



Plant
Protection
Division

HERBICIDES IN THE AMERICAS



'GRAMOXONE' INFORMATION BULLETIN

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Introduction

Paraquat was discovered by ICI in the late 1950's. Sold under its trade name GRAMOXONE it was introduced into most countries in the Americas in 1962 and over the following years developed into the most versatile and valuable weedkiller ever sold throughout North, Central and South America.

During that time research and extension workers have developed numerous ways of using GRAMOXONE's unique properties to revolutionise agriculture. At the same time thorough investigations have been made of GRAMOXONE's safety in use, behaviour in the environment, etc. As a result GRAMOXONE is probably one of the most comprehensively researched pesticides in the world today.



The purpose of this leaflet is to review the current state of knowledge of GRAMOXONE for the benefit of agronomists, extension and research workers who are involved in the development of paraquat. It thus also aims to enable them to provide the most up to date advice on the techniques of use, the safe handling and application of GRAMOXONE as well as to answer questions which inevitably arise concerning the safety of this widely used herbicide.

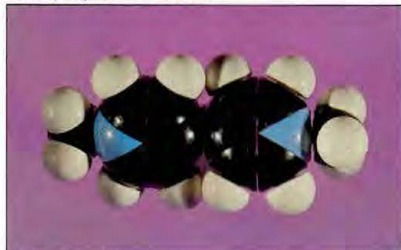
There have from time to time been a number of often poorly informed or distorted accounts appearing in the press which have created understandable concerns among growers. This booklet therefore provides source references for the scientific papers to which it refers, whilst also covering in the text a number of areas of possible concern.

The product

The principal paraquat based product sold in the Americas is GRAMOXONE — a 20% water based formulation of paraquat containing wetters to ensure optimum activity and incorporating — in accordance with local registration requirements — an ICI patented emetic agent, a stench and a blue dye.

GRAMOXONE is a broad spectrum contact desiccant of plant foliage, active on a very wide range of weeds. The product dilutes easily in water and can be applied by agricultural aircraft or ground sprayers. GRAMOXONE leaves no harmful residues in either crops or soil, when used as recommended.

Model of paraquat dichloride molecule.



Analytical laboratory.



Key characteristics which make GRAMOXONE one of the world's most reliable herbicides

Broad spectrum

Excellent control of a wide spectrum of annual grass and broad leaved weeds. Economic suppression of perennial weeds.

Low cost

Cost effective compared with both manual/mechanical weed control systems and other herbicides.

Rapid action

Weeds are killed within 2-4 days, rapidly removing competition with the crop for water, nutrients and light.

Rainfast

GRAMOXONE penetrates into plants quickly, making it particularly rainfast. Rain falling even half an hour after application has little or no detrimental effect on the herbicidal activity. (Ref. 2)

Inactivated by soil

Immediate inactivation on contact with most soils. Because there is no active residue in the soil, seeding can be carried out close to spraying. (Ref. 5)

Rapid uptake

Rapid absorption into the weed leaf allows cultivation after only four hours following application; this is a major benefit when preparing seedbeds after GRAMOXONE application. Other chemicals need several days to penetrate and translocate in the plant before cultivation. No other herbicide works as quickly as GRAMOXONE (Ref. 32)

Safe in crops

Kills only green matter it touches so that accidental application to a few crop leaves (eg in low hanging foliage in coffee or interrow weeding in maize) will only kill the few leaves affected and not have a detrimental effect on the whole plant (Ref. 14)

No effect on bark

No effect on mature bark. As GRAMOXONE has no effect on woody growth it can be sprayed on to the base of established orchard trees and vines without damaging the plants. (Ref. 8)

Easy mixing

Mixes easily with other herbicides, such as residual herbicides if long term control of weed germination is required, or hormone herbicides such as 2, 4-D and MCPA.

Typical 'Gramoxone' trial.



How do these characteristics translate into benefits for the farmer?

Reduced costs of weed control

Weed control using GRAMOXONE permits considerable savings when compared with hand labour costs or when compared with traditional weed control practices involving mechanical cultivation which are time consuming, and involve increasingly costly fuel.

Improved yields

Improves crop yields both because of improved weed control over hand or mechanical cultivation and also because these techniques can damage crop roots, and provoke moisture loss from the soil. The mulch of dead weeds remaining after treatment with paraquat can reduce moisture loss.

Simplified soil preparation

GRAMOXONE is used in many ways to reduce or eliminate soil cultivations necessary for weed control before planting. It provides a simple aid to conventional cultivations or controls weeds germinating after soil preparation but before planting. In the stale seedbed technique, land preparation is completed well in advance of planting, earlier in the season. GRAMOXONE is then used to "burn off" any seedling weeds which emerge before planting.

A logical extension of reduced cultivation systems is no-tillage planting, where all seedbed cultivations are eliminated and GRAMOXONE is used for total pre-plant weed control. Using GRAMOXONE in a no-tillage programme means that it is possible to ensure consistent establishment of the following crop, as in dry areas increased moisture levels resulting from no-tillage aid optimum seed germination. In many areas this has led to guaranteed two crop rotations per year as in the case of wheat/soya in the USA and Brazil, and maize/beans in El Salvador and Colombia (Ref. 31).

Figure 1

Work rates and fuel consumption to establish soya crops by conventional and no-tillage planting systems (Brazil) (Ref. 28)

Soil type and system	Work rate hr/ha	Fuel consumption l/ha
Clay soil		
No-tillage (Rotovator-based planter)	2.6	6.0
Conventional	7.1	24.5
Sandy loam soil		
No-tillage (Wavy disc planter)	1.1	2.6
Conventional	5.8	25.4

No-tillage soya after pre-plant weed control with 'Gramoxone'.



How these characteristics are used in some of the main uses:

No-tillage

An economic revolution in agriculture

GRAMOXONE is the ideal no-tillage herbicide. Its quick action, ability to mix with other products and inactivation on contact with soil make it the weedkiller of choice for the no-tillage farmer. It is unlikely that no-tillage farming would have evolved to its present extensive scale had the discovery of GRAMOXONE not occurred. These are some of the advantages which the no-tillage technique has brought to farmers from Argentina to Canada (Refs. 10 & 33).

Time saving

No-tillage eliminates cultivations, permitting the planting of large areas in a short timescale. This means that maximum yields can be obtained on the whole farm by planting the total area at the optimum time for each crop. More important, a rapid establishment of the next crop is possible in double cropping situations. Often, no-tillage is the only method by which double cropping systems can be established reliably.

Conservation of soil moisture

Soils planted by no-tillage have higher levels of available soil moisture which is particularly important in free draining, drought susceptible soils in both tropical and temperate regions. In these situations, germination is generally improved compared to conventional systems reflected in increased yields at harvest.

Savings in labour, machinery and fuel.

No-tillage allows considerable fuel economy as well as effective labour and machine use at a time when these are most in demand. A reduced number of operations for land preparation and planting also signifies a significant reduction in wear and tear of machinery (Fig. 1) (Refs. 12 & 28).

Major contribution to erosion control.

Because no-tillage leaves crop and weed residues on the surface, soil is protected from erosion by wind and rain. The surface residues together with the absence of compacted soil created by disc harrow cultivation, stabilise the soil surface, improve water penetration and reduce surface run-off, soil erosion and crop losses (Ref. 20)

Figure 2

The effect of no-tillage and conventional cropping on water run-off and soil loss (USA) (Ref. 20)

Tillage system	Run-off (percent)	Soil loss (ton/hectare)
No-tillage soya beans-wheat	23	1.8
No-tillage corn after soya beans	33	5.2
No-tillage continuous soya beans	23	2.5
Conventionally tilled continuous soya beans	29	17.5

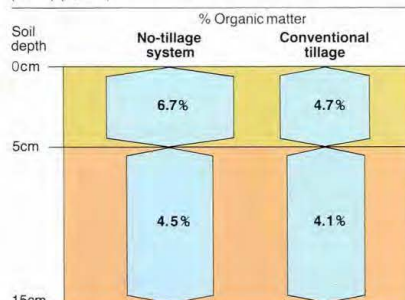
Improved soil structure.

The benefits of soil conservation, minimum compaction and build-up of organic content become evident after several seasons of no-tillage and start to pay off in increased yields (Fig. 3) (Refs. 10 & 12).

The result of these benefits is that no-tillage is the biggest single use for GRAMOXONE in the Americas. The total area under no-tillage systems is growing steadily and is expected to increase still further over the next decade as fuel costs increase and the need for conservation tillage becomes more widely recognised.

Figure 3

Percentage (%) of organic matter levels after seven consecutive maize crops comparing no-tillage and conventional systems on Santo Angelo soil series (Brazil) (Ref. 12)



Planting no-tillage maize into a rye cover crop controlled with 'Gramoxone'



Aerial application of 'Gramoxone' to desiccate sugar cane.



Harvest aid

The use of GRAMOXONE to aid harvesting efficiency is an increasing agricultural practice in a wide range of crops. In most crops at harvest time the presence of green weeds can seriously impede combine harvesters and lead to long delays in completing the operation. GRAMOXONE rapidly desiccates all green plant tissue and permits a speedier passage of the harvester through the field. The result is a cleaner and consequently a more valuable harvested product.

One situation in which the benefits of rapid desiccation are well recognised is sugar cane, particularly in humid climates where dry-down of foliage is slow and often does not allow a complete burn. In these circumstances, the application of GRAMOXONE speeds leaf drying and greatly improves the "burn" prior to harvest, improving harvesting efficiency and considerably reducing the amount of trash. Reducing trash levels in sugar cane saves money right through from the harvesting to the milling operation. On average, GRAMOXONE desiccated burnt cane increases harvested work rate by 20%. Loading, transport and cleaning costs are reduced and once in the mill, less trash means more efficient milling and less sucrose loss. Once again the rapid contact effect of paraquat permits tightly controlled management of the harvest operation and better scheduling of mill-run time. (Fig. 4) (Refs. 16, 17, 19, 26, 27 & 34).

In cotton, the use of paraquat alone or in combination with defoliant not only desiccates the cotton permitting easier harvest but causes boll opening thereby increasing harvested yields. The high speed of kill using GRAMOXONE means that harvesting can be planned carefully, crop desiccation being an integral and essential part of the harvesting procedure. (Ref. 22).

Figure 4

Typical examples of the effect of desiccation and burning on % trash levels in sugar cane in Puerto Rico, Mexico, Peru and the USA (Ref. 19)

Trash levels	Untreated and burnt	'Gramoxone' treated and burnt	Reduction of % trash in cane from 'Gramoxone' application
High	20.00	14.00	6.00
Low	5.30	2.50	2.80

In general, the greater the trash content of the cane the greater the benefit from desiccation. This is particularly important in Latin America where levels can be as high as 20% at the start of the harvest season.

Desiccated sugar cane after aerial application of 'Gramoxone'.



General weed control

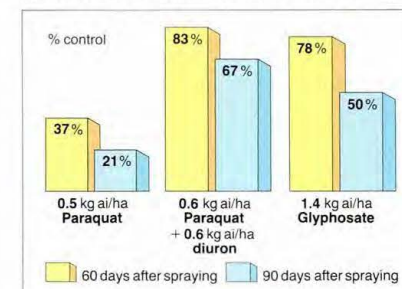
The versatility of GRAMOXONE permits its use in a wide range of situations for solving weed problems. The following are some typical examples:

The regular use of GRAMOXONE in banana plantations has been an established practice for many years. In normal shade conditions, weed populations are so reduced that after about two years only regular spot spraying is needed. The economics of this type of weed control compared with hand labour practices means that GRAMOXONE is the leading product used in banana plantations throughout the Americas. Furthermore, regular GRAMOXONE use has increased yields by 30% compared to weed control using hand hoeing. (Ref. 13)

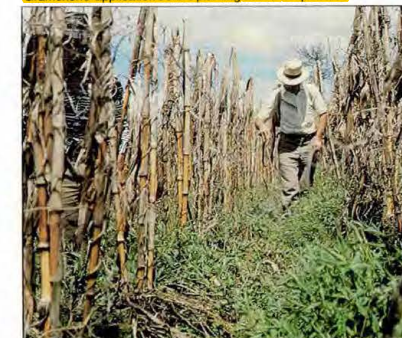
In shaded coffee in Central America the regular use of GRAMOXONE for many years has also given the same economic benefits of spot spraying as in banana plantations. In unshaded coffee in Brazil the Instituto Brasileiro do Café have demonstrated that the use of GRAMOXONE together with residual weedkillers such as diuron represent the most rational and economic form of weed control. (Fig. 5) (Ref. 23).

Figure 5

Control of annual grass weeds in Brazilian coffee (Ref. 23)



'Gramoxone' application before planting double crop beans.



Pre-plant weed control for small growers

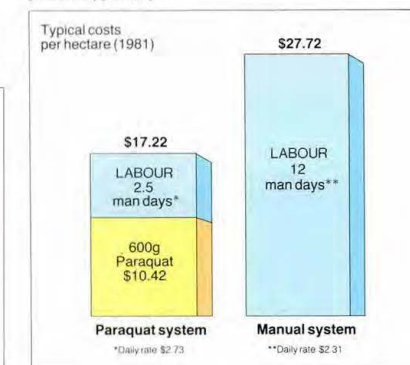
Rapid weed kill and absence of soil residues have made GRAMOXONE an ideal tool for the small grower. In north eastern Brazil, at the onset of the rainy season, weeds are killed with GRAMOXONE prior to planting rice which can then germinate and grow without weed competition.

In Central America and Colombia growers have developed a simplified no-tillage system for the traditional double crop rotation of maize and beans. Weeds are controlled with GRAMOXONE before planting maize, without soil cultivation. One directed interrow application of GRAMOXONE is made during the maize season then a second before harvest, when the cobs are doubled over. Beans are then planted in the maize row, subsequently utilising the maize stalks for support. GRAMOXONE used in this way allows a significant saving in cost over hand weeding (Fig. 6) (Ref. 31).

There are numerous other uses of GRAMOXONE which utilise its unique characteristics to make it the most widely used weedkiller in North, Central and South America.

Figure 6

Weed control in maize interplanted with *phaseolus* beans (Colombia) (Ref. 31)



Beans double cropped in maize after pre-plant 'Gramoxone' weed control.



The principal uses of GRAMOXONE in the Americas

Table 1	CANADA	USA	MEXICO	C. AMERICA	CARIBBEAN	COLOMBIA	VENEZUELA	ECUADOR	PERU	CHILE	BRAZIL	PARAGUAY	BOLIVIA	URUGUAY	ARGENTINA
• Regular use															
• Major use															
No-till															
Soya		••									••	•	•		•
Maize		••				•					••				•
Other crops	•	•		••											
Harvest aid		••				•					••	•		•	••
Weed control															
Bananas				•	••	•	•	••			•				
Coffee			•	••		••	•	•	•		••				
Fruit/vines	••	••	•			•			•	•	•			•	•
Maize/sorghum			••	••		••	•	•			•				
Plantations				•		•	•				•				
Vegetables	••	•		•	•	•	••				•				•
Non-crop	•	•	•	•		•				•	•				•
Sugar cane		•	••	••	•	•			•						••
Pre-plant		••		•		••	•	••			•				•

No tillage maize after pre-plant 'Gramoxone' weed control.



Cotton defoliated by 'Gramoxone' to aid harvest.



'Gramoxone' use on small farms can be a major factor improving productivity.



Weed control in vines with 'Gramoxone'.



How GRAMOXONE works

Paraquat requires active photosynthesis to achieve its herbicidal effect which is characterised by rapid disruption of cell membranes and cytoplasm, leading to a collapse of cellular structure and consequent desiccation of green tissue. The active agent is actually a superoxide liberated during the re-oxidation of paraquat "free radicals", originally formed by the reduction of paraquat ions by free electrons from the chloroplast. This process re-cycles as long as free electrons are available within the cell and the rate of the reaction is governed by the level of photosynthetic activity.

In warm sunny conditions (high rate of photosynthesis) herbicidal activity will be rapid (a few hours) but due to the quick kill, the effect can be localised. In cloudy conditions or late in the day (low rate of photosynthesis) kill will be slower but eventually more complete as the paraquat is better translocated throughout the plant. (Ref. 4).

Photosynthetic inhibition

The enhancement in effect through alteration of photosynthetic rate can be simulated artificially when mixing GRAMOXONE with herbicides which are photosynthetic inhibitors. Absorbed into weed tissue these products slow down photosynthesis, reducing the rate of production of the paraquat derived superoxide, and subsequent cell destruction. This synergises GRAMOXONE's action by allowing greater translocation and subsequently improves kill of the treated weeds. Common photosynthetic inhibitor herbicides regularly mixed with GRAMOXONE are diuron, metribuzin, linuron, atrazine, simazine (Refs. 18, 29, 30 & 31).

The benefits of addition of low rates of diuron and metribuzin to GRAMOXONE are clearly shown in Fig 7.

Figure 7

Enhancement of paraquat with photosynthetic inhibitors for grass weed control (Brazil) (Ref. 29)

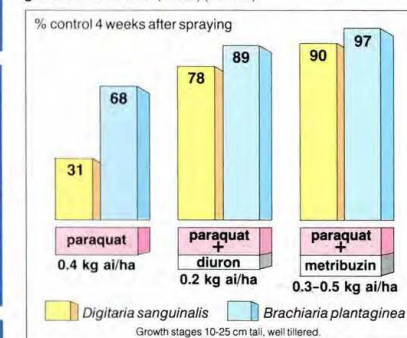


Figure 8

How GRAMOXONE works

1. Application ensuring good coverage.
2. Sunlight activates photosynthesis in the chloroplast. This produces free electrons.
3. Free electrons reduce paraquat ion to free radical.
4. Oxygen re-oxidises free radical back to paraquat ion, but at the same time produces a superoxide by-product, which is the active agent causing cell destruction.
5. Production of sufficient superoxide causes the death of the whole leaf.

The fate of GRAMOXONE in the environment

On average, only about 50% of the paraquat applied reaches the soil; most of the remainder is photochemically degraded on leaf surfaces by sunlight. An outstanding property of GRAMOXONE is the speed with which the active ingredient of paraquat is absorbed and rendered biologically inactive on contact with the soil. Adsorption on to clay is particularly strong and once in this firmly bound state paraquat is unavailable to plants and there is therefore no residual activity.

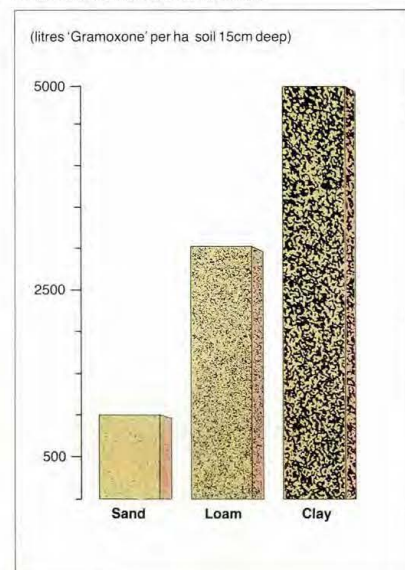
The capacity of soil to strongly absorb and deactivate paraquat ranges from about 5,000–50,000 mg paraquat per kg of soil, the value increasing with the clay content. Figure 9 shows the de-activation capacity of soils expressed as the number of litres of GRAMOXONE which could be applied per hectare of soil 15 cm deep (Refs. 24 & 5).

It can be noted that even on sandy soils normal applications of GRAMOXONE, of say 5 litres per year could continue for 100 years even assuming no degradation whatsoever of paraquat took place in the soil.

In fact, soils contain micro-organisms such as *Lipomyces starckii* which are able rapidly to degrade free paraquat. In practice, however, the paraquat is not free but bound to the soil particles and the rate of degradation is reduced the more strongly bonded the chemical is to the soil. Long term field trials have shown that this rate of degradation is sufficient to prevent the de-activation capacity being exceeded even of sandy soils (Refs. 4, 11 & 25).

Figure 9

De-activation capacity of soils (Ref. 4).



8

Paraquat in water

Paraquat rapidly disappears from water when used as recommended for aquatic weed control. In normal circumstances it is usually non-detectable 4–7 days after application in a total volume system for control of submerged weeds. Residues disappear more quickly for applications sprayed to control surface weeds. This is mainly due to rapid absorption on to growing plants and suspended solids as well as soil sediment. (Ref. 6)

Safety to wildlife

Extensive field and laboratory studies have shown that GRAMOXONE, used correctly, has no detrimental effect on wildlife. Birds, including ground nesting species, are not affected by GRAMOXONE and there has been no observed effect on populations of mammals.

GRAMOXONE has no adverse effects on soil micro-organisms, earthworms or soil micro-arthropods. In fact, earthworm populations have been observed to be higher when using GRAMOXONE rather than mechanical cultivation to control weeds—for example in no-tillage farming (Refs. 1 & 9).

Paraquat used as recommended, for water weed control is not toxic to fish or other forms of aquatic life (Ref. 7).

Safety to human health

GRAMOXONE has been used throughout the world for over two decades. During this period there have been extensive experimental studies which, combined with practical experience, show clearly that there are no health hazards to workers using GRAMOXONE when it is handled normally and as recommended on labels.

For example, an epidemiological study of spray workers in Malaysia who had used the product intensively for long periods, showed that their health was not adversely affected (Ref. 15). In addition this experience has been borne out by several investigators, who by examining the occupational exposure and health of workers exposed to paraquat, have shown that, in practice, there is no health hazard associated with the normal use of paraquat.

Although paraquat has been shown to be safe in normal use, there have been a small number of drinking accidents which have been due to the incorrect handling of concentrate, in particular the re-packing of GRAMOXONE into unauthorised containers—often soft drink bottles—subsequently left unlabelled. This is illegal in a number of countries but not unfortunately, in many others. This dangerous practice causes problems throughout the chemical industry, with reports not only of pesticides, but other potentially dangerous chemicals such as household bleach, acids and antiseptics being mis-handled in this way. In order to help prevent accidents ICI have (where registration authorities permit) incorporated blue dye and an unpleasant odour into GRAMOXONE in an attempt to reduce the possibility of the product being accidentally drunk.

As a further safeguard ICI has also incorporated a powerful emetic agent into GRAMOXONE formulations. This product will cause vomiting even if only a small

amount of product has been swallowed. However, it is important to underline that in the case of paraquat being accidentally ingested *even if vomiting has occurred* accident victims must be taken immediately to hospital and treated for paraquat poisoning in the recommended way (see below).

One category of poisoning for which it is much more difficult to provide a solution is suicides. The vast majority of paraquat poisoning deaths reported have been suicides but whilst suicide is a regrettable, social problem it is clearly difficult to stop people mis-using any product for this purpose.

However, it is important to keep even these incidents of suicidal deaths in perspective. For example, in the UK, where reliable statistics are available, paraquat poisoning deaths (which are almost entirely suicides) account for only 0.7% of all deaths arising from accidental or intentional swallowing of chemicals. Paracetamol causes six times as many deaths and barbiturates 20 times as many (Ref. 21).

Handling and use of paraquat

The toxicity of paraquat

Handling concentrated GRAMOXONE.

GRAMOXONE concentrate can damage the skin if in contact for prolonged periods—for example following accidental splashing whilst the liquid concentrate is being poured into spraying equipment. For this reason it needs to be handled with care and gloves and face shields are strongly recommended whenever handling it. If any splashes of concentrate do reach the skin they should be washed off in water as soon as possible.

Splashes of GRAMOXONE concentrate in the eyes cause severe irritation and must be washed out with water immediately.

Handling spray strength dilutions

When diluted to recommended spray strength, GRAMOXONE does not cause eye irritation nor does it cause injury to healthy skin (though prolonged exposure should be avoided).

Treatment of paraquat poisoning

If paraquat is swallowed the key to successful treatment is speed. Basically the treatment uses the absorptive properties of Fuller's Earth which is administered to the patient with a purgative. Details of this treatment have been widely disseminated to hospitals and poison centres throughout the world. If anyone has accidentally swallowed paraquat it is important that treatment be commenced as soon as possible and certainly within 4 hours. In cases of doubt enquiries should be directed to ICI's distributor. All distributors of ICI's GRAMOXONE have full details of the treatment of paraquat poisoning available for use by qualified medical staff.

Examining a fish cage at an ICI environmental research site.



Preparing foodstuffs (apples) for residue analysis.



Before sales are permitted, ICI pesticides are thoroughly tested for possible undesirable environmental effects.



9

Answers to some frequently asked questions about GRAMOXONE

GRAMOXONE has been used perfectly safely by millions of farmers throughout the world for more than 20 years. However, there are from time to time reports in the popular press about the dangers of paraquat. Clearly misleading or even grossly inaccurate, these can create considerable and understandable concern. The following series of questions and answers responds to the major areas of doubt.

Q Is paraquat registered in many countries?

A Paraquat is registered in 130 countries around the world (including the United States, Canada and Western Europe).

Q What is the registration situation in the United States?

A Paraquat plus emetic is the only formulated product registered for use in the USA.

Paraquat was selected in 1978, along with other pesticides, for examination as a candidate for RPAR (Rebuttable Presumption Against Registration). During the period of investigation paraquat remained registered for the then existing uses until early 1983 when the EPA announced that the threat of an RPAR notice had been withdrawn and paraquat returned to the normal registration process.

Paraquat is a "restricted use" pesticide which means that it can only be applied by operators and farmers who have demonstrated their competence in the correct handling and use of pesticides.

Paraquat is registered for use on all the principal crops grown in the United States.

Q What is the toxicity of paraquat?

A The toxicity of all chemicals can be divided into three categories.

- Oral toxicity (direct ingestion).
- Inhalation toxicity (breathing the vapour).
- Dermal toxicity (absorption through the skin).

Oral toxicity. Paraquat is a poisonous substance if swallowed. Its LD₅₀ for rats is 150 mg per kilo. This compares with the following widely used chemicals: Endosulfan (insecticide) (LD₅₀: 80–110) Ethylene dibromide (fumigant) (LD₅₀: 146) 2,4-D (weedkiller) (LD₅₀: 470) Parathion (insecticide) (LD₅₀: 4–13)

However it is important to recognise that oral toxicity of a pesticide is not relevant to its safety in use (see 'dermal toxicity', below).

Paraquat does not have an antidote but there is an effective treatment for it if administered immediately after ingestion occurs. This treatment has proved successful in many cases of paraquat poisoning. (See below for treatment of paraquat poisoning).

Inhalation toxicity. Paraquat itself is not volatile and has no vapour that can be inhaled. The spray droplets of diluted GRAMOXONE produced by the

conventional tractor and knapsack sprayers are too large to be inhaled, so that there is no risk of serious harmful effects from the inhalation of the product. However, it is possible that in high pressure or low volume spray equipment fine droplets of spray mist can be produced. GRAMOXONE must not be used in this type of equipment; it must only be applied using low pressure spray jets.

Dermal toxicity. In normal, good agricultural practice, dermal exposure is the primary potential route of intoxication. So it is the dermal toxicity of a pesticide that is most relevant. When GRAMOXONE has been diluted as recommended ready for spraying, it is not at all readily absorbed through undamaged human skin and consequently there is no hazard to the user. In practical conditions of use, any contamination of operators by spray drift is on clothes or on to the skin; even so, no special protective clothing is needed when handling spray strength solutions. However, it is good practice and strongly recommended that spray operators avoid exposing damaged skin to the spray solutions; wash thoroughly after work and remove and wash heavily contaminated clothing before re-using.

Q Is GRAMOXONE really safe in use?

A Yes, certainly. The product has been used around the world in agriculture for more than two decades and when used correctly, without problems. There have been many studies showing that paraquat is safe to use in normal practice. Of particular relevance is a study carried out in Malaysia to examine the health of agricultural workers who have handled and sprayed large quantities of GRAMOXONE over several years. Because the ambient temperature and humidity is high workers do not wear protective clothing and in the dense vegetation, exposure to GRAMOXONE spray can be higher than normal usage situations. In spite of these unfavourable circumstances, however, regular monitoring shows that there has been no adverse effect on their health due to GRAMOXONE over this period (Ref. 15).

This has been the experience worldwide; use of the product at recommended dilutions causes no problems to operators. GRAMOXONE concentrate like other concentrated pesticides, needs to be handled with care using gloves and a face shield to avoid accidental splashing on to the skin.

Q Can paraquat poisoning be treated?

A Yes. Although paraquat like the majority of chemicals in common use today, does not have an antidote an effective method of treatment has been developed. This has been distributed to the medical profession. *The key to successful treatment is speed.*

GRAMOXONE use recommendations

Introductory note

These GRAMOXONE recommendations are general, covering a very wide range of conditions within the Americas. Because, therefore, of the wide diversity of weed problems, cropping systems and environmental conditions, users should always consult the GRAMOXONE pack label for the appropriate local recommendations.

GRAMOXONE acts on all green plant matter and is particularly active against annual grasses and broad leaved weeds. The following summary of recommendations covers annual weeds growing in crop and non crop situations. In many perennial crops such as coffee, bananas and rubber, weeds grow in heavy shade. This improves 'Gramoxone' efficacy since rate of photosynthesis in the weeds is reduced compared to open sunny conditions, giving slower 'Gramoxone' action, better translocation of the herbicide and better control.

General weed control with 'GRAMOXONE'

Method of application	Rate of 'Gramoxone'	
	Open, sunny conditions	Heavy shade conditions
Hand held sprayers (eg knapsack, premix drum, tractor lance)	Concentration 0.1–0.15% (eg 1–1.5 l per 200 l drum)	0.05–0.1% (eg 0.5–1 l per 200 l drum)
Tractor boom sprayer	1.5–3 l/ha in 2–400 l water	1–2 l/ha in 2–400 l water

Notes:

- Concentration and rates of 'Gramoxone' vary with weed species, density and development, which also influence volume per hectare.
- Optimum control obtained when weeds are 10–15 cm high. Well developed or dense weed situations may require sequential application 5–10 days later.
- Perennial weeds 'Gramoxone' will give suppression and top kill. Respray when perennial weeds have regrown 25–30%.
- Maximum concentration for 'Gramoxone' with hand held sprayers is 0.5% (ie 1 l 'Gramoxone' in 40 l water). Equipment such as CDA and mistblowers, which apply 'Gramoxone' at higher concentrations, should not be used.
- Surfactant. Add a full strength non-ionic surfactant/wetter such as 'Agris' 90 at 0.05% v/v in final spray solution.

Special weed control situations

Control of persistent broad leaved weeds

'Gramoxone' mixtures with hormone herbicides
Mix recommended rates of 'Gramoxone' with 2,4-D at 0.5–1.0 kg a.i./ha. Do not apply in susceptible crops such as bananas. Mixtures with MCPA or dicamba can improve control of specific weed problems.

'Gramoxone' and 'Reglone' mixture
Substitute half recommended 'Gramoxone' rate above for 'Reglone'.

NB. When spraying 'Reglone' add a non-ionic surfactant such as 'Agris' 90 at 0.1% v/v in spray solution.

Improved 'GRAMOXONE' contact effect with photosynthetic inhibitor mixtures

Open conditions

Add diuron active ingredient at half the rate of paraquat active ingredient, ie for 2 l 'Gramoxone' add 0.25 kg diuron, 80% WP. **Note:** In annual crops, use only where diuron is registered.

NB. Photosynthetic inhibition also occurs with other photosynthetic inhibitors such as atrazine, linuron, ametryne.

Heavy shade

Add diuron as for open conditions. Since broad leaved weeds predominate in shade, add 2,4-D at 0.5–1.0 kg a.i./ha, except in susceptible crops such as bananas.

Contact and long term weed control

Perennial crops

Tank mix appropriate soil acting residual herbicide with 'Gramoxone' according to manufacturer's recommendations.

NB. If total residual herbicide rates applied with 'Gramoxone' spray at beginning of season, control regrowth with 'Gramoxone' alone.

Annual crops

Either tank mix 'Gramoxone' with appropriate pre-emergence herbicide for residual control of grass or broad leaved weeds, or apply 'Gramoxone' to eliminate vegetation prior to planting, followed by the residual herbicide after planting but before crop emergence.

With residual herbicides which are photosynthetic inhibitors, eg atrazine, simazine, diuron, linuron, metribuzin, better control of weeds is given if tank mixed with 'Gramoxone' pre-plant rather than applied separately.

Harvest aid

Desiccation of such crops as sugar, oil seeds and cotton

Method of application	Rate of 'Gramoxone'
Aircraft	2–3 l in 50 l water/ha
Tractor	2–3 l in 2–400 l water/ha

Thoroughly wash out all sprayers, including aircraft, with clean water after use.

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