# METOLACHLOR A NEW PRE-EMERGENCE HERBICIDE FOR GRASS CONTROL IN SUGARCANE

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## Abstract

Results are presented of over 80 trials carried out over a 4-year period on more than 40 farms and estates, with metolachlor, a new pre-emergence grasskiller herbicide, and marketed under the trade name DUAL®. It controls the major grass weeds effectively and has a strong effect on *Cyperus esculentus*. Its relatively poor activity on broadleaf weeds can be augmented by the addition of relatively low rates of either atrazine or ametryne. Metolachlor has very little post-emergence activity. It can, however, be applied post-emergence provided a suitable post-emergence herbicide is added to kill the emerged weeds. Metolachlor will then provide good residual control of grasses and also to a large extent of *C. esculentus*. Ametryne plus 2,4-D or MCPA, diuron plus 2,4-D or MCPA, ametryne alone and paraquat have been used successfully as early post-emergence partners for metolachlor.

## Introduction

Metolachlor [2-ethyl-6-methyl-N-(1'-methyl-2'-methoxyethyl)-chloroacetanilide] is a new pre-emergence herbicide, marketed under the trade name DUAL.® Its excellent grasskilling activity and basic characteristics were first described by Gerber[1] *et. al.* in 1974. The behaviour of metolachlor in combination with atrazine under South African conditions as a broad spectrum pre-emergence herbicide in maize was described by Jooste and van Biljon[2] in 1976.

Metolachlor belongs to the chloroacetanilide group of herbicides. Its major site of uptake is the shoots in grass species and the roots in dicotyledonous (broadleaf) species (Gerber[1] *et. al.* and Pillai[3] *et al*). It has, however, a considerably longer residual activity in the soil than alachlor. Under laboratory conditions the half-life of metolachlor was 26 days compared to 8 days for alachlor (Gerber[1] *et al.*). Similar trends were obtained in field studies (Jooste and van Biljon[2]).

During the 4 seasons from 1974 to 1977, metolachlor was evaluated in all major sugarcane growing regions of South Africa in over 80 trials on more than 40 farms and estates. The results obtained on the most important grass weeds as well as *Cyperus esculentus* are summarised below.

## Materials and Methods

The trials were designed as randomised complete blocks with 4 (efficacy) and 6 (yield) replications. The trials were so designed that each plot could be compared with an adjacent control strip. Plot size comprised 4 rows of sugarcane, each 6 metres long. Sites for efficacy trials were selected on various farms and sugarcane planted by the farmer or on ratoon cane. Yield trials were specially planted to limit variance due to factors other than the herbicide treatments to the minimum. Each plot was assigned a number and assessments were carried out 'blind', i.e. the trialist was unaware of the allocation of the treatments when assessing the trials. Weed control and phytotoxicity were assessed on a logarithmic scale of 1-9 according to the EWRS method of assessment. A score of 1 represents complete weed control or no phytotoxicity and a score of 9 represents less than 30% weed control or the crop completely killed. Weed control of 90% (EWRS 4) or better is considered acceptable. Likewise a phytotoxicity score of 4 or less is considered acceptable and will not affect yield. In the case of yield trials, the number of stalks on the two centre rows of sugarcane were recorded per plot and stalk height was measured on 20 randomly selected stalks per plot.

The herbicides were applied by means of a $CO_2$- precision sprayer using T-jet nozzles arranged on a boom treating a swath 4 metres wide. The spray volume was approximately 400 ℓ/ha in all cases.

Both pre- and early post-emergence trials were carried out on plant as well as ratoon cane. Pre-emergence trials were sprayed immediately after planting or cutting but prior to the emergence of the weeds. Early post-emergence treatments were applied when the grass weeds were in the 2-3 leaf stage and the sugarcane in the spike to 3-leaf stage. The correct stage for early post-emergence treatments normally occurred between 3 to 4 weeks after planting or cutting.

Alachlor + atrazine (2,5+1,0 kg ai/ha) and metribuzin + diuron (1,4+1,6 kg ai/ha) were selected as the standard treatments for comparison in pre- and early post-emergence trials respectively.

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TABLE I

**The herbicidal efficacy of metolachlor on annual grasses in pre-emergence applications**

| Treatment | | Median EWRS scores and number of trials per species | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Herbicide | kg ai/ha | Eleusine indica | | Digitaria sanguinalis | | Panicum laevifolium | | Panicum maximum | |
| | | Number of trials | EWRS score | Number of trials | EWRS score | Number of trials | EWRS score | Number of trials | EWRS score |
| metolachlor + atrazine | 1,25 + 1,25 | 3 | 1 | 2 | 2 | 1 | 4 | – | – |
| metolachlor + atrazine | 1,5 + 1,5 | 6 | 2 | 3 | 2 | 3 | 3 | 3 | 5 |
| metolachlor + atrazine | 2,0 + 1,0 | 8 | 1 | 8 | 2 | 6 | 2 | 8 | 3 |
| metolachlor + atrazine | 2,5 + 1,25 | 5 | 1 | 3 | 2 | 3 | 1 | – | – |
| alachlor + atrazine | 2,5 + 1,0 | 8 | 2 | 5 | 2 | 6 | 2 | 8 | 3 |

## Results

*Pre-emergence trials*

(a) *Control of annual grasses*

The results obtained with pre-emergence treatments on the most important grasses occurring in sugarcane fields, i.e. *Eleusine indica, Digitaria sanguinalis, Panicum laevifolium* and *Panicum maximum* are summarised in Table 1.

From Table 1 it is clear that metolachlor controlled all the grass species effectively at a rate of 1,5 kg ai/ha except *P. maximum*, which required a rate of 2,0 kg ai/ha. It has earlier been reported (Jooste and van Biljon[2]) that soil clay content has very little, if any, effect on the activity of metolachlor on grasses. This was again confirmed.

Other grass species that were effectively controlled at the abovementioned rates in sugarcane were: *Brachiaria eruciformis, Echinochloa colonum, E. crusgalli, Panicum glabrescens, Pseudo-brachiara deflexa, Sorghum verticilliflorum, Tragus racemosus, Urochloa mosambicensis* and *U. panicoides.*

(b) *Control of broadleaf weeds*

Relative to its activity on grasses, the activity of metolachlor on broadleaf weeds is poor. (Gerber[1] *et al.* and Jooste and van Biljon[2]). This limitation can be overcome by the addition of a broadleaf herbicide. Atrazine and ametryne at rates of 1,0 to 1,5 kg ai/ha were found to be effective partners for metolachlor in this respect.

(c) *Control of C. esculentus*

The results of pre-emergence trials for the control of *C. esculentus* in sugarcane are summarised in Table 2.

**TABLE 2**

**The herbicidal efficacy of metolachlor on Cyperus esculentus in pre-emergence applications**

| Treatment | | | EWRS score | | |
|---|---|---|---|---|---|
| Herbicide | kg ai/ha | Number of trials | Minimum | Median | Maximum |
| metolachlor + atrazine | 1,25 + 1,25 | 4 | 7 | 7 | 8 |
| metolachlor + atrazine | 1,5 + 1,5 | 6 | 6 | 7 | 8 |
| metolachlor + atrazine | 2,0 + 1,0 | 18 | 4 | 6 | 8 |
| metolachlor + atrazine | 2,5 + 1,25 | 8 | 5 | 6 | 7 |
| metolachlor + atrazine | 3,0 + 1,5 | 9 | 3 | 5 | 6 |
| alachlor + atrazine | 2,5 + 1,0 | 18 | 6 | 8 | 9 |

It is clear from Table 2 that the control of *C. esculentus* was variable. At a rate of 2,0 kg ai/ha it varied between an EWRS score of 4 (90% control) and 8 (about 45% control) whilst at a rate of 3,0 kg ai/ha it varied between 3 (95% control) and 6 (75% control). However, metolachlor was clearly superior to alachlor.

The clay content of the soil in these trials varied between 7 and 40 percent. It has been reported earlier (Jooste and van Biljon[2]) that under South African conditions, an inverse relationship exists between soil clay content and metolachlor activity on *C. esculentus*, i.e. the higher the clay content of the soil the weaker the activity of metolachlor. It was also reported that although soil clay content might be partially responsible for this variability, climatic factors were found to be much more important. Good control of *C. esculentus* could be obtained on soils with a clay content as high as 50 percent, provided that good rain fell shortly after herbicide application. The importance of good rain soon after metolachlor application for the control of *C. esculentus* is clearly demonstrated in Table 3.

**TABLE 3**

**The effect of rainfall on the activity of metolachlor on Cyperus esculentus**

| Treatment | | Median EWRS score | | |
|---|---|---|---|---|
| Herbicide | kg ai/ha | Trial 23018 | Trial 32002 | |
| metolachlor + atrazine ... | 1,5 + 1,0 | 8 | 7 | 6 |
| metolachlor + atrazine ... | 2,0 + 1,0 | 8 | 5 | 5 |
| metolachlor + atrazine ... | 2,5 + 1,25 | 6 | 5 | 5 |
| metolachlor + atrazine ... | 3,0 + 1,5 | 6 | 4 | 5 |
| alachlor + atrazine ..... | 2,5 + 1,0 | 8 | 6 | 8 |
| metribuzin + diuron ..... | 1,4 + 1,6 | 6 | 8 | 8 |
| Days initiation to assessment ..... | | 67 | 40 | 84 |
| Days initiation to first rain ..... | | 8 | 1 | |
| First rain (mm) ..... | | 5 | 31 | |
| Total rain first 4 weeks (mm) ..... | | 72 | 126 | |
| Soil clay content % ..... | | 12 | 9 | |

(d) *Residual activity*

From the results in Table 4 it is evident that the residual action of metolachlor + atrazine on annual grasses as well as on *C. esculentus* is considerably longer than that of alachlor + atrazine. This finding is in line with the laboratory results reported by Gerber[1] *et al.*

**TABLE 4**

**The residual activity of metolachlor on Cyperus esculentus and annual grasses in pre-emergence applications**

| Treatment | | Median EWRS score per species | | | | | |
|---|---|---|---|---|---|---|---|
| Herbicide | kgai/ha | Cyperus esculentus | | Panicum laevifolium | | Eleusine indica | |
| metolachlor + atrazine | 2,0 + 1,0 | 5 | 5 | 2 | 3 | 2 | 2 |
| alachlor + atrazine ... | 2,5 + 1,0 | 6 | 8 | 2 | 6 | 4 | 6 |
| Days initiation to assessment .... | | 40 | 84 | 48 | 81 | 39 | 83 |
| Soil clay content % ..... | | 9 | | 34 | | 7 | |

*Early Post-emergence Trials*

In practice it is not always possible to apply timely pre-emergence treatments due to the difficulties experienced by growers to synchronise land preparation, planting and herbicide application. This may also happen in the case of ratoon cane. Some growers deliberately prefer to delay herbicide application to an early post-emergence situation. Under such conditions a truly pre-emergence herbicide, such as metolachlor, will give poor results. The emerged weeds must, therefore, be removed by means of a suitable post-emergence herbicide or herbicide combination such as paraquat or ametryne + 2,4-D to allow the pre-emergence herbicide to act. Metolachlor may be applied in tank mixture with the post-emergence herbicide of choice.

It has been our experience that the terms early and late post-emergence are not properly understood in the South African sugar industry. It is, therefore, necessary for the purpose of this paper to redefine these terms. Grasses are the most difficult weeds to control with the existing post-emergence herbicides and are, therefore, used to define these terms. "Early post-emergence" refers to grasses in the 2 to 3-leaf stage, i.e. prior to the start of tillering. "Late post-emergence" refers to grasses in the 4 to 6-leaf stage, i.e. early tillering. Grasses normally start to tiller at the 3 to 4-leaf stage. During summer under rainfed conditions, the early post-emergence stage is normally reached 3 to 4 weeks after cultivation and the late post-emergence stage 5 to 8 weeks after cultivation. The early post-emergence stage normally coincides with the spike to 3-leaf stage of the sugarcane

**TABLE 5**

**Herbicidal efficacy of metolachlor in combination treatments applied early post-emergence 1975/76 season**

| Treatment | | Median EWRS score per species | | | | |
|---|---|---|---|---|---|---|
| Herbicide | kg ai/ha | Cyperus esculentus | Panicum laevifolium | Panicum maximum | Digitaria sanguinalis | Eleusine indica |
| metolachlor + ametryne + MCPA ..... | 2,0 + 2,0 + 1,5 | 4 | 3 | 7 | 2,5 | 1 |
| metolachlor + diuron + MCPA ..... | 2,0 + 2,0 + 1,5 | 4,5 | 3 | 7 | 3 | 1 |
| metolachlor + atrazine + paraquat ..... | 2,0 + 1,0 + 0,4 | 4 | 1 | 3 | 2 | 1 |
| metribuzin + diuron ..... | 1,4 + 1,6 | 4 | 1 | 9 | 2 | 1 |
| Number of trials ..... | | 4 | 4 | 2 | 1 | 1 |

**TABLE 6**

**Herbicidal efficacy of metolachlor in combination treatments applied post-emergence 1976/77 season**

| Treatment | | Median EWRS score per species after weeks | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Herbicides | kg ai/ha | Cyperus esculentus | | Panicum laevifolium | | Panicum maximum | | Digitaria sanguinalis | Eleusine indica |
| | | 2-3 | 7-9 | 4 | 8 | 4 | 8 | 6-8 | 2-3 |
| metolachlor + ametryne + 2,4–D . | 2,0 + 2,0 + 1,5 | 4 | 4,5 | 2 | 3 | 6 | 8 | 2 | 1 |
| metolachlor + ametryne + paraquat | 2,0 + 1,0 + 0,3 | 4 | 5 | 2 | 3 | 2 | 3 | 2 | 1 |
| metolachlor + atrazine + paraquat | 2,0 + 1,0 + 0,3 | 3 | 4,5 | 2 | 3 | 4 | 5 | 2 | 1 |
| metribuzin + diuron ..... | 1,4 + 1,6 | 4 | 5 | 2 | 4 | 6 | 8 | 2 | 1 |
| Number of trials ..... | | 8 | | 3 | | 2 | | 3 | 1 |

**TABLE 7**

**Herbicidal efficacy of metolachlor in combination treatments applied post-emergence 1977/78 season**

| Treatment | | Median EWRS score per species after weeks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Kg/ai/ha | Cyperus esculentus | | | Panicum maximum | | | P. laevifolium et glabrescens | | Digitaria sanguinalis | |
| | | 2-3 | 6-7 | 9-11 | 2-3 | 6-7 | 9-11 | 2-3 | 6-7 | 2-3 | 9-11 |
| metolachlor + ametryne + paraquat | 2,0 + 1,5 + 0,2 | 2,5 | 3 | 3 (7)* | 3 | 2 | 3,5 | 1 | 2,5 | 2 | 2 |
| metolachlor + atrazine + paraquat | 2,0 + 1,0 + 0,2 | 3 | 3 | 3 (7) | 3 | 3 | 3,5 | 1 | 2 | 2 | 3 |
| metolachlor + ametryne ..... | 2,0 + 3,0 | 2,5 | 3 | 2,5(7) | 4 | 3,5 | 6 | 1 | 2,5 | 4 | 3 |
| metribuzin + diuron ..... | 1,4 + 1,6 | 2,5 | 4 | 3,5(7) | 5 | 5 | 7 | 1 | 2 | 3 | 2 |
| Number of trials ..... | | 4 | | | 4 | | | 2 | | 2 | |

* One trial where control of **C. esculentus** broke down after 8 weeks

and the late post-emergence stage with the 4 to 6-leaf stage. In the trials reported here the early post-emergence applications were always applied not later than the 3-leaf stage of the sugarcane.

The treatments varied slightly from season to season and, therefore, the results are presented per season in Tables 5, 6 and 7. A nonionic surfactant was added to all treatments at a rate of 0,2 percent (v:v) except to those treatments which contained paraquat.

All treatments, i.e. metolachlor + ametryne, metolachlor + ametryne + 2,4-D, metolachlor + ametryne + paraquat, metolachlor + atrazine + paraquat and the standard treatment metribuzin + diuron gave effective control of *P. laevifolium, E. indica, D. sanguinalis* and *C. esculentus* both with regard to initial and residual control. Only in one trial (Table 7) did the control of *C. esculentus* break down after about 8 weeks.

Of considerable significance is the fact that the control of *C. esculentus* was far superior in early post-emergence applications to the pre-emergence applications discussed earlier. When it is condidered that the early post-emergence application was made 3 to 4 weeks after planting or cutting, these results indicate that effective control of the abovementioned weeds could be maintained for a period of longer than 16 weeks from the date of planting or cutting.

*P. maximum* was not effectively controlled by any of the treatments including the standard, except the treatments which contained paraquat. It may, therefore, be concluded that diuron + MCPA, ametryne + MCPA or 2,4-D, ametryne alone and metribuzin + diuron could not control *P. maximum* effectively. However, once the emerged plants of *P. maximum* had been removed by paraquat, metolachlor afforded effective residual control of this weed.

*Selectivity*

No phytotoxicity symptoms were observed on any of the treatments in any of the pre-emergence trials. This was

**TABLE 8**

***Selectivity of metolachlor in combination treatments applied early post-emergence***

| Treatment | | EWRS score Phytotoxicity | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1976/77 season | | | 1977/78 season | | |
| Herbicide | kg ai/ha | Minimum | Median | Maximum | Minimum | Median | Maximum |
| metolachlor + ametryne + 2,4-D ..... | 2,0 + 2,0 + 1,5 | 1 | 2 | 4 | – | – | – |
| metolachlor + ametryne + paraquat ... | 2,0 + 1,0 + 0,3 | 1 | 3 | 4 | 1 | 3 | 4 |
| metolachlor + atrazine + paraquat .... | 2,0 + 1,0 + 0,3 | 1 | 3 | 4 | 1 | 3 | 4 |
| metolachlor + ametryne ..... | 2,0 + 3,0 | 1 | 2 | 3 | 1 | 1,5 | 2 |
| metribuzin + diuron ..... | 1,4 + 1,6 | 1 | 2 | 3 | 1 | 1,5 | 2 |
| Number of trials ..... | | 8 | | | 6 | | |

confirmed in 6 yield trials carried out on soils with 8, 9, 9, 10, 6 and 7 percent clay. No significant effect on the number of stalks per plot or stalk height attributable to any of the treatments were recorded at double the recommended application rates.

In all post-emergence trials, the herbicides were applied over the top of the sugarcane. No phytotoxic symptoms were observed on any of the treatments during the 1975/76 season except for the remains of burn marks on the tips of the lower leaves where paraquat was applied. Assessments were, however, made 4 to 6 weeks after application and any phytotoxic symptoms might have been outgrown at the time of the assessment. During the 1976/77 and 1977/78 seasons, assessments were carried out 2 weeks after application. The results on phytotoxicity are summarised in Table 8.

Although some phytotoxic symptoms were observed in some of the trials, the symptoms were not considered to be unacceptable in any of the trials and were mostly of the same magnitude as that obtained with the standard except in treatments where paraquat was applied. On the paraquat treated plots the typical white burn marks were observed on those parts of the leaves that were actually covered by the spray. The paraquat symptoms were not considered unacceptable 2 weeks after herbicide application and no retardation in the growth rate of the sugarcane was noted. This was confirmed in two yield trials on soils with 6 and 7 percent clay. No significant effect on the number of stalks per plot or stalk height was obtained at double the recommended dosage rates 4 months after herbicide application.

Where ametryne alone, or ametryne + 2,4-D was added to metolachlor, the symptoms were a slight reddish-brown discolouration of the leaves covered by the spray. In trials where ametryne or ametryne + 2,4-D were included on their own without metolachlor for comparative purposes, the symptoms were of the same magnitude as that obtained where metolachlor was added. It was, therefore, concluded that metolachlor did not enhance the phytotoxic effects of the standard post-emergence herbicides to which it was added.

## Discussion

Metolachlor is an excellent broad spectrum pre-emergence grasskiller with good selectivity in sugarcane. It is also very dependable, giving good control of grasses under a wide variety of soil and climatic conditions. The relatively long residual activity of metolachlor is of particular importance in rainfed sugarcane where canopy is only reached after 12 to 16 weeks and longer. In comparison to its activity on grasses the activity of metolachlor on broadleaf weeds is relatively poor. This can, however, be rectified easily and economically by the addition of 1,0 to 1,5 kg ai/ha atrazine or ametryne depending on soil type.

The control of *C. esculentus* is variable due to the fact that certain specific conditions are required for metolachlor to be active on this weed. These conditions have been clearly established and are described below:

All existing *C. esculentus* plants must be destroyed prior to herbicide application. This is best done by cultivation with a mouldboard plough. A relatively fine, even and firm seedbed should be prepared. Rain or irrigation should leach the herbicide into the surface layers of the soil prior to the emergence of *C. esculentus*. The minimum amount of rainfall or irrigation for this purpose should be between 10 and 20 mm depending on the clay content of the soil. Heavier soils require more rain or irrigation and soils that contain considerable quantities of organic matter (more than 3%) require even more rain. Frequent rain (once per week) which keeps the surface layers of the soil moist will improve results. Excessive rain, especially on light soils, may shorten the residual activity.

If rain does not occur in time, the *Cyperus* plants that had emerged at the time that the rain occurs and those that emerge one or two days later will not be killed. The *Cyperus* plants that start to grow after the rain will be controlled. Thus, although complete control of *C. esculentus* by metolachlor is seldom observed under practical conditions in sugarcane, the herbicide always reduced the population of *C. esculentus* considerably. Up to 45% control was still obtained under poor conditions (refer Table 1).

Metolachlor on its own lacks versatility in that it is a true pre-emergence herbicide with very little if any post-emergence activity. However, when used in mixture with post-emergence herbicides such as paraquat, ametryne and ametryne + 2,4-D or MCPA its versatility is enhanced. Metolachlor can be applied pre-emergence in combination with low rates (1,0-1,5 kg ai/ha) of ametryne or atrazine. Because it is not always feasible in practice to apply such a combination at a truly pre-emergence stage, the addition of 0,2 to 0,3 kg ai/ha of paraquat is recommended to create a true pre-emergence situation. Metolachlor can also be applied early post-emergence in combination with ametryne (3,0 kg ai/ha) or ametryne + 2,4-D or MCPA (2,0 + 1,5 kg ai/ha) or diuron + 2,4-D or MCPA (2,0 + 1,5 kg ai/ha). These early post-emergence treatments showed a clear advantage over the pre-emergence treatments with regard to the control of *C. esculentus* (refer Tables 2, 5, 6 and 7). *P. maximum* will not be effectively controlled under rainfed conditions by either ametryne alone, ametryne + 2,4-D or MCPA or diuron + 2,4-D or MCPA. Where this weed is a problem, paraquat should rather be used as the post-emergence herbicide in early post-emergence applications.

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