNS were taken as the primary use patterns

| Crop/situation | Concentration of active | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Concep II treated sorghum seed | 500 g/L | Pre-emergent | 2.5 litres/ha (1.25 kg/ha) | Plus Dual Herbicide |
| Established ryegrass seed crops | 900 g/kg | After good Autumn rains | 0.83 to 1.1 kg/ha | |
| Eucalyptus plantations | 500 g/L | pre and post-planting | 9-16 litres/ha (4.5 - 8 kg/ha) | |
| Eucalyptus plantations | 900 g/kg | pre- and post-planting | 5 to 8.8 kg/ha | |
| Grass pastures | 500 g/L | Post-emergent | 4 to 6 l/ha (2 to 3 kg/ha) | |
| Grass seed crops - established stands of Sirocco Phalaris, Demeter Fescue and Currie Cocksfoot.<br>Seedling Signal grass and *Panicum maximum* | 500 g/L | <br>Pre-emergent | 1.8 to 2.2 l/ha (0.9 to 1.1 kg/ha)<br>4.5 to 6 l/ha (2.25 to 3 kg/ha) | After Autumn break for Brome grass control |
| Grass seed crops - established stands of Sirocco Phalaris, Demeter Fescue and Currie Cocksfoot.<br>Seedling Signal grass and *Panicum maximum* | 900 g/kg | <br>Pre-emergent | 1 to 1.2 kg/ha<br>2.5 to 3.3 kg/ha | After Autumn break for Brome grass control. |
| Lucerne | 500 g/L | At Mintweed germination | 1.1 litres/ha (550 g/ha) | Lucerne more than 1 year old. |
| Lucerne | 900 g/kg<br>800 g/kg | At Mintweed germination | 600 g/ha<br>700 g/ha | Lucerne more than 1 year old. |
| Lupins -weedfree seedbed | 500 g/L | Immediately before or at seeding | 1-2 litres of mixture/ha | 0.5-1 litre + 0.5-1 litre of Gesatop 500 FW liquid herbicide |
| Lupins -weedfree seedbed | 900 g/kg | Before or at seeding | 930 g/ha to 1.2 kg/ha of mixture | Mixture: 280-560 g of formulation plus 500 mL to 1 litre flowable simazine. |

## Attachment 1 (CONT).

| Crop/situation | Concentration of active | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Maintenance of fallow areas prior sowing wheat, peas, lupins | 900 g/kg | Pre-plant | 650 g to 870 g/ha | Vic only. |
| Maintenance of fallow areas prior to planting a sorghum crop in a conservation tillage system | 500 g/L | Pre-plant | 3.6 to 6 litres/ha (1.8 to 3 kg/ha) | |
| Maintenance of fallow areas prior to planting a sorghum crop in a conservation tillage system | 900 g/kg | Pre-plant | 2 to 3.3 kg/ha | |
| Maize and sorghum | 900 g/kg | Pre-emergence Post-emergence | 1.2 kg/ha<br>350 g or 1.2 kg/ha<br><br>0.83-1.1 kg/ha | Post-emergence use requires use of adjuncts.<br><br>Do not use sufactants or crop oil. Requires admixture with another formulation |
| Maize and sweetcorn (irrigated & dryland) | 500 g/L | Pre-plant, pre-emergent, post-emergent | 4.5 to 6 litres/ha (2.25 to 3 kg/ha) | Post-emergent use requires addition of crop oil or surfactant to spray mixture. |
| Maize and sweetcorn (irrigated & dryland) | 900 g/kg<br><br><br><br><br><br><br><br>800 g/kg | Pre-plant, pre-emergent, post-emergent<br><br><br><br><br><br><br><br>Pre- and post-emergent | 2.5 to 3.3 kg/ha<br>600 g/ha (mintweed )<br>320 g or 1.2 kg (post-emergence)<br><br>1.2 kg (pre-emergence)<br><br>2.8 to 4.2 kg/ha | Post-emergent use: add a non-ionic surfactant and crop oil. Some formulations recommended use of wetting agents for the pre-emergence use also.<br><br>The 4.2 kg/ha rate should now be 3.75 kg/ha to meet 3 kg atrazine/ha/year. |
| Pinus Radiata plantations | 500 g/L | Pre- and post-planting | 9-16 litres/ha (4.5 - 8 kg/ha) | |
| Pinus Radiata plantations | 500 g/L | pre- and post-planting | 2.8-8 litres/ha (1.4-4 kg/ha) | Plus other actives e.g Ciba-Geigy TL Plus or CRG Weed Free |
| Pinus Radiata plantations | 500 g/L | pre- and post-planting | 2.8-4 litres/ha (1.4-2 kg/ha) | Plus amitrole or other formulations |

## Attachment 1 (CONT).

| Crop/situation | Concentration of active | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Pinus Radiata plantations | 900 g/kg | pre- and post-planting | 5 to 8.8 kg/ha | Lower rates plus other actives were used in some product formulations. |
| Potatoes | 500 g/L | | 2.3 litres/ha (1.15 kg/ha) | Applied after potato haulms have died off. Used with amitrol and ammonium thiocyanate solution (2.3 litres plus 4.6 litres of the mixed solution (250 g amitrol/l and 220 g thiocyanate/l) |
| Roadsides and rights of way | 500 g/L | | 450 mL/100 litres (225 g/100 litres)<br><br>250 mL/ 10 litres (125 g/10 litres) | High volume and misting machine rates respectively. Mintweed control only. Reference in use pattern to creeks and fencelines considered inappropriate. |
| Roadsides and rights of way | 500 g/L | Pre- and post-emergent | 6 litres/ha (3 kg/ha) | |
| Roadsides and rights of way | 900 g/kg<br><br>800 g/kg | | 250 g/100 L or 0.14 kg/10 L<br><br>280 g/100 L or 0.156 kg/10 L | High volume or misting machines respectively. Reference in use pattern to creeks inappropriate. |
| Roadsides and rights of way | 900 g/kg | Pre- and post-emergent | 3.3 kg/ha | |
| Seedling ryegrass, seed crops | 900 g/kg | tillering | 550 g/ha | Plus MCPA & Dicamba |
| Sorghum | 900 g/kg | Mintweed<br>Pre-emergence<br>Post-emergence | 600 g/ha<br>1.2 kg/ha<br>350 g or 1.2 kg/ha<br>1.1 kg/ha | Adjuncts to be added as well as 2,4-D-amine for the 1.1 kg/ha post-emergence use |
| Sorghum | 900 g/kg | Pre-emergent<br>Post-emergent | 3.3 kg/ha<br>1.1 kg/ha | Post-emergent use requires addition of Amicide 500 |
| Sorghum | 500 g/L | Pre-emergent | 2-4 litres/ha | Parthenium weed control plus wetting agent. |
| Sorghum (Irrigated and dryland) | 500 g/L | Post-emergent | 2 litres/ha (1 kg/ha) | Plus 500 mL of a 500 g/litre 2,4D-amine or 700 mL of a 200 g/L Dicamba solution |

## Attachment 1 (CONT).

| Crop/situation | Concentration of active | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Dryland) | 500 g/L | Pre-plant or pre-emergent | 3.6 litres/ha (1.8 kg/ha) | |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Dryland) | 500 g/L | Pre-plant or pre-emergent followed by a post-emergent application | 3.6 followed by 2.4 litres/ha (1.8 followed by 1.2 kg/ha) | |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Dryland) | 500 g/L | Post-emergent | 3.6-4.5 litres/ha (1.8-2.25 kg/ha) | Add a non-ionic surfactant |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Dryland) | 900 g/kg | Pre-plant or pre-emergent<br><br>Pre-plant or pre-emergent followed by a post-emergent use<br><br>Post-emergent | 2 kg/ha<br><br>2 kg followed by 1.3 kg<br><br>2-2.5 kg | Some products required addition of surfactant for pre-emergent use.<br><br>Plus a non-ionic surfactant |
| | 800 g/kg | Post-emergent | 4.2 kg/ha | Blanket spray application. Needs to be a maximum of 3.75 kg/ha to meet the 3 kg/ha/year limit. |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Irrigated and dryland) | 500 g/L | Pre-plant, pre-emergence or post-emergent application | 2.3 litres/ha (1.15 kg/ha) | |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Irrigated and dryland) | 900 g/kg | Pre-plant, pre-emergence or post-emergent application | 1.3 kg/ha | Post-emergent uses require addition of a non-ionic surfactant |
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Irrigated) | 500 g/L | Pre-plant or pre-emergence followed by a post-emergent application | 3 litres followed by 2.5 - 3 litres/ha (1.5 followed by 1.25-1.5 kg/ha) | |

## Attachment 1 (CONT).

| Crop/situation | Concentration of active | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Sorghum, Broom Millet, Saccaline and Forage Sorghum (Irrigated) | 500 g/L | Pre- or post-emergent only | 4.5 to 6 litres/ha (2.25 to 3 kg/ha) | Add a non-ionic surfactant to post-emergent applications. |
| ? | 900 g/kg<br><br><br><br><br><br><br><br><br><br><br><br><br>800 g/kg | Pre-plant or pre-emergence followed by a post-emergent application<br><br><br><br>Post-emergence<br><br>Pre- or post-emergent only<br><br>Pre- or post-emergent only | 1.7 kg followed by 1.4 to 1.6 kg or 1.4 or 2 kg/ha plus 1.4 or 2 kg/ha (800 g/kg formulation).<br><br>1.9 kg<br><br>2.5 to 3.3 kg<br><br>4.2 kg/ha | Add a non-ionic surfactant to post-emergent applications<br><br><br><br><br><br><br><br><br><br><br><br><br>Needs to be 3.75 kg/ha to meet the 3 kg/ha/year requirement. |
| Sugarcane | 500 g/L | Pre-emergent | 4-6 litres/ha (2-3 kg/ha) | A recommended post-emergent herbicide can be added on occasion |
| Sugarcane | 500 g/L | Pre- or early post-emergent | 6 litres/ha (3 kg/ha) | Plus 4 litres of Flowable Primatol Z. |
| Sugarcane | 500 g/L | Post-emergent | 4-6 litres/ha (2-3 kg/ha) | Herbicide and surfactant recommended by some products. |
| Sugarcane | 900 g/kg | Pre-emergent | 3.3 kg/ha | If grasses already emerged, add a post-emergent grass herbicide (e.g. paraquat) plus a non-ionic surfactant |
| Sugarcane | 900 g/kg | Post-emergence | 2.2 to 3.3 kg/ha | Where plants are large or conditions dry, add 2,4-D amine plus a non-ionic surfactant. |

# ATTACHMENT 2

## Label use patterns 2 (as at commencement of review). Atrazine and a second active present

| Crop/situation | Formulation Concentration of actives | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Maize (not Waxy Maize) and Sweet corn | 223 g/litre of atrazine and 277 g/litre of metolachlor | Pre-emergent | 5.3 litres/ha (1.2 kg atrazine/ha) | |
| Pinus radiata plantations | 150 g/kg atrazine and 50 g/kg hexanzinone | Post-planting | 30 kg/ha (4.5 kg atrazine/ha)<br><br>3 g/square metre (4.5 g atrazine/ha) | |
| Pinus radiata plantations | 320 g/litre atrazine and 320 g/litre amitrole | Pre- and post-planting | 4-6 litres/ha (1.3-1.9 kg atrazine/ha)<br><br>200-300 mL/100 litres (64-96 g atrazine/100 litres)<br><br>20-30 mL/50 $m^2$ (1.3-1.9 kg atrazine/ha) | |
| Rights of way | 400 g/kg atrazine and 400 g/kg amitrole | | 300-400 g/100L (120-160 g atrazine/100 L)<br><br>90-130 g/15 litre knapsack (36-52 g atrazine/15 litres) | Total weed control. 3.5 kg atrazine/ha if 2200 litres/ha used at 400 g/100 litres.<br><br>Addition of surfactant at either rate improves performance. |
| Roadways | 320 g/litre atrazine and 320 g/litre amitrole | Just before or during the active growing season. | 7 litres/ha (2.24 kg atrazine/ha)<br><br>350 mL/100 litres (112 g atrazine/ 100 litres)<br><br>35 mL/50 square metres (11. 2 g atrazine/50 $m^2$ , 2.2 kg atrazine/ha) | A "spreader-sticker" can be added to the spray. |

## Label use patterns 2. Atrazine and a second active present (cont).

| Crop/situation | Formulation Concentration of actives | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Roadways | 400 g/kg atrazine and 400 g/kg amitrole | | 25 g/ 8 litres/ 40 $m^2$. (2.5 kg atrazine/ha) | |
| Roadways | 400 g/kg atrazine and 400 g/kg amitrole | | 10 kg/ha (4 kg atrazine/ha) | |
| | | | 1 kg/200 litres at 2500 litres/ha (5 kg atrazine/ha) (Power spray) | Rates used are considered high in relation to the general reduction in atrazine rates of use. |
| | | | 50 g/12 litres/ 40 square metres (5 kg atrazine/ha) (Knapsack spray) | Repeat applications permitted for the knapsack and power spray uses. |
| Sorghum seed treated with Concep II Seed Safener | 223 g/litre of atrazine and 277 g/litre of metolachlor | Pre-emergent | 5.3 litres/ha (1.2 kg atrazine/ha) | Plus 1 to 2 litres of Dual per ha. |
| Sugar cane (plant and ratoon) | 500 SC 250 g/litre atrazine and related triazines and 250 g/litre ametryn and related triazines | Pre- or early post-emergent application to both crop and weeds. | 6-8 litres/ha (1.5-2 kg atrazine/ha) | Nil withholding period specified. |
| | | | 6 litres/ha (1.5 kg atrazine/ha) plus 2 litres of a flowable diuron (500 g/litre) | |
| Sugar cane (plant and ratoon) | 800 WG 400 g/kg atrazine and related triazines and 400 g/kg ametryn and related triazines | Pre- or early post-emergent application to both crop and weeds. | 3.75-5 kg/ha (1.5-2 kg atrazine/ha) | Nil withholding period specified. |
| | | As above plus for Green Summer Grass. | 3.75 kg (1.5 kg atrazine/ha) plus 2 litres of a flowable diuron (500 g/litre) | |

## Label use patterns 2. Atrazine and a second active present (cont).

| Crop/situation | Formulation Concentration of actives | Application | Application rate of product /treatment | Remarks |
|---|---|---|---|---|
| Sugarcane | 250 g/litre of atrazine and 130 g/litre of dicamba | | 2 to 4 litres/ha (0.5 to 1 kg atrazine/ha) | Label requirement that the product be use no more than once per season. Do not graze or cut for stockfood for 7 days after application. |
| Sugarcane | 250 g/litre of atrazine and 250 g/litre of ametryn | | 6-8 litres/ha (1.5-2 kg atrazine/ha) or 550-725 mL/100 litres of water (138-181 g atrazine/100 litres), or 80-100 mL/15 mL (assume this should be litres) knap-sack or 55-70 mL/litre misting (13.8-17.5 g atrazine/litre). | |
| Sugarcane (plant and ratoon) | 223 g/litre of atrazine and 277 g/litre of metolachlor | Pre- or post-emergent | 6-10 litres/ha (1.3 to 2.2 kg atrazine/ha) | Add a surfactant spray in all uses. Can be used with other herbicides under some conditions. |