THE TECHNICAL PROPERTIES OF ICIA0051, A NEW HERBICIDE FOR MAIZE AND SUGARCANE

By T. J. PURNELL

ICI Agrochemicals, Fernhurst, UK

Abstract

The chemical and physical properties of ICIA0051, a member of the new triketone class of herbicides, are described. The compound shows selectivity in maize and sugarcane, and may be applied either pre-emergence or post-emergence to control a wide range of annual broadleaf weeds and some grasses. The spectrum of biological activity may be extended by the addition of atrazine or other herbicides. Studies indicate that when applied post-emergence, ICIA0051 is active both in contact with foliage and by root uptake. Once absorbed by the plant, ICIA0051 interferes with carotenoid synthesis which quickly leads to chlorosis and plant death. ICIA0051 is broken down by soil microbial activity and half-lives of 15 to 74 days have been measured, depending on soil type, pH, and organic matter content. This low level of persistence provides excellent residual weed control under South African conditions, but ensures that degradation is virtually complete by the end of the growing season.

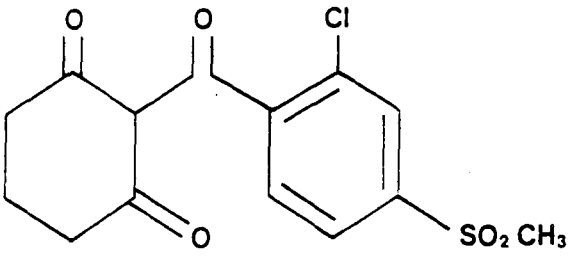
Introduction

This paper describes the chemical, physical and biological properties of ICIA0051 (proposed common name chlormesulone).

The compound is a member of the new triketone class of herbicides invented in the USA at the Richmond Laboratories of ICI Agrochemicals, and is being developed in several maize and sugarcane growing countries.

Chemical and physical properties

Structural formula



IUPAC chemical name	2- (2-chloro-4-mesylbenzoyl) cyclohexane - 1, 3 - dione.
Molecular formula	$C_{14} H_{13} SO_5 Cl$
Appearance	a yellow powder
Melting point	123°C
Odour	no characteristic odour
Solubility	570 ppm in water (unbuffered), and 5 600 ppm in water at pH7

Toxicology

ICIA0051 has a low acute toxicity to mammals, birds, fish, bees and other wildlife species (Table 1). The technical material is classified as a moderate eye irritant, but it is not a skin irritant. The compound is formulated as a water-based suspension concentrate containing 300 g active ingredient

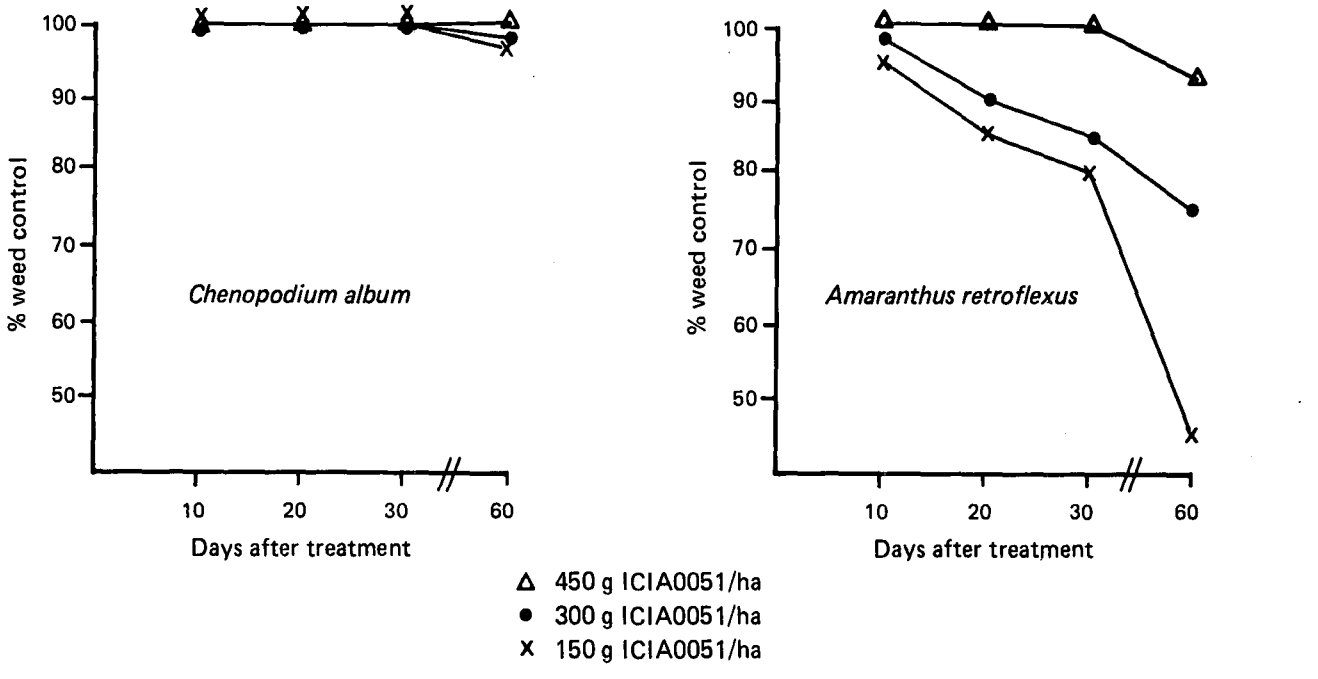


Figure 1 Effect of rate of application on the biological activity of ICIA0051

(ai) per litre. This formulation is of similar toxicity to the technical material. Other formulations are being developed for specific uses.

Table 1

The acute toxicity of ICIA0051 (technical)

Administration route	Species	Median lethal dose/ concentration
Oral	Rat	> 5 000 mg/kg
Dermal	Rabbit	> 4 000 mg/kg
Oral	Bobwhite quail	> 2 250 mg/kg
Oral	Mallard duck	> 486 mg/kg
Static exposure (96 hrs)	Rainbow trout	227 mg/l
Static exposure (96 hrs)	Mirror carp	240 mg/l
Oral	Honey-bee	> 200 mg/bee

Biological activity

ICIA0051 is selective in both sugarcane and maize, and is being developed in these crops in several countries throughout the world. The herbicide may be applied either pre-emergence or post-emergence, and rates of application between 200-500 g ai/ha will provide consistent control of many weed species. The biological activity of ICIA0051 in sugarcane has been described by Blesovsky and Johnson (1991), so data presented in this paper are limited to factors affecting the performance of the compound.

Rate of application influences the spectrum of weeds controlled, and also affects residual activity. Data from 1988 trials in France illustrate this relationship (Figure 1).

Although low rates of application give good initial and residual control of the very sensitive *Chenopodium album*, higher rates of the compound are necessary for the long term control of moderately resistant species, e.g. *Amaranthus retroflexus*.

When applied post-emergence to sensitive weeds ICIA0051 has a relatively wide window of application. Species including *Chenopodium album*, *Datura ferox* and *Polygonum aviculare* may be controlled at any time from emergence to a stage when the weeds are 200-250 mm across (Figure 2).

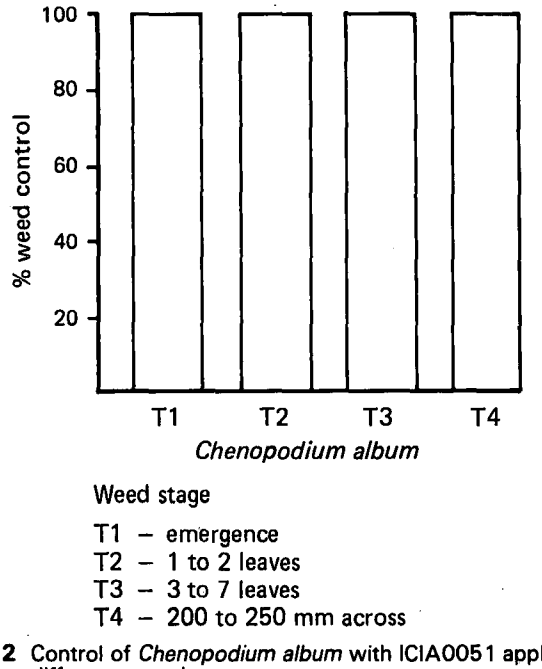


Figure 2 Control of *Chenopodium album* with ICIA0051 applied at different growth stages

Nevertheless, for good control of broadleaf weeds and grasses, optimum results are achieved either following a pre-emergence spray or application at the one to two leaf stage. In a number of situations, however, more flexibility may be gained by the addition of a second herbicide, e.g. a low rate of atrazine (Figure 3).

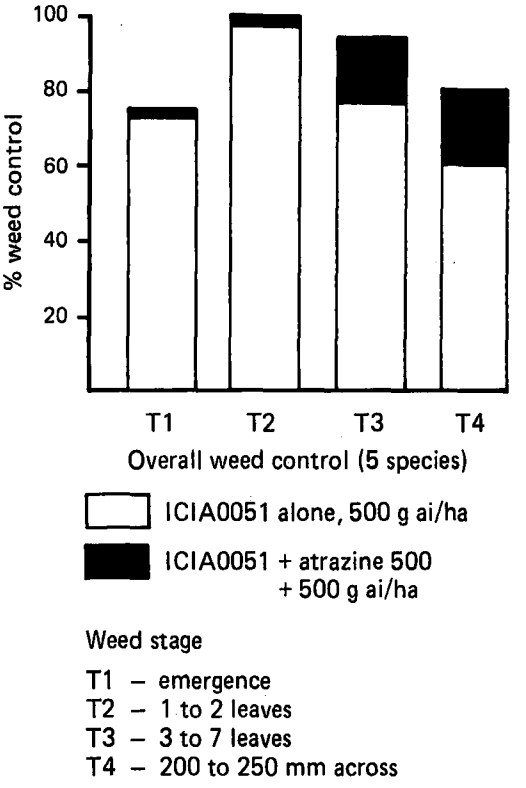


Figure 3 Effect of Atrazine addition on the application window for ICIA0051

Environmental studies

Many of the chemical and physical properties of soils influence the behaviour of a herbicide. For example, soil organic matter content and pH often play an important role in mineralisation, degradation and mobility.

Laboratory experiments have shown that, in moist aerated soil, ICIA0051 is broken down by microbial action and that the rate of degradation is correlated with organic matter content. The data presented in Table 2 show half-lives of 24 and 74 days in two soils containing 4,2% and 0,3% organic matter respectively. The shortest half-life measured was 15 days for a sandy soil in the southern part of France.

Table 2

Effect of soil properties on the degradation (half-life) of ICIA0051

Soil sample	Type	% Organic matter	% Clay content	pH	Half-life (days)
Iowa, USA	Silt loam	4,2	25	5,6	24
San Jose, USA	Sandy loam	0,3	11	7,3	74

The mobility of ICIA0051 in a particular soil may be expressed by calculating the K_d value (Swoboda and Thomas, 1968). This constant is a measure of the extent of binding between compound and soil. Thus the larger the K_d value, the more a compound is bound to the soil.

Soil column experiments suggest that movement of ICIA0051 in the soil is influenced more by pH than by clay or organic matter content (Table 3). Thus, in acid soils, the compound is more tightly bound than under neutral to alkaline conditions and mobility is limited.

Table 3

Effect of soil properties on the mobility (K_d) of ICIA0051

Soil sample	Type	% Organic matter	% Clay content	pH	K_d value
San Jose, USA	Sandy loam	0,3	11	7,3	0,01
Sorrento, USA	Loam	2,1	23	6,7	0,21
St John's, USA	Sand	2,0	5	5,1	1,44
Bigg's, USA	Clay	1,7	50	5,5	1,59

Sandy loam and sandy clay loam soils treated with ICIA0051 were incubated at 20°C for 28 days under laboratory conditions. When compared with similar untreated soils there were no statistical differences in nitrate, nitrite or ammonium levels. In a second experiment the short term respiration rate of treated soil was measured. From this work it was concluded that ICIA0051, at application rates of up to 4,5 kg ai/ha, had no adverse effects on nitrogen mineralisation or short term respiration in soil.

No detectable residues (limit of detection 0,05 mg/kg) of the parent compound have been found in sugarcane, or in maize grain at harvest, following post-emergence application at recommended and double rates. (See Table 4).

Table 4

Analysis of ICIA0051 residues in sugarcane and maize

Crop	Application rate (kg ai/ha) †	Crop part	Days after treatment	ICIA0051 residue (mg/kg)*
Sugarcane	0	Juice	–	< 0,05
	0,75	Juice	252	< 0,05
	1,50	Juice	252	< 0,05
Maize	0	Grain	–	< 0,05
	0,30	Grain	70	< 0,05
	0,60	Grain	70	< 0,05

* Limit of detection = 0,05 mg/kg
† Trials conducted in South Africa during 1989

Mode of action

Preliminary studies indicate that, when sprayed post-emergence, ICIA0051 is active both when placed in contact with foliage and by root uptake. The chemical is absorbed through leaf surfaces and is translocated in both xylem and phloem, accumulating in meristematic tissues. This movement quickly leads to chlorosis and in sensitive species to plant death. More resistant weeds, e.g. *Cyperus rotundus*, often show these 'bleached' symptoms, but generally growth is only suppressed for a short period. When applied pre-emergence, ICIA0051 will usually prevent the germination of sensitive weeds but, if some do manage to emerge, they soon become chlorotic and die.

A glasshouse study was undertaken to determine the importance of foliar and soil uptake in the mode of action of ICIA0051 (personal communication PJ Batten, 1991). Foliar/soil treatments were sprayed over emerged weed species growing in trays, allowing the chemical to reach both foliage and soil. For foliar only sprays, the soil was protected with a layer of vermiculite.

The data showed some interesting trends (see Table 5). When applied post-emergence the inital activity of ICIA0051 (five days) was mainly by contact with foliage. For very sensitive weeds such as *Chenopodium album* and *Echinochloa crus-galli* this inital action was well able to kill the weed. For sensitive species, including *Digitaria sanguinalis* and *Polygonum aviculare*, some chemical uptake from the soil was needed to boost control. However for control of *Amaranthus retroflexus*, which is moderately resistant to ICIA0051, soil uptake played an important part in the extent of control achieved. In addition, chemical reaching the soil also provided the residual element of a post-emergence spray.

Table 5

Biological activity of foliar and soil applications of ICIA0051

Weed species	Percentage control					
	Foliar only			Foliar + Soil		
	5 (Days after treatment)	14	25	5 (Days after treatment)	14	25
Echcg	94	100	100	90	100	100
Digsa	90	89	82	93	100	100
Polav	80	84	85	83	94	99
Amare	68	68	38	70	77	65
Cheal	83	100	100	81	100	100

There is limited research on the precise mode of action of ICIA0051. Mayonado *et al.*, (1989), working with soybeans, concluded that the bleaching effect is caused by interference in reactions which ultimately prevent the formation of carotenoid pigments. The role of such pigments is to minimise the photo-oxidative destruction of chlorophylls. The authors stated, however, that this mechanism did not preclude other herbicide effects by ICIA0051. Indeed, Nandihalli and Bhowmik (1988) suggested that the compound may interfere directly with chlorophyll synthesis.

Discussion

In South Africa sugarcane is grown extensively in the coastal areas of Natal. Soils of this region are usually acid, often low in organic matter, and range texturally from loamy sands to heavy clays. Such soils are well suited to ICIA0051, as they allow optimum biological activity at a relatively low rate of application.

In low organic matter soils the compound has a half life of about 74 days, which provides excellent residual activity from either a pre-emergence or post-emergence spray, but which ensures almost complete degradation by the end of the growing season. Furthermore, under acid conditions, there is considerable binding of the compound by the soil and thus limited chemical movement away from the surface. This not only keeps ICIA0051 in the weed zone, but again assists residual activity.

Unlike many herbicides, the efficacy of ICIA0051 is not affected by clay content and therefore one rate of application is suitable for all soil types. This will be an advantage for easy use by growers. Resistance to photodegradation (half-life 100 days) is also an asset since, in areas where rainfall is unpredictable, the herbicide will remain in the soil surface to be activated by the first rains.

REFERENCES

1. Blesovsky, JS and Johnson, G (1991). New products for short term weed control in sugarcane. *Proc S Afr Sug Technol Ass*, 65: (in preparation).
2. Mayonado, DJ, Hatzios, KK, Orcutt, DM and Wilson, HP (1989). Evaluation of the mechanism of action of the bleaching herbicide SC-0051 by HPLC analysis. *Pesticide Biochemistry and Physiology* 35: 138-145.
3. Nandihalli, UB and Bhowmik, PC (1988). Effect of SC-0051 on photosynthetic pigment synthesis in cucumber cotyledons. Proc. Northeast. *Weed Science Soc* 42: 49.
4. Swoboda, AR and Thomas, GW (1968). Movement of parathion in soil columns. *J Agric Food Chem* 16: 923 - 927.