

## LUMAX<sup>®</sup>: AN ALTERNATIVE TO ATRAZINE FOR PRE- AND POST-EMERGENCE CONTROL OF WEEDS IN SUGARCANE

By

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### Abstract

ATRAZINE has successfully been used for more than 40 years in various tank-mixes for both pre- and post-emergence control of weeds in sugarcane. However, the product is banned in the EU for environmental reasons. Lumax, consisting of three active ingredients namely mesotrione (0.0375 kg a.i./L), terbutylazine (0.125 kg a.i./L) and s-metolachlor (0.375 kg a.i./L), has been evaluated as a substitute for atrazine in Mauritius in ten field trials in both plant and ratoon sugarcane. Lumax at rates varying between 3.5 and 5.0 L/ha proved effective on a wide spectrum of broad-leaved weeds and some grasses, including *Digitaria horizontalis*. In general, Lumax was superior to the standard s-metolachlor + atrazine and comparable to the tank-mixes tebuthiuron + atrazine and oxyfluorfen + diuron. In post-emergence of weeds, although Lumax tank-mixed with 2,4-D amine salt showed a better control of weeds than atrazine tank-mixed with s-metolachlor + 2,4-D amine salt, it was slightly inferior to the other standards containing hexazinone or tebuthiuron. In all situations, Lumax provided a residual activity varying between 10 and 12 weeks and showed no phytotoxicity on the various sugarcane varieties tested. Lumax has been recommended as an alternative to atrazine at rates varying between 4.0 and 5.0 L/ha.

### Introduction

Traditionally, weed control in sugarcane in Mauritius has been achieved by application of at least two herbicide treatments from planting or harvest up to complete canopy closure (MSIRI, 2004). While the first application consists solely of pre-emergence, subsequent applications also include a post-emergence herbicide such as 2,4-D amine salt in the tank-mixes. Atrazine has been one of the most-used pre-emergence herbicides during the last 50 years; it is normally tank-mixed with selective grass herbicides to broaden the spectrum of control and, together with a post-emergence herbicide, also provides early post-emergence control of weeds. The extensive use of atrazine is also associated with its broad tolerance by sugarcane varieties as compared to diuron which is restricted to tolerant ones (Mc Intyre and Barbe, 1995).

Although atrazine does not represent any risk of contamination of underground waters as reported elsewhere (MSIRI/ACIAR, 2001) and has no weed resistance being reported yet in Mauritius, there has been growing pressure to seek alternatives to it and several of its tank-mix partners which are no longer authorised in the EU, where the main importing countries of Mauritian sugar are found.

Lumax<sup>®</sup> consists of mesotrione, terbutylazine and s-metolachlor. Mesotrione is a member of the triketone family and is a selective herbicide used for pre- and post-emergence control of broad-leaved and some grass weeds in field corn (Armél *et al.*, 2001; Mitchell *et al.*, 2001). The formulation of Lumax tested in this study contained 37.5 g mesotrione, 375 g s-metolachlor and 125 g terbutylazine per litre of product. At rates varying between 3 to 4 L/ha, Lumax has been reported to provide satisfactory control in both pre- and early post-emergence of weeds in maize

(Rapparini and Fabbi, 2005). The objective of this study was to evaluate the efficacy of Lumax in pre- and early post-emergence of weeds in sugarcane and to assess its potential as an alternative to atrazine.

### Materials and methods

Ten trials were conducted in both plant and ratoon sugarcane to evaluate the efficacy of Lumax in pre- and early post-emergence of weeds. The first four trials (Trials 1 – 4) involved pre-emergence control of weeds in plant cane where Lumax at 3.5, 4.0, 4.5 and 5.0 L/ha was compared to three standards, namely, oxyfluorfen + diuron (0.5 + 2.0 kg a.i./ha), tebuthiuron + atrazine (1.6 + 2.4 kg a.i./ha) and s-metolachlor + atrazine (1.4 + 2.4 kg a.i./ha), and to an untreated control. The same treatments were also assessed in ratoon cane in two other trials (Trials 5 and 6). The remaining trials (Trials 7 – 10) involved post-emergence control of weeds in plant cane (Trials 7 and 8) and in ratoon cane (Trials 9 and 10). For the post-emergence trials, the four rates of Lumax were tank-mixed with 2,4-D amine salt at 3.0 L/ha and were compared to three standards, namely, hexazinone + atrazine + 2,4-D amine salt (0.6 + 2.4 + 2.2 kg a.i./a.e./ha), tebuthiuron + atrazine + 2,4-D amine salt (1.3 + 2.4 + 2.2 kg a.i./a.e./ha) and s-metolachlor + atrazine + 2,4-D amine salt (1.4 + 2.4 + 2.2 kg a.i./a.e./ha). A non-ionic adjuvant @ 0.025% v/v was added to all post-emergence treatments. The characteristics and details of all trial sites are given in Table 1.

**Table 1**—Characteristics and details of trial sites.

Trial no.	Site	Soil group *	Mean annual rainfall (mm)	Altitude (m)	Date of planting/harvest	Cane variety	Date of spraying
1	Bel Air	Low Humic Latosol	1775	95	28.04.05	R 573	03.05.05
2	Belle Mare	Lithosol	1300	30	21.03.06	R 570	28.03.06
3	Rose Belle	Latosolic Brown Forest	3575	345	25.07.06	M 1394/86	01.08.06
4	FUEL	Low Humic Latosol	2450	170	12.09.06	R 579	02.10.06
5	Riche en Eau	Humic Ferruginous Latosol	2500	150	25.10.06	R 570	06.11.06
6	FUEL	Humic Latosol	2875	255	06.04.07	M 1246/84	13.04.07
7	Belle Mare	Lithosol	1300	30	21.03.06	R 570	17.05.06
8	Rose Belle	Latosolic Brown Forest	3575	345	25.07.06	M 1394/86	21.09.06
9	Riche en Eau	Latosolic Brown Forest	2600	140	15.10.06	M 1400/86	14.11.06
10	Combo	Humic Ferruginous Latosol	3200	410	16.04.07	R 579	04.05.07

\* According to Parish and Feillafé (1965).

Spraying was carried out using hand-operated knapsack sprayers, delivering 350 L/ha at 300 kPa. The statistical design was a completely randomised block with three replicates; each plot consisted of four 1.6-m rows 10 m long (plot size of 64 m<sup>2</sup>).

For pre-emergence trials, data collection comprised visual observations at four and eight weeks after spraying (WAS) to record weed species appearing in the various treatments, followed by two weed surveys between 12 and 16 WAS using the 'Frequency Abundance Method' (Rocheouste, 1967). The level of control by each treatment on predominating weeds at each site was also highlighted. Regular visual observations on possible phytotoxicity on sugarcane were also made, followed by cane measurements in the plant cane at 12 WAS to determine any effect of Lumax on cane growth and tillering.

For post-emergence trials, a weed survey was carried out prior to spraying about eight weeks after planting or harvest in each individual plot to identify and quantify all weeds present. Following spraying, a second weed survey was carried out as from 4 WAS to assess the post-

emergence efficacy of each treatment; the percent weed kill was calculated by dividing the difference in weed infestation using the 'Frequency Abundance Method' between the two surveys by the initial infestation. The second survey made around 12 WAS was focused on assessing the length of residual activity of Lumax treatments with respect to the standards.

## Results

### Efficacy of Lumax in pre-emergence of weeds

#### *In plant cane*

At all four sites, the predominant broad-leaved weeds included *Ageratum conyzoides*, *Bothriospermum zelanicum*, *Chamaesyce hirta*, *Phyllanthus* sp., *Oxalis* spp., *Solanum nigrum* and *Youngia japonica*. *Digitaria horizontalis*, *Paspalum urvillei* and *Panicum subalbidum* were the main grass species in the untreated plots in Trials 2, 3 and 4 respectively. *Cyperus rotundus* was present in Trials 2 and 4 whereas *Kyllinga bulbosa* and *K. erecta* were recorded in Trial 3.

Observations made at 4 WAS revealed that the Lumax treatments were almost similar in efficacy to the standards and no difference among the four rates was apparent. At 8 WAS, the level of control obtained by the Lumax treatments were either similar or slightly inferior to the two standards, oxyfluorfen+diuron and tebuthiuron+atrazine; Lumax showed some superiority over the third standard, s-metolachlor + atrazine, due to its better efficacy on some broad-leaved weeds (Table 2).

The weed surveys made between 12 and 16 WAS revealed that the efficacy of Lumax, particularly at the two higher rates, was comparable to the standard oxfluorfen + diuron and slightly inferior to tebuthiuron+atrazine (Figure 1). Irrespective of sites, control with Lumax was superior to s-metolachlor+atrazine; this indicates the contribution of mesotrione in the new product. Although the good performance of Lumax is explained by its efficacy on broad-leaved weeds which were predominant at those sites (Table 2), some weaknesses were observed on grass species such as *P. subalbidum*. For *D. horizontalis*, a good level of control was obtained with the two higher rates. Comparing the four rates of Lumax between 12 and 17 WAS showed that the highest rate of 5.0 L/ha had a slightly longer residual activity. The relatively better control obtained by Lumax at FUEL (Trial 4) may be explained by a longer residual activity associated with the dry conditions which prevailed throughout the duration of the trial at that site. Cane measurements made at all sites showed no difference in growth and tillering among the treatments; this confirms that this new herbicide is not phytotoxic to the sugarcane varieties tested.

**Table 2**—Relative efficacy of Lumax for the pre-emergence control of some common weeds in plant cane (Trials 1–4).

	Lumax (L/ha)				oxyf+diuron (0.5+2.0 kg a.i./ha)	teb+atraz (1.6+2.0 kg a.i./ha)	s-meto + atraz (1.5+2.0 kg a.i./ha)
	3.5	4.0	4.5	5.0			
<i>A.conyzoides</i>	+++	+++	+++	++++	+++	++++	+++
<i>B. zelanicum</i>	+++	+++	++++	++++	++++	++++	+++
<i>C. rotundus</i>	+	+	+	+	+	+	+
<i>D. horizontalis</i>	++	++	+++	+++	++++	+++	++
<i>K. bulbosa</i>	+	+	+	+	+	+	++
<i>K. erecta</i>	++++	++++	++++	++++	++++	++++	++++
<i>O. corniculata</i>	+++	+++	+++	++++	++++	++++	++
<i>P. urvillei</i>	++	++	++	++	+++	++	++
<i>P. subalbidum</i>	++	++	++	++	+++	+++	++
<i>S. nigrum</i>	+++	++++	++++	++++	++++	++++	+++

+ Poor ++ Fair +++ Good ++++ very good

oxyf+diuron= oxyfluorfen + diuron, teb+atraz= tebuthiuron + atrazine; s-meto+atraz = s-metolachlor + atrazine

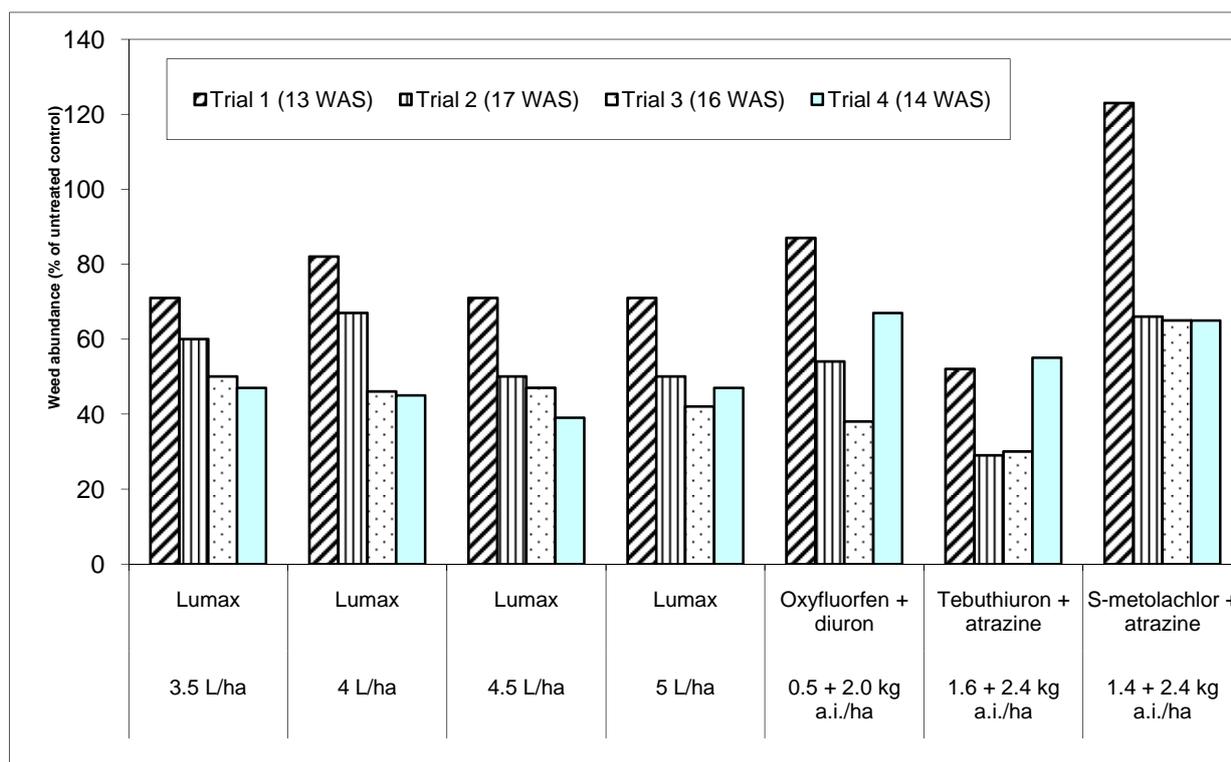


Fig. 1—Pre-emergence control of weeds by Lumax in plant cane and expressed as % of weed infestation in the untreated control.

**In ratoon cane**

The two trials carried out in ratoon cane confirmed the results from the plant cane trials. The two higher rates of Lumax were again more effective than the lower rates and were comparable to the three standards (Figure 2). The survey carried out at 17 WAS in Trial 6 showed that the residual activity of Lumax was shorter than that of oxyfluorfen + diuron under more humid conditions. It was found to provide a similar level of control to the standards of *D. horizontalis* at the highest rate tested.

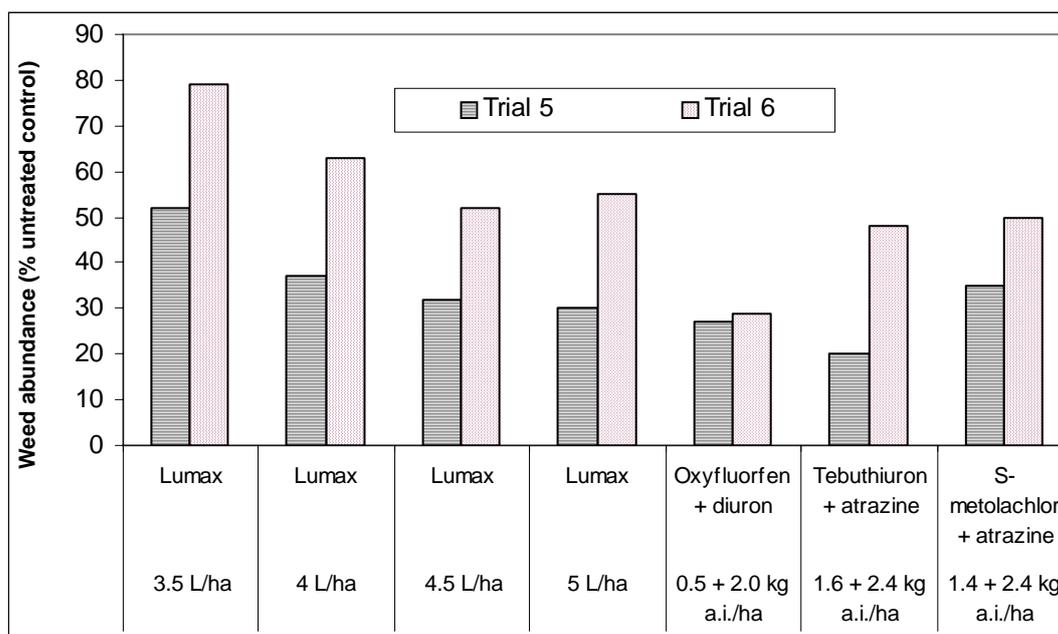


Fig. 2—Pre-emergence control of weeds by Lumax in ratoon cane and expressed as percent of weed infestation in the untreated control.

## Efficacy of Lumax in early post-emergence of weeds

### *In plant cane*

The predominating weeds before spraying in Trial 7 consisted of *Cleome viscosa*, *C. rotundus*, *D. horizontalis*, *C. hirta*, *Ipomoea obscura*, *Phyllanthus sp.* and *Vernonia cinerea*.

Near complete eradication of most weeds except *D. horizontalis* was obtained 2 WAS with the lowest rates of Lumax. *V. cinerea* was only partly scorched; efficacy on this weed species improved with increase in dosage and, at the highest rate, was comparable to the two standards hexazinone + atrazine + 2,4-D amine salt and tebuthiuron + atrazine + 2,4-D amine salt.

The third standard was slightly inferior to Lumax due to a less effective control of *C. hirta*. The percent weed kill determined as from 4 WAS showed the standard hexazinone + atrazine + 2,4-D amine salt to be the best treatment, closely followed by the two other standards (Figure 3).

Control by Lumax was on the whole very satisfactory with more than 70% weed kill in Trial 7 (Figure 3). No significant difference between the four rates of Lumax was apparent.

Predominating weeds at Rose Belle (Trial 8) consisted of *A. conyzoides*, *Crassocephalum rubens*, *D. horizontalis*, *D. radicata*, *Eleusine indica*, *Kyllinga bulbosa*, *Lobellia cliffortiana*, *O. debilis*, *O. corniculata*, *Paspalum urvillei*, *Solanum nigrum* and *Youngia japonica*.

A good knockdown of broad-leaved weeds was obtained 2 WAS with Lumax, irrespective of rate, and was comparable to the standard s-metolachlor + atrazine + 2,4-D amine salt (Figure 3). The two other standards were superior due to a more effective control of grasses.

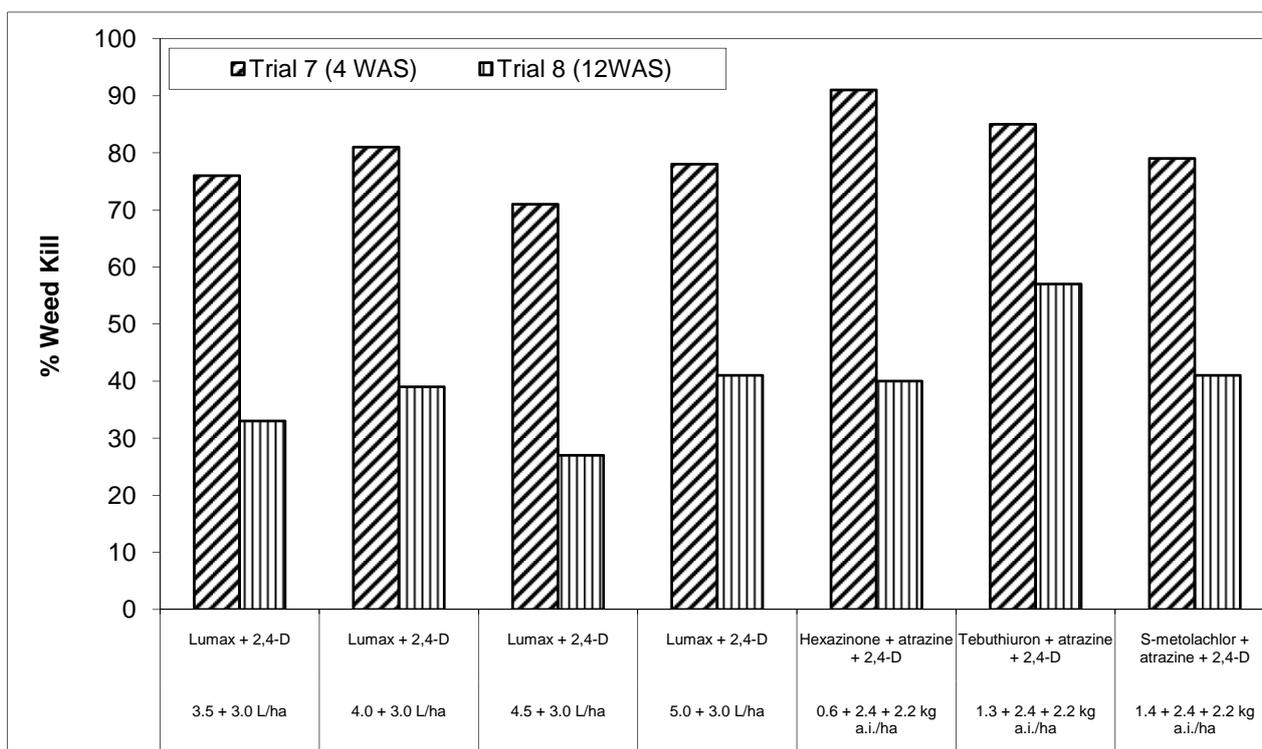


Fig. 3—Post-emergence control of weeds by Lumax in plant cane.

In both trials, the tank-mixes with Lumax were shown to be safe to cane varieties R 570 and M 1394/86. Cane variety R 570 which is known to be very susceptible to some post-emergence herbicide treatments showed some phytotoxicity towards the standard tank-mix hexazinone+atrazine+2,4-D amine salt (Figure 4).

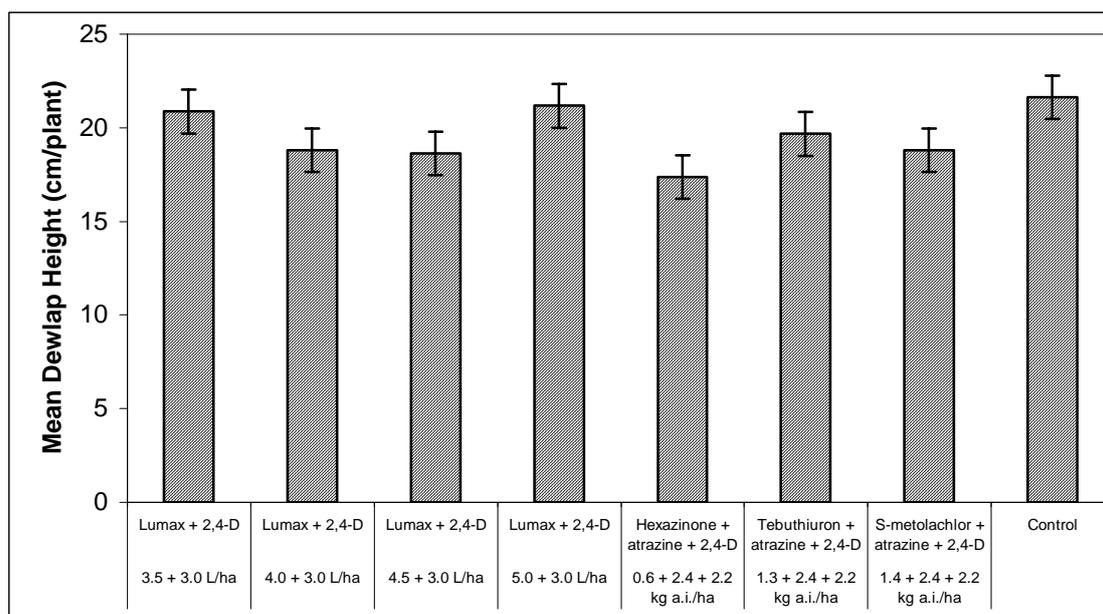


Fig. 4—Effect of post-emergence application of Lumax on plant cane. Error bars show standard error of means.

The residual activity of the Lumax treatment, following the knock-down of weeds present at spraying, was found to increase with higher dosage; the highest rate of Lumax was better or as good as the best standard in the two trials.

**In ratoon cane**

Broad-leaved weeds were predominant in Trial 9 and *P. subalbidum* was the only grass present. Five WAS, Lumax, irrespective of rate in the tank-mixes, had completely eradicated *Solanum nigrum*. Species of the Euphorbiaceae family, namely *Phyllanthus* sp., *C. hirta* and *C. prostrata* were partly defoliated and had stunted growth whereas *P. subalbidum* was unaffected. Lumax treatments were in general comparable to the s-metolachlor tank-mix but inferior to the two other standards (Figure 5).

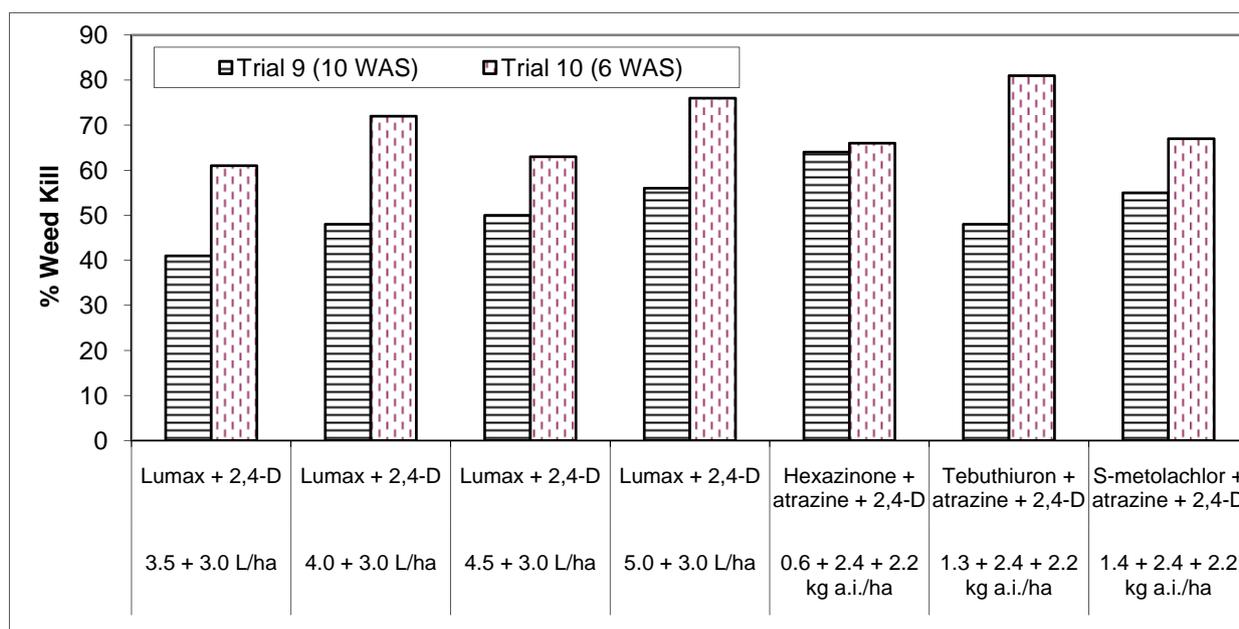


Fig. 5—Post-emergence control of weeds by Lumax in ratoon cane.

With the predominance of broad-leaved weeds in Trial 10, very good control was obtained with Lumax, irrespective of dosage. Only two species were not totally controlled, namely *Drymaria cordata* (severely scorched) and *Clidemia hirta* (showing partial chlorosis and scorching). The best treatment was the standard tebuthiuron tank-mix with near eradication of most weeds except *C. hirta*. The two other standards were comparable to Lumax treatments (Figure 5).

Visual observations made throughout the duration of trials revealed all Lumax treatments to be safe to sugarcane varieties M 1400/86 and R 579. The latter, classified as a moderately susceptible variety to some post-emergence herbicide treatments, showed some phytotoxicity to the tank-mix containing hexazinone.

## Discussion

### Pre-emergence potential of Lumax

In general, the level of control obtained with Lumax was found to improve with increasing rates. The three higher rates tested were often superior to the standard s-metolachlor + atrazine; the superiority of Lumax over s-metolachlor+atrazine has also been demonstrated by Palacio-Vazquez *et al.* (2004). Compared to the two other standards of oxyfluorfen + diuron and tebuthiuron + atrazine, Lumax showed some potential under drier conditions at FUEL, where it provided the best pre-emergence control. However, tebuthiuron + atrazine proved to be more effective than Lumax at all remaining sites. Lumax was comparable to oxyfluorfen + diuron at sites where broad-leaved weeds predominated and inferior to the latter and tebuthiuron + atrazine on some grasses except *D. horizontalis*. The efficacy of Lumax on the latter weed complements observations reported by Armel *et al.* (2001) where *D. sanguinalis* is listed among weeds controlled by mesotrione. Despite its relative efficacy on *Kyllinga erecta*, Lumax was generally ineffective on sedges, including *Cyperus rotundus*. The latter concurs with results reported by Earl *et al.* (2004) showing mesotrione to be less effective than MSMA and halosulfuron on *C. esculentus*. As the three standards are also ineffective on *C. rotundus* and some other sedges, the potential of Lumax as a pre-emergence treatment for general weed control cannot be underestimated.

The trials have also revealed that Lumax has a relatively long residual activity up to 16 WAS. There seemed to be no significant difference among the three higher rates which implies that the highest rate of 5.0 L/ha is not justified and the optimum rates would be between 4.0 and 4.5 L/ha.

### Post-emergence potential of Lumax

Lumax tank-mixed with 2,4-D amine salt proved particularly effective on broad-leaved weeds and was found to be as good as the standard s-metolachlor tank-mix and slightly inferior to the two other standards due to a less effective control of grasses.

No significant difference between the four rates of Lumax was observed. However, as the residual activity following the initial kill is also an important factor in weed management, the lowest rate of Lumax proved less effective. The highest rate of Lumax did not improve significantly the residual activity over the mid-rate.

The tank-mix Lumax + 2,4-D amine salt was well tolerated by the sugarcane varieties tested. As two of the trials consisted of susceptible varieties (R 570 and R 579), this implies that Lumax can be safely applied in post-emergence of both plant and ratoon sugarcane.

## Conclusion

Based on results obtained in the ten trials, Lumax has a potential for use in pre- or post emergence of broad-leaved weeds and some grasses such as *D. horizontalis* in both plant and ratoon sugarcane. Lumax is a good alternative to conventional treatments such as s-metolachlor or acetochlor + atrazine which have been used since the early 1980s. Lumax has been recommended as an alternative to atrazine at rates varying between 4.0 and 4.5 L/ha in post-emergence of weeds, and the same rates of Lumax may be tank-mixed with 2,4-D amine salt @ 3.0 L/ha.

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**LUMAX® : UNE ALTERNATIVE À L'ATRAZINE POUR LA MAÎTRISE EN PRÉ ET POST EMERGENCE DES MAUVAISES HERBES EN CANNE À SUCRE**

Par

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**MOTS-CLÉS: Mesotrione, Terbutylazine, S-Metolachlor.**

**Résumé**

L'ATRAZINE a été employée avec succès pendant plus de 40 ans dans différents mélanges afin de maîtriser l'enherbement en canne à sucre, à la fois en pré et post émergence. Cependant le produit n'est plus homologué en Europe pour des raisons environnementales. Le Lumax, un mélange comprenant 3 molécules actives, la mesotrione (0.0375 kilogramme m.a./L), la terbutylazine (0.125 kilogramme m.a./L) et le s-metolachlor (0.375 kilogramme m.a./L), a été évalué comme produit de remplacement de l'atrazine à l'île Maurice, dans dix essais au champ à la fois en canne

plantée et en repousses. Du Lumax, à des doses variant entre 3.5 et 5.0 L/ha s'est montré efficace sur une vaste gamme de mauvaises herbes à larges feuilles et de quelques graminées, comprenant *Digitaria horizontalis*. Généralement Lumax s'est montré supérieur au mélange standard s-metolachlor + atrazine et comparable au mélange de tebuthiuron + atrazine et de oxyfluorfen + diuron. En post émergence des mauvaises herbes, bien que le Lumax mélangé à un sel de 2,4-D amine ait provoqué une meilleure maîtrise des mauvaises herbes que l'atrazine mélangée à du s-metolachlor + un sel de 2,4-D amine, ce premier mélange à base de Lumax fut légèrement inférieur aux autres produits standards contenant de l'hexazinone ou du tebuthiuron. Dans toutes les situations, le Lumax a présenté une activité résiduelle variant entre 10 et 12 semaines et n'a montré aucune phytotoxicité sur les variétés de canne à sucre testées. Lumax a été recommandé comme alternative à l'atrazine à des doses variant entre 4.0 et 5.0 L/ha.

## **LUMAX®: ALTERNATIVA A LA ATRAZINA PARA CONTROL EN PRE Y POST-EMERGENCIA DE MALEZAS EN CAÑA DE AZÚCAR**

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**PALABRAS CLAVE: Mesotrione, Terbutilazina, S-Metolacloro.**

### **Resumen**

LA ATRAZINA ha sido utilizada con éxito por más de 40 años en variadas mezclas de tanque para control, tanto en pre y post- emergencia, de malezas en caña de azúcar. Sin embargo, el producto está prohibido en la UE por razones ambientales. Lumax, consistente en tres ingredientes activos llamados mesotrione (0.0375 kg i.a./L), terbutilazina (0.125 kg i.a./L) y s-metolacloro (0.375 kg i.a./L), ha sido evaluado como un sustituto de la atrazina en Mauricio, en diez ensayos de campo tanto en caña de azúcar planta como soca. Lumax, en dosis que varían entre 3,5 y 5 L/ha, probó su efectividad en un amplio espectro de malezas de hoja ancha y algunos pastos, incluyendo *Digitaria horizontalis*. En general, Lumax fue superior a la mezcla estándar s-metolacloro + atrazina y comparable a las mezclas de tanque tebuthiuron + atrazina y oxyfluorfen + diuron. En post-emergencia de malezas, a pesar que la mezcla de tanque de Lumax con 2,4-D sal amina mostró un mejor control de malezas que la mezcla de tanque de atrazina con s-metolacloro + 2,4-D sal amina, fue levemente inferior a otras estándares que contienen hexazinona o tebuthiuron. En todas las situaciones, Lumax proveyó una actividad residual que varió entre 10 y 12 semanas y no evidenció fitotoxicidad en las diferentes variedades de caña de azúcar evaluadas. Lumax ha sido recomendado como una alternativa a la atrazina en dosis que varían entre 4 y 5 L/ha.