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# THE MANAGEMENT OF *CRASSOCEPHALUM CREPIDIOIDES* AND *ERIGERON SUMATRENSIS* IN HIGH-GROWN TEA

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The *Crassocephalum crepidioides* and *Erigeron sumatrensis* are most common broad leaved weeds in the higher elevations of tea plantations in Sri Lanka. The chemical control of these weeds by paraquat does not seem to be successful. This study was conducted to compare the performance of selected post- and pre-emergent herbicides and their combinations in order to control *C. crepidioides* and *E. sumatrensis.*

*C. crepidioides* was susceptible to glyphosate, glufosinate ammonium and 2,4-D only at the mature stages of development but was susceptible to paraquat only at the 2-4 leaf stage.

*E. sumatrensis* was susceptible to glyphosate at the 5-8 leaf stage and at the other mature stages. Glufosinate ammonium and 2,4-D were effective at all growth stages. This weed was killed by paraquat at the 2-4 leaf stage.

Oxyfluorfen was superior to linuron and diuron against *C. crepidioides* and *E. sumatrensis* regardless of the post-emergent herbicide, and lowered dry weights. Linuron also satisfactorily lowered dry weight of *E. sumatrensis*, but diuron was less effective. The dry weights of total weeds were lowest with glyphosate + oxyfluorfen combination.

## INTRODUCTION

*Crassocephalum crepidioides* (Benth) S. Moore and *Erigeron sumatrensis* Retz have been recognized as two problematic broad leaf weeds at all elevations where tea is grown in Sri Lanka. When uncontrolled, weeds overgrow and interfere with the growth of the tea bush and plucking. Both species produce a large number of wind-borne seeds thus threatening all tea growing areas. These two species display a tolerance to common chemical weed management practices adopted in tea lands. Although *C. crepidioides* is vulnerable for hand pulling, the deep sturdy root system of *E. sumatrensis* resists hand pulling. Manual weeding becomes impracticable in tea lands due to the large extents involved; however, this method is practised during June-July to prevent flowering and seed production. Application of paraquat (Wettasinghe and Rajendran, 1969; Anon. 1983/84) and diuron (Anon. 1969a) has been reported to be unsuccessful in controlling both species in mature stages.

This study was conducted to compare the performance of selected post- and pre-emergent herbicides and to identify a suitable combination to effectively control *C. crepidioides* and *E. sumatrensis* in high-grown tea.

## MATERIALS AND METHODS

This experiment was conducted at the Tea Research Institute, Talawakele from June to December 1990 and was repeated in 1991. The soil type is red yellow podsolic (RYP). The total rainfall during the study was 886.6 mm in 1990 and 996.2 mm in 1991.

Twelve factorial combinations of 4 post-emergent herbicides viz. glyphosate (0.44 kg a.i. $ha^{-1}$), 2,4-D (0.95 kg a.i. $ha^{-1}$), glufosinate ammonium (0.2 kg a.i. $ha^{-1}$) and paraquat (0.22 kg a.i. $ha^{-1}$) and 3 pre-emergent herbicides viz. diuron (0.96 kg a.i. $ha^{-1}$), Linuron (0.41 kg a.i. $ha^{-1}$) and oxyflourfen (0.2 kg a.i. $ha^{-1}$), were tested for their effects on the control of 2 problem weeds, namely, *C. crepidioides, E. sumatrensis* in a pruned tea field. An unweeded plot in the same field served as the control. The experimental design was of the randomized complete block type with 3 replicates.

The plot size was 4m x 4m. Mature tea bushes were pruned in June 1990, and prunings were removed out from the experimental plots. Soil pH was raised to 5.5 by applying 2000 kg $ha^{-1}$ of dolomite. The field was left undisturbed for 6 weeks for the weeds to grow prior to spraying herbicides. The herbicide combinations were sprayed onto the weeds when they were in the 2-4 leaf stage.

The response of weeds to post-emergent herbicides was observed at 2, 4, 6, 10 and 18 days after herbicide application (DAH). The dry weight of the above weed species was recorded 3 months after herbicide application (MAH). The weeds were uprooted from a sample area of 2 $m^2$ selected randomly and dried at 85°C for 2-3 days until a constant weight was obtained.

The General Linear Model and Orthogonal contrasts, as well as ANOVA were employed to determine the treatment effects and to compare the performance of herbicides and their interactions, if any.

## RESULTS

### Growth stage of weeds and herbicide response

Results of the susceptibility study conducted at different growth stages of weeds selected in patches during 1990 showed differences in plant response to post-emergent herbicides (Tables 1 and 2).

TABLE 1. – *Response of C. crepidioides to post-emergence herbicides applied at different growth stages, during 1990.*

| *Herbicide* | *Growth stage* | *Response (DAH)* 2 | 4 | 6 | 10 | 18 |
|---|---|---|---|---|---|---|
| Glyphosate | | | | | | |
| | 2-4 leaf stage | – | – | – | – | – |
| | 5-8 do | – | – | – | C | C |
| | Flower bud stage | – | – | C | L | K |
| | Mature stage | – | – | C | L | K |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2,4-D | | | | | | |
| | 2-4 leaf stage | – | – | – | W | D |
| | 5-8 do | W | D | K | K | K |
| | Flower bud stage | W | D | K | K | K |
| | Mature stage | W | D | K | K | K |
| Glufosinate ammonium | | | | | | |
| | 2-4 leaf stage | – | – | – | – | – |
| | 5-8 do | S | L | K | K | K |
| | Flower bud stage | S | L | K | K | K |
| | Mature stage | S | L | K | K | K |
| Paraquat | | | | | | |
| | 2-4 leaf stage | S | S | L | K | K |
| | 5-8 do | – | – | – | – | – |
| | Flower bud stage | – | – | – | – | – |
| | Mature stage | – | – | – | – | – |

DAH – Days after herbicide application
Responses of weeds :

1. – = No response
2. C = Chlorosis
3. W = Wilting of leaves
4. D = Dried leaves
5. S = Scorching of leaves
6. L = Leaf fall
7. K = Kill of plant

TABLE 2. – *Response of E. sumatrensis to post-emergence herbicides applied at different growth stages, during 1990.*

| *Herbicide* | *Growth stage* | *Response (DAH)* | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 10 | 18 |
| Glyphosate | 2-4 leaf stage | – | – | – | C | L |
| | 5-8 do | – | – | C | L | L |
| | Flower bud stage | – | C | C | K | K |
| | Mature stage | – | C | C | K | K |
| 2,4-D | 2-4 leaf stage | W | K | K | K | K |
| | 5-8 do | W | K | K | K | K |
| | Flower bud stage | W | D | K | K | K |
| | Mature stage | W | D | D | K | K |
| Glufosinate ammonium | | | | | | |
| | 2-4 leaf stage | S | K | K | K | K |
| | 5-8 do | S | K | K | K | K |
| | Flower bud stage | S | L | L | K | K |
| | Mature stage | S | L | L | K | K |
| Paraquat | 2-4 leaf stage | S | L | K | K | K |
| | 5-8 do | S | S | L | L | L |
| | Flower bud stage | S | S | S | L | L |
| | Mature stage | S | S | S | L | L |

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*C. crepidiodes*

*C. crepidioides* was tolerant to glyphosate at the 2-4 leaf stage (Table 1). Plants became chlorotic at 10 DAH when applied at 5-8 leaf stage. When glyphosate was applied at the flower bud and mature stages chlorosis appeared at 6 DAH and the plants were killed at 18 DAH.

This weed was somewhat tolerant to 2,4-D when applied at the 2-4 leaf stage, but wilting of leaves took place at 10 DAH. This weed was very susceptible to 2,4-D when applied at the 5-8 leaf stage itself. A complete kill resulted at 6 DAH.

Glufosinate ammonium had no effect at the 2-4 leaf stage. However, leaf scorching (at 2 DAH) followed by a complete kill was observed at 6 DAH when glufosinate ammonium was applied as early as the 5-8 leaf stage. This effect was similar to that of 2,4-D. In contrast, paraquat caused scorching and death only when it was sprayed at the 2-4 leaf stage. The stem remained alive even at 6 DAH and the plants died by 10 DAH.

*E. sumatrensis*

The application of glyphosate to *E. sumatrensis* at 2-4 leaf stage resulted in light chlorosis at 10 DAH and leaf fall in 18 DAH (Table 2). Early chlorosis of leaves (at 6 DAH) and leaf fall at 10 DAH resulted from glyphosate sprayed at the 5-8 leaf stage, but the stem survived until 18 DAH. Glyphosate caused chlorosis at 4 DAH followed by death at 10 DAH when it was applied at the flower bud and mature stages.

When 2,4-D was sprayed wilting of leaves occurred at 2 DAH irrespective of the stage of development. The weed was killed in 4 DAH when 2,4-D was applied either at 2-4 or 5-8 leaf stage. There was a 2-day delay in kill with the application of 2,4-D at the flower bud stage and further 4-day delay when applied to mature plants.

The effect of glufosinate ammonium was similar to that of 2,4-D except that when the former was sprayed at the flower bud or mature stage it caused a 2-day delay in the death of the weed.

Paraquat caused scorching of leaves at 2 DAH. The leaves were defoliated by 4 DAH and the plants killed at 6 DAH when it was applied at the 2-4 leaf stage.

As the plant reached maturity, tolerance to paraquat increased. The stem remained alive even after 18 DAH, after scorching of leaves.

## Dry weight of weeds

*C. crepidioides*

During 1990, post-emergent herbicides significantly decreased dry weight of *C. crepidioides* (calculated average weight of 310 kg $ha^{-1}$ in herbicide treated plots) compared to unweeded plot (705 kg $ha^{-1}$) (Fig.1).

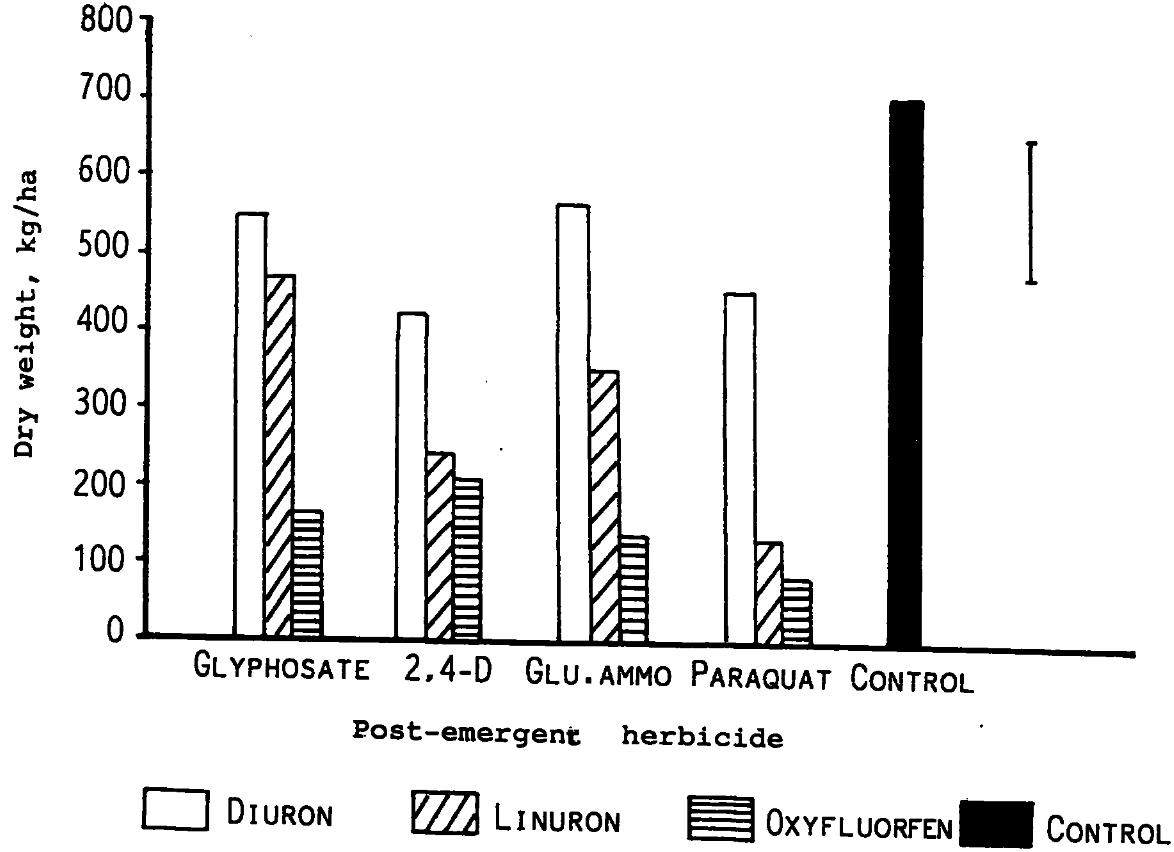


Fig. 1 – *The effect of post- and pre-emergence herbicide interaction for the dry weight of C. crepidioides, during 1990.*

There was a significant effect of herbicides on the dry weight of C. crepidioides during both years (Table 3). The dry weight of *C. crepidioides* was 705 kg ha$^{-1}$ during 1990 and 434 kg ha$^{-1}$ during 1991, when unweeded.

TABLE 3. – *Orthogonal comparison for dry weight of selected weed species, during 1990 and 1991.*

| *Contrast* | *DF* | *Dry weight* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *C. crepidioides* | | *E. sumatrensis* | | *Total weeds* | |
| | | 90 | 91 | 90 | 91 | 90 | 91 |
| Cntrl. vs. Herb. | 1 | * | * | * | * | * | * |
| Syst. vs. Cont. | 1 | NS | NS | ** | ** | * | NS |
| Gly. vs 2,4-D | 1 | NS | NS | NS | NS | NS | NS |
| Gluf. vs Paraq. | 1 | NS | NS | ** | * | ** | * |
| Oxy vs Diu. & Lin. | 1 | * | NS | * | * | ** | ** |
| Diu. vs. Lin. | 1 | NS | NS | NS | NS | NS | NS |
| Inter. 1 (Post vs. Pre.) | 1 | * | NS | ** | ** | ** | ** |
| Inter. 2 (Oxy. vs Diu. & Lin.) | 1 | NS | NS | * | NS | * | * |

* Significant level at P=0.05
** Significant level at P=0.01

There was a significant interaction between post- and pre-emergent herbicides for dry weight of *C. crepidioides* (Table 3) and the results are given in Fig. 1. There were no significant differences in the dry weight among post-emergent herbicides. Among pre-emergent herbicides, diuron had the highest dry weight of *C. crepidioides*, and hence the lowest control on weed growth. Linuron lowered the dry weight of *C. crepidioides* when compared to diuron, while in all cases, oxyfluorfen gave the lowest dry weights. Significant reductions were seen in the dry weight of *C. crepidioides* due to linuron when used as a mixture with 2,4-D, paraquat or glufosinate ammonium compared to either diuron mixtures or linuron with glyphosate. There were no significant differences in the dry weights when oxufluorfen was combined with selected post-emergent herbicides. Linuron also gave non significantly similar dry weight of *C. crepidioides* except with glyphosate.

During 1991, dry weight of *C. crepidioides* ranged from 201 kg ha$^{-1}$ in glufosinate ammonium to 243 kg ha-1 in 2,4-D treated plots respectively, but the differences were not significant (Table 4). The weed suppression ranged from 44% in 2,4-D to 54% in glufosinate ammonium treated plots respectively, when compared to unweeded (434 kg ha$^{-1}$). The application of oxyfluorfen gave the lowest dry weight of 175 kg ha$^{-1}$ in *C. crepidioides*, a 60% suppression compared to unweeded, which was significantly lower than the other pre-emergent herbicides.

TABLE 4. – *Effect of post- and pre-emergence herbicides on weed dry weight of selected species.*

| *Treatment* | *Dry weight* | |
|---|---|---|
| | *C. crepdioides* *1991* | *E. sumatrensis* *1991* |
| | kg ha$^{-1}$ | |
| Unweeded (Control) | 434 | 176 |
| Post-emerg. herbicides | | |
| Glyphosate | 239 | 17 |
| 2,4-D | 243 | 12 |
| Glufosinate ammonium | 201 | 20 |
| Paraquat | 212 | 25 |
| LSD(P=0.05) | NS | NS |
| Pre-emerg. herbicides | | |
| Diuron | 254 | 24 |
| Linuron | 231 | 20 |
| Oxyfluorfen | 175 | 11 |
| LSD(P=0.05) | 42.2 | NS |
| CV % | 22.31 | 42.50 |

*E. sumatrensis*

The dry weights of *E. sumatrensis* in unweeded plots (control) were 113 and 176 kg ha$^{-1}$, during 1990 and 1991 respectively, which was significantly lowered by herbicide applications in both years (Fig. 2, Table 4).

There was a significant interaction between post- and pre-emergent herbicides for the dry weight of *E. sumatrensis* during 1990 (Fig. 2). Among the post-emergence herbicides only 2,4-D significantly decreased the dry weight of *E. sumatrensis* when combined with diuron. All post-emergence herbicides when combined with oxyfluorfen gave the lowest weed dry weights, which accounted for 91-96% suppression of *E. sumatrensis.* Linuron too had significant suppression of weeds ranging from 86-89%, but diuron had only 50-84% suppression. The dry weight of *E. sumatrensis* in post-emergence herbicides combined with linuron was not significantly different from post-emergence herbicides that combined with oxyfluorfen. The highest suppression of *E. sumatrensis* (96%) was by glyphosate + oxyfluorfen.

During 1991, the dry weight of *E. sumatrensis* ranged from 12 kg ha$^{-1}$ in 2,4-D to 25 kg ha$^{-1}$ in paraquat treated plots respectively (Table 4). The suppression ranged from 85% in Paraquat to 93% in 2,4-D, compared to 176 kg ha$^{-1}$ in unweeded (control) strips. There was no significant difference among post- and pre- emergence herbicides for the dry weight of *E. sumatrensis* (Table 4). But pre-emergent herbicides gave significant reductions in dry weight of *E. sumatrensis* ranging from 86% in diuron (24 kg ha$^{-1}$) to 93% in oxyfluorfen (11 kg ha$^{-1}$), when compared to unweeded.

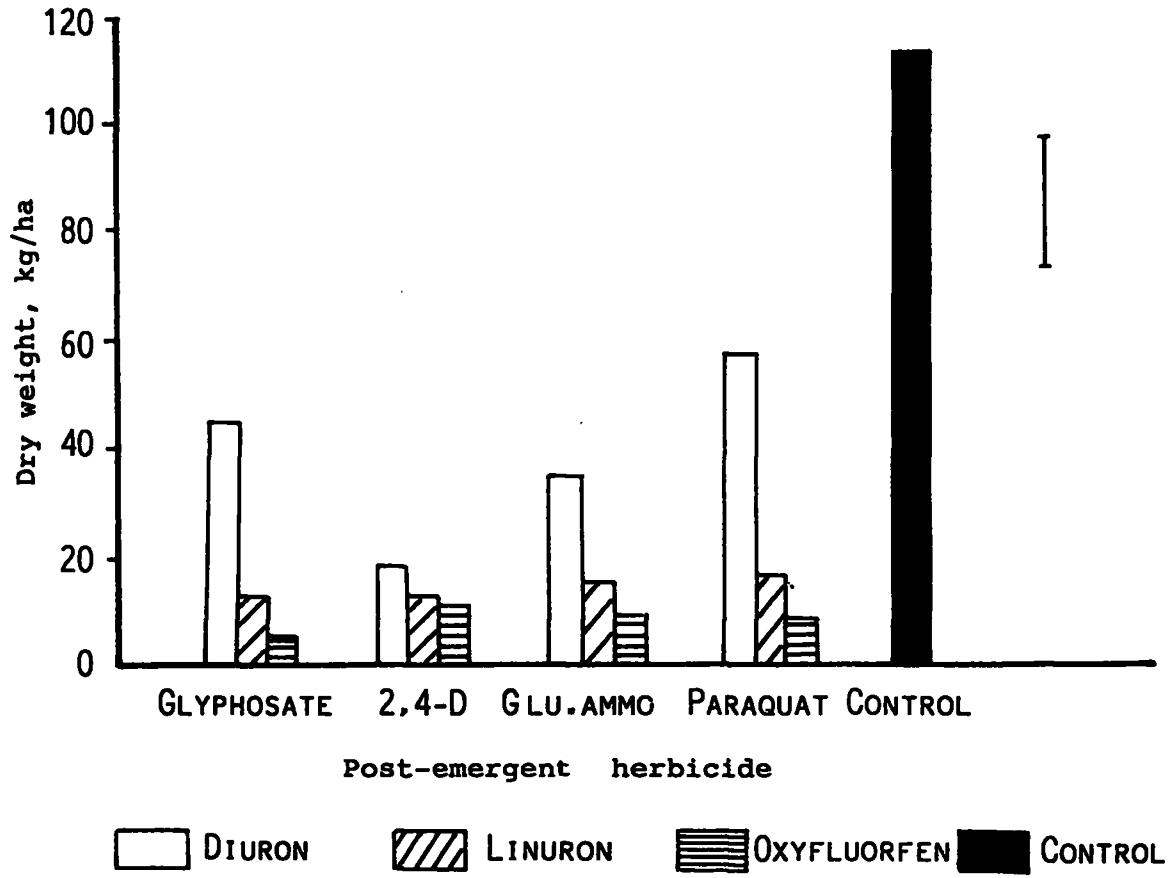


Fig. 2 – *The effect of post- and pre-emergence herbicide interaction for the dry weight of E. sumatrensis, during 1990.*

*Total weeds*

The total dry weight of weeds included a lot of non-problematic low growing weeds such as *Oxalis* spp., *Commolina diffusa, Borreria laevis, Borreria ocymoides*, etc. in addition to *C. crepidioides, E. sumatrensis, Panicum repens, Ageratum conyzoides, Polygonum capitatum, Polygonum nepalensis, Bidens pilosa, Gnapalium* spp. etc. There was a significant decrease in the dry weight of total weeds at 3 MAH in herbicide treatments (981 kg $ha^{-1}$) when compared to (unweeded) 2732 kg $ha^{-1}$ (a 64% suppression) in 1990, and also 963 kg $ha^{-1}$ in herbicides vs 3011 kg $ha^{-1}$ in unweeded (a 68% suppression) in 1991. There were significant interactions between post- and pre-emergence herbicides during both years (Table 3).

At 3 MAH, the highest dry weight of total weeds (1505 kg $ha^{-1}$) was in the glyphosate + diuron mixture-treated plots, during 1990 (Fig.3). The second highest dry weight of 1457 kg $ha^{-1}$ was from plots treated with paraquat + diuron mixture. Significant suppression of the total weed dry weight was obtained with 2,4-D compared to the other post-emergence herbicides, except glufosinate ammonium.

Among the pre-emergent herbicides, diuron was less effective in overall weed control. Although linuron gave a decrease ranging from 62% with paraquat to 67% with 2,4-D, oxyfluorfen was far superior in weed control, which caused a weed suppression ranging from 71% with paraquat (780 kg $ha^{-1}$) to 82% with 2,4-D, when compared to unweeded plots. There were no significant differences among oxyfluorfen-based post-emergence herbicides.

During 1991, weed dry weights were lower than 1990 (Fig.4) but the results were similar, except that glyphosate + oxyfluorfen and paraquat + linuron mixtures which gave better suppression of weeds than the same post-emergence herbicides mixed with other pre- emergence herbicides and 2,4-D which gave slightly lower weed suppression when compared to the weed dry weights during 1990.

## DISCUSSION

### Plant response to herbicides

Response of a plant to an applied herbicide is mainly governed by a number of factors such as stage of plant growth, internal herbicide concentration, inherent physiological characteristics, inherent toxicity of the herbicide and environmental factors (Anderson, 1984 a). Tolerance of *C. crepedioides* and *E. sumatrensis* to paraquat (Wettasinghe and Rajendran, 1969; Anon, 1971a; Anon, 1985) and diuron (Anon, 1969a; Anon, 1971b) has been previously reported. *C. crepedioides* has also showed tolerance to paraquat and 2,4-D (Anon, 1985). However, the type of response and response time vary with the herbicide and growth stage of the weed. This may be attributed to the rate of herbicide uptake and translocation to the site of action to meet the threshold level (Anderson, 1984 b; Gupta, 1984).

*C. crepidioides* at the 2-4 leaf stage showed a greater tolerance to glyphosate, 2,4-D and glufosinate ammonium than the other mature stages. This may be attributed to various reasons such as hairiness, erect leaves, etc that reduced the availability of adequate dosage of herbicide for absorption (Anon, 1969b). This weed did not show any response within the first 18 days after application of glyphosate. Glyphosate, a systemic

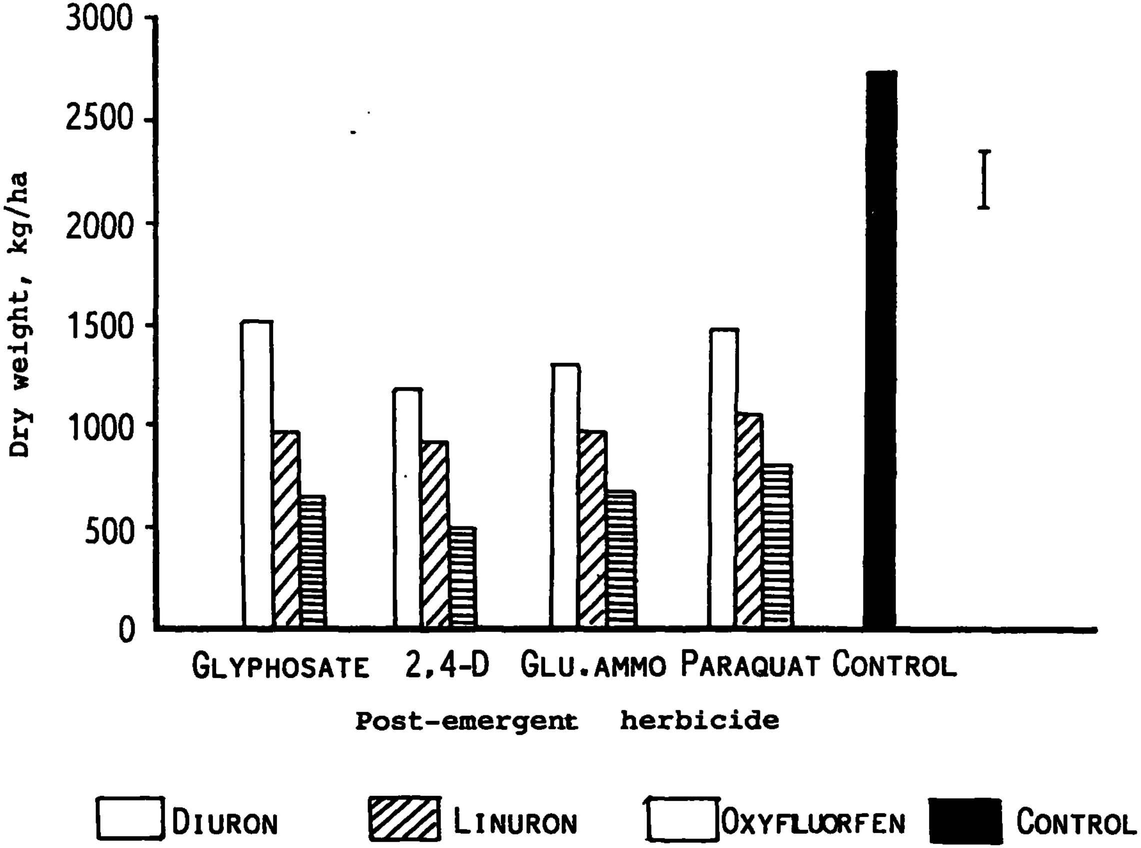


Fig. 3 – *The effect of post- and pre-emergence herbicide interaction for the dry weight of total weeds during 1990.*

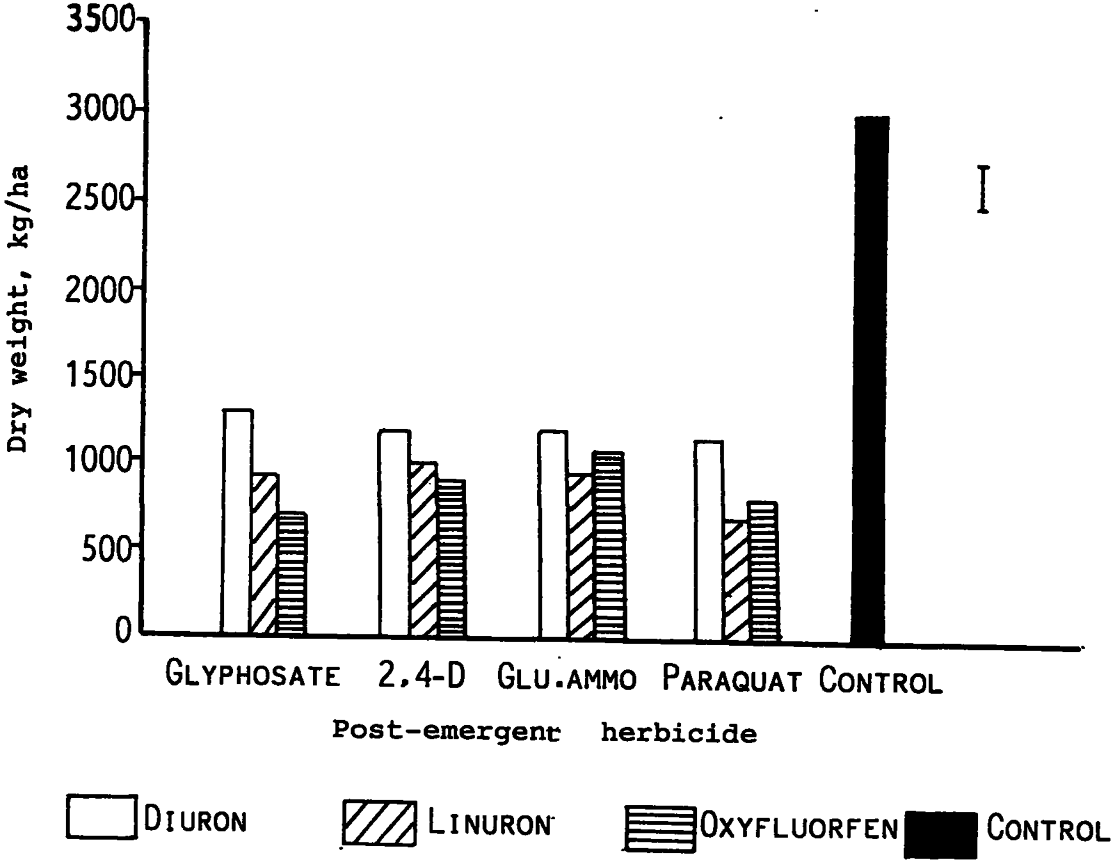


Fig. 4 – *The effect of post- and pre-emergence herbicide interaction for the dry weight of total weeds during 1991.*

herbicide, needs to be first absorbed by the plant tissues and translocated in adequate concentrations to the site(s) of action to inhibit the aromatic amino bio-synthesis pathway (Anon, 1979a; Jaworski, 1972; Anderson, 1984b). This weed was susceptible to herbicides at 5-8 leaf stage and afterwards. This may be due to growth stage effect that leads to selectivity (Anon, 1969c; Anderson, 1984a).

The response of *C. crepidioides* to 2,4-D was similar to glyphosate when applied at the 2-4 leaf stage and symptoms of phytotoxicity appeared in about 10 DAH. 2,4-D, a systemic in action, is expected to take a relatively longer time period for phytotoxicity on weeds (Anon, 1979b) when compared to glufosinate ammonium and paraquat. 2,4-D disrupts the translocation of assimilates by inducing massive cell formation and proliferation resulting in the starvation of roots (Anderson 1984b). *C. crepidioides* did not respond to glufosinate ammonium within 18 days when applied at the 2-4 leaf stage. This may be due to the systemic action of glufosinate ammonium other than the contact action (Anon, 1983).

Paraquat is a contact herbicide, which leads to the disintegration of leaf epidermal cells followed by wilting and desiccation of plants (Waidyanatha, 1968; Anderson, 1984b; Anon 1979c), and which performs well in young stage of plant. *E. sumatrensis* was killed by both glyphosate and glufosinate ammonium, but the response occurred after 10 days when sprayed at mature stages. When glyphosate was sprayed at 2-4 leaf stage it took nearly 10 days for chlorosis to appear. At 5-8 leaf stage chlorosis occurred in 6 days, and at maturity stages chlorosis occurred in 4 DAH. This is indicative of the influence of growth stage on the plant response to herbicides, as reported by Anderson (1984a). 2,4-D and glufosinate ammonium also showed the same trend of destroying *E. sumatrensis* at all stages.

Like *C. crepidioides, E. sumatrensis* showed a greater susceptibility to paraquat at 2-4 leaf stage, which may be due to its contact nature.

In this study, the combination of oxyfluorfen with all post-emergence herbicides showed satisfactory control of these weed spp. and total weeds than combinations with linuron or diuron. Oxyfluorfen is a pre-emergent herbicide and selective in action and its effects is more prominent on broad leaved than grass weeds ( Anon 1979d; Anderson 1984b).

Linuron also showed satisfactory control against *E. sumatrensis* than diuron.

**Dry weight of weeds**

There was a significant difference among post-emergence herbicides for the dry weight of weed when compared to unweeded control. However, the degree of control varied with the herbicide and weed species.

Herbicide combinations containing post-and pre-emergent herbicides are known to suppress weeds over a long period of time when compared to post-emergent herbicides (Rao, 1983). The post emergent herbicides primarily kill the already emerged and growing weeds, while pre-emergent herbicides inhibit both seed germination and seedling emergence prevents seedling emergence until seed food reserves have been depleted (Bingham and Schmidt, 1984). This avoids weed emergence and potential problems for a considerable period of crop growth thus minimizing weed crop competition.

## CONCLUSION

The post-emergent herbicides, namely, glyphosate, 2,4-D, glufosinate ammonium and paraquat could be used to control above two weed spp. when it is applied to the proper stage of growth of weed spp. The most susceptible stage was 5-8 leaf stage for glyphosate, 2,4-D and glufosinate ammonium, and 2-4 leaf stage for paraquat. Post emergent herbicides individually combined with oxyfluorfen (a pre-emergent herbicide) successfully controlled both *C. crepidioides* and *E. sumatrensis*. Although weeds display susceptibility, it may not be advisable to delay herbicide application until the flower bud stage, since it may, by chance, lead to viable seed production.

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