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GERMINATION AND GROWTH RESPONSES OF *EUPATORIUM ODORATUM* TO HERBICIDES APPLIED AT VARIOUS LEVELS OF SOIL DEPTH

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Abstract

The germination and growth responses of *Eupatorium odoratum* to herbicides applied at various levels of soil depth is demonstrated .Germination of *E. odoratum* seeds was completelyinhibited by EPTC or molinate when applied to the soil surface; atrazine, diuron, monuron and simazine did not inhibit germination but the seedlings when emerged died within three weeks. All herbicides applied to various levels of soil depth caused a significant reduction in the growth of seedlings. Greatest effects were observed for herbicides applied to the soil surface. The most effective herbicides in the control of germination and subsequent growth of *E. odoratum* were Atrazine, 2,4-D, diuron, EPTC, molinate, monuron and simazine.

Introduction

Eupatorium L. is a native of South America and West Indies (Henderson & Anderson, 1966). Its occurrence has been widely reported in Africa (Sheldrick, 1968) and in Asia (Yadav & Tripathi, 1982). The weed is often found growing in dense stands along major roads, in forests, farmlands and pasteurs causing restriction in the movement of stock and machinery, affecting crop yield and reduction in the carrying capacity of grazing lands. It is characterized by rapid growth rate and the ability to colonize new habitats. Its success has thus made it to colonize various habitats such as rock surfaces, swamps and other odd places. Attempts at controlling this weed by use of biological methods have been reported (Wilson, 1964). Other methods of control including mechanical (Sheldrick, 1968) and chemical (Etejere, 1980; 1982) have also been reported.

Although total control of this weed by use of herbicides seems very promising, one major problem however which results from foliar treatments of plants with herbicides is the resprouting of the weed from the stems (Sheldrick, 1968). In addition, the plants are also known to produce a large number of viable seeds (Etejere, 1980; Yadav & Tripathi, 1982). These seeds have been known to retain viability under room temperatures for about 25 months (Etejere, 1980).

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This study therefore attempts to examine the germination of the seeds and the development of emerging seedlings in soils in which herbicides have been incorporated at various levels of soil depth. The overall objective is to determine how best to apply herbicides on a recently cleared vegetation infested by the seeds of *E. odoratum* and arrest the germination of the seeds or growth of seedlings into mature plants.

Materials and methods

Seed collections were randomly made from one hundred plants occupying approximately an acre of land. The collections were made during the fruiting season, December – March 1978. Loamy soil obtained from the forest was sieved, sterilized in a soil sterilizer and distributed into 20 cm diameter plastic pots to a height of 19 cm from the bottom. A commercially formulated herbicide and at a particular rate of application (Table 1) was sprayed evenly on the soil surface in each pot. The herbicide was then worked into the top 1-2 cm layer of soil. Immediately after the herbicide incorporation, 50 seeds were planted at 2 cm depth. Control pots were sprayed with sterile distilled water and each treatment was replicated five times.

Table 1. Germination of *Eupatorium odoratum* seeds in soil with herbicides at various levels of soil depth. Data for each herbicide are averages of five replicates.

Herbicide Treatment	Rate of application (kg/ha)	% Germination Soil Surface application	5 cm soil depth application	10 cm soil depth application
Sterile distilled water		78 ± 2.1 a	81 ± 2.3 a	80 ± 1.6 ae
Alachlor	2.60	73. ± 1.8 a	56 ± 1.4 bfg	68 ± 0.3 bde
AMA + 2,4-D	2.20	61 ± 1.8 b	36 ± 2.3 c	55 ± 1.4 c
Asulam	2.20	63 ± 2.2 b	65 ± 1.1 dfh	65 ± 0.3 bd
Atrazine	2.50	20 ± 1.7 c	50 ± 0.3 be	59 ± 5.4 cd
2,4-D	2.20	13 ± 0.6 d	49 ± 1.4 e	62 ± 3.4 d
Diuron	2.38	39 ± 3.2 e	60 ± 1.7 fh	74 ± 0.9 e
EPTC	2.38	0 ± 0 f	51 ± 2.4 be	74 ± 1.8 e
Molinate	2.38	0 ± 0 f	54 ± 2.0 eg	63 ± 3.4 d
Monuron	2.38	64 ± 5.2 g	63 ± 1.8 h	63 ± 1.3 d
Prometryne	2.20	65 ± 2.4 b	72 ± 1.5 i	65 ± 2.5 bd
Simazine	2.50	24 ± 1.4 c	59 ± 1.4 gh	59 ± 2.1 cd

Data in each vertical column not followed by the same letter are significantly different at 95% probability level.

In the second set the soil in pots was removed to a depth of 5 cm before the herbicide was incorporated. The soil was immediately replaced and the seeds planted at 2 cm depth from the surface. The third set was similar to the second except that herbicide was incorporated at a soil depth of 10 cm. Twenty-four hours after treatment, the soil in each pot was watered and all pots transferred into a greenhouse with 12 hour day temperature of 30 ± 2°C alternating with 23 ± 2°C night temperatures. Subsequently the pots were watered daily.

Seeds with hypocotyl + plumule emerging from the soil were considered as germinated. Germination count was determined by counting total number of emerging seedlings daily for 15 days after herbicide treatments. Three weeks after treatment, the seedlings in each pot were thinned down to one and allowed to grow for five additional weeks during which time the number of leaves produced by each seedling was determined weekly. Growth was evaluated by measuring the area of two largest leaves (by tracing on graph papers) and height of plants from soil surface. Subsequently the seedling was carefully removed, washed in running tap water and the length of primary roots measured. The seedlings were then wrapped in aluminum foil and dried at 60°C in an oven to constant weight for the total dry weight of above and below-ground tissues. All data were subjected to Duncan's Multiple range test (Duncan, 1955).

Results

There was no germination in pots in which EPTC or molinate was incorporated at the surface level (Table 1). However germination did occur in pots in which EPTC or molinate was incorporated at 5 cm or 10 cm below the soil surface. All the seedlings which emerged from pots treated with atrazine, diuron, monuron or simazine on the soil surface died from chlorosis three weeks after treatment (Table 2), while those in pots treated with the same herbicides but at 5 cm or 10 cm below soil surface survived and showed no chlorotic symptoms (Tables 3 & 4). Thus herbicides incorporated to the surface of the soil caused greater effect on germination and seedling survival than when applied at 5 cm or 10 cm below the soil surface (Tables 2-4). The number of leaves produced per seedling was significantly reduced by AMA + 2,4-D, or 2,4-D when applied to the soil surface (Table 2). Similar effects were observed when atrazine, EPTC or simazine was applied 5 cm below soil surface with no significant reduction in leaf number by herbicides applied 10 cm below soil surface.

Leaf area was significantly reduced by all the herbicides applied at different depths but greater reduction was caused by AMA + 2,4-D, or 2,4-D applied to soil surface and by atrazine, EPTC, molinate and monuron applied 5 cm below the soil surface (Tables 1-4).

Shoot height was significantly reduced by all the herbicides applied at different

Table 2. Growth of *Eupatorium odoratum* seedlings in soil incorporated with herbicide at the surface level. Data for each herbicide are averages of five replicates.

Herbicide Treatment	Rate of application (kg/ha)	Total no. of leaves	Leaf area (sq. cm)	Shoot height (cm/seedling)	Length of Primary root (cm/seedling)	Total dry wt. (mg/seedling)
Sterile distilled water		10 a	56 ± 1.5 a	45 ± 0.4 a	36 ± 1.3 a	210 ± 1.9 a
Alachlor	2.60	80 ab	15 ± 0.6 bc	19 ± 0.4 b	13 ± 1.3 bc	10 ± 1.2 b
AMA + 2,4-D	2.20	6 b	10 ± 0.5 c	13 ± 1.0 c	10 ± 1.0 b	9 ± 0.5 b
Asulam	2.20	8 ab	18 ± 0.2 b	20 ± 0.5 b	16 ± 1.4 c	43 ± 1.0 c
Atrazine *	2.50	–	–	–	–	–
2,4-D	2.20	6 b	10 ± 0.3 c	20 ± 0.4 b	15 ± 1.3 c	10 ± 0.4 b
Diuron*	2.38	–	–	–	–	–
EPTC +	2.38	–	–	–	–	–
Molinate +	2.38	–	–	–	–	–
Monuron *	2.38	–	–	–	–	–
Prometryne	2.20	8 ab	20 ± 1.4 b	23 ± 0.6 b	16 ± 3.2 c	51 ± 0.6 c
Simazine *	2.50	–	–	–	–	–

Data in each vertical column not followed by the same letter are significantly different at 95% probability level.

+ No germination in buckets.

* Seedlings died three weeks after treatment.

Table 3. Growth of *Eupatorium odoratum* seedlings in soil incorporated with herbicide at 5 cm level. Data for each herbicide are averages of five replicates.

Herbicide Treatment	Rate of application (kg/ha)	Total no. of leaves	Leaf area (sq. cm)	Shoot height (cm/seedling)	Length of Primary root (cm/seedling)	Total dry wt. (mg/seedling)
Sterile distilled water		10 a	58 ± 1.5 a	59 ± 1.4 a	38 ± 1.3 a	195 ± 1.9 a
Alachlor	2.60	8 ab	18 ± 1.4 bc	22 ± 1.7 bc	16 ± 0.5 bc	60 ± 2.2 b
AMA + 2,4-D	2.20	8 ab	16 ± 1.4 bd	18 ± 1.5 bd	14 ± 1.5 bd	52 ± 0.7 c
Asulam	2.20	8 ab	22 ± 1.6 c	25 ± 1.3 c	19 ± 2.5 c	83 ± 0.2 d
Atrazine	2.50	6 b	12 ± 2.1 de	16 ± 0.4 d	13 ± 0.4 bd	10 ± 1.3 e
2,4-D	2.20	8 ab	15 ± 0.2 bd	22 ± 1.3 bc	14 ± 2.5 bd	12 ± 1.0 e
Diuron	2.38	8 ab	18 ± 2.3 bc	16 ± 1.1 d	11 ± 0.7 d	50 ± 4.2 c
EPTC	2.38	6 b	9 ± 0.9 e	14 ± 1.2 d	9 ± 1.0 e	31 ± 1.7 f
Molinate	2.38	8 ab	10 ± 0.7 e	14 ± 2.5 d	9 ± 1.2 e	32 ± 1.8 f
Monuron	2.38	8 ab	13 ± 2.6 de	22 ± 3.4 bc	11 ± 1.2 de	46 ± 3.4 c
Prometryne	2.20	8 ab	30 ± 3.1 f	28 ± 2.3 c	20 ± 1.9 c	53 ± 3.0 c
Simazine	2.50	6 b	14 ± 1.5 de	16 ± 1.4 d	13 ± 1.2 bd	10 ± 1.4 e

Data in each vertical column not followed by the same letter are aignificantly different at 95% probability level.

Table 4. Growth of *Eupatorium odoratum* seedlings in soil incorporated at 10 cm level. Data for each herbicide are averages of five replicates.

Herbicide Treatment	Rate of application (kg/ha)	Total no. of leaves	Leaf area (sq. cm)	Shoot height (cm/seedling)	Length of Primary root (cm/seedling)	Total dry wt. (mg/seedling)
Sterile distilled water		10 a	60 ± 1.5 a	57 ± 0.8 a	40 ± 1.3 a	225 ± 2.8 a
Alachlor	2.60	10 a	26 ± 0.9 bd	30 ± 4.1 bd	20 ± 1.3 bdef	108 ± 1.1 b
AMA + 2.4-D	2.20	10 a	31 ± 3.3 bcf	31 ± 1.7 b	27 ± 2.2 c	175 ± 2.3 c
Asulam	2.20	10 a	33 ± 0.4 cf	36 ± 1.9 c	26 ± 1.5 cd	192 ± 0.9 d
Atrazine	2.50	10 a	27 ± 1.5 bcd	30 ± 1.5 bd	22 ± 1.3 df	115 ± 1.4 e
2,4-D	2.20	10 a	22 ± 2.1 de	30 ± 2.0 bd	22 ± 3.5 df	59 ± 1.2 f
Diuron	2.38	10 a	30 ± 5.2 bcf	25 ± 0.5 d	16 ± 2.4 ef	184 ± 3.2 g
EPTC	2.38	10 a	21 ± 2.6 de	25 ± 0.6 d	17 ± 1.7 ef	155 ± 2.9 h
Molinate	2.38	8 a	24 ± 0.9 bd	27 ± 3.2 bd	18 ± 0.5 ef	135 ± 0.5 i
Monuron	2.38	10 a	25 ± 3.1 bd	27 ± 1.2 bd	14 ± 1.6 e	170 ± 2.5 c
Prometryne	2.20	10 a	22 ± 2.7 de	27 ± 0.7 bd	20 ± 1.9 def	103 ± 3.5 b
Simazine	2.50	10 a	30 ± 2.3 bcf	32 ± 1.6 bc	22 ± 1.6 df	125 ± 0.8 j

Data in each vertical column not followed by the same letter are significantly different at 95% probability level.

soil levels, although reduction occurred with AMA + 2,4-D applied to soil surface and with EPTC or molinate applied 5 cm below the soil surface (Tables 2-4).

All the herbicides applied at various soil depths caused significant reduction in the length of primary root, although alachlor or AMA + 2,4-D, caused greater reduction when applied to the soil surface. Atrazine, diuron, EPTC, molinate, monuron and simazine also caused similar reduction when applied 5 cm below the soil surface (Tables 2-4).

The total dry weight of seedlings was also significantly reduced by all the herbicides at various soil levels of herbicide application. However alachlor, AMA + 2,4-D, 2,4-D caused greater reduction when they were applied to the soil surface (Tables 2-4). Generally the effects of herbicides applied at 10 cm soil depth were mild.

Discussion

Herbicides applied to the soil surface caused a greater reduction in germination and subsequent growth of *E. odoratum* than when applied 5 cm or 10 cm below the soil surface. Fasidi (1975) also reported that herbicides incorporated at the upper third of a soil column were more toxic to *Chlorophora excelsa* seedlings than those of the middle and bottom thirds of the same column. Two of the herbicides, EPTC and molinate, completely inhibited seed germination when applied to the soil surface, while four herbicides, atrazine, diuron, monuron and simazine completely killed the seedlings three weeks after herbicide treatments. Germinating seeds apparently come in contact first with herbicides applied to the soil surface (because they eventually get leached to lower levels) and later with herbicides incorporated at various depths in the soil. The primary roots and absorbing surfaces of root haris of growing seedlings also come in contact with herbicides incorporated into the former than with those applied at the inner depths of soil. Herbicides incorporated into the soil may also not be taken up if they do not persist in the soil for several weeks. These factors may account for the high reduction in germination and seedling growth caused by herbicides applied to the soil surface compared with those applied 5 cm or 10 cm below the soil surface.

The herbicides which were most consistent in reduction of germination and seedling growth were atrazine, 2,4-D, diuron, EPTC, molinate, monuron and simazine. The others had generally less effect. Since *E. odoratum* seeds after dispersal are mainly lodged in the upper 2 cm portion of the soil (Yadav & Tripathi, 1982). Application of these herbicides to the soil surface of any land infested by *E. odoratum* seeds is recommended.

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