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RELATIONSHIP OF YELLOW NUTSEDGE (CYPERUS ESCULENTUS L.) CONTROL TO PERSISTENCE AND MOBILITY OF SEVERAL ACETANILIDE HERBICIDES IN THE SOIL.

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RELATIONSHIP OF YELLOW NUTSEDGE (CYPERUS ESCULENTUS L.) CONTROL TO PERSISTENCE AND MOBILITY OF SEVERAL ACETANILIDE HERBICIDES IN THE SOIL

By

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ABSTRACT

RELATIONSHIP OF YELLOW NUTSEDGE (CYPERUS ESCULENTUS L.) CONTROL TO PERSISTENCE AND MOBILITY OF SEVERAL ACETANILIDE HERBICIDES IN THE SOIL.

By

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The acetanalide herbicides alachlor [2-chloro-2',6'diethyl-N-(methoxymethyl) acetanilide], metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide], H-22234 [N-chloroacetyl-N-(2,6-di ethylphenyl)-glycine ethyl ester] and H-26910 [N-chloroacetyl-N-(2-methyl-6-ethylphenyl)-glycine isopropyl ester] at 3.5×10^{-6} M did not inhibit yellow nutsedge (*Cyperus esculentus* L.) tuber sprouting in petri dishes. The herbicides at 3.5×10^{-6} M and 3.5×10^{-7} inhibited growth of newly emerging shoots, and a dosage response was evident. The viability of yellow nutsedge sprouts decreased with increased exposure to the acetanilide compounds, however, after 192 h exposure, the tubers were not killed. In petri dish studies, there was no significant difference in activity among herbicide treatments on yellow nutsedge sprouts.

Treatments applied to the soil exhibited a significant difference in activity on yellow nutsedge. In the field, all acetanilide herbicides reduced the number of yellow nutsedge shoots per m^2, compared to the untreated control. Visual control ratings, stand density measurements, shoot dry weights, and plant heights indicate the following order of

activity on yellow nutsedge: metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234. Activity of all treatments was enhanced by incorporation into the soil and by increasing the rate. As soil organic matter and clay content levels increased, the activity of all herbicides decreased. The acetanilide compounds were effective on yellow nutsedge when applied to the soil, above or at the level of the tuber. Herbicide applied below the tuber had no significant effect upon shoot development. All treatments significantly reduced the number of yellow nutsedge shoots and consequently increased soybean yield compared to the untreated control.

Acetanilide herbicide persistence and mobility were determined in the soil. The rate of dissipation in the 0 to 8 cm soil depth for the chemicals indicated the half life of metolachlor $\geq$ H-26910 $\geq$ H22234 $\geq$ alachlor. The greatest soil persistence 8 weeks after application was exhibited by metolachlor and H-26910. Significant interactions for method of application indicated that the rate of dissipation was slower and persistence longer for soil incorporated treatments. The concentration of herbicide applied to the soil did not effect dissipation rate. However, for all dates sampled, greater residues were detected in the treatments receiving 6.72 kg/ha. Trace amounts of herbicide were detected at the 8 to 16 cm soil depth.

Movement of ^{14}C-labeled acetanilide chemicals on silica gel plates indicated increased adsorption and lower water solubility for H-22234 as compared to the other herbicides. Mobility on soil thin layer chromatography plates was as follows: metolachlor = alachlor > H-22234. All treatments exhibited a decrease in mobility as soil organic matter and clay content increased.

To Lynn the love and strength in my life.

To my mom and dad, who through their love have been my inspiration.

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INTRODUCTION

Yellow nutsedge (*Cyperus esculentus* L.) is a weed infesting all continents and ranks as a major agronomic problem in the world (20). Once confined to low wet areas, yellow nutsedge has spread at an alarming rate into upland mineral soils. Contributing to its spread are the current agronomic trends toward earlier planting, fewer tillage operations, and reduced competition from annual weeds.

Approximately 12.6% of the soybean acres, and 10.5% of the corn acres in the North Central States are infested with this weed (1). Yellow nutsedge reduces yields, escalates production and harvesting costs, and lowers crop quality. Biological, cultural, and chemical methods are employed in programs to control yellow nutsedge. However, no effective biological control is presently available; promising results have been reported with the insect *Bactra veruntana* Zeller (25). Cultural methods are a very important part of all weed control programs. Tillage operations alone can reduce the severity of the problem, but many viable tubers remain dormant in the soil and will germinate when tillage operations stop. Herbicide treatments are presently an instrumental tool in the control of yellow nutsedge in agronomic crops.

It has been reported repeatedly that the herbicide alachlor controls yellow nutsedge in corn (1) and soybeans (1). Alachlor preplant incorporated delayed sprouting of tubers and provided 6 to 12 weeks control (24). Recent advances in acetanilide chemistry have resulted in new herbicides with structures similar to alachlor. The acetanilide compounds metolachlor, H-22234, and H-26910 were developed as selective herbicides for use in corn and soybeans.

The objectives of these studies were: (1) to comparatively evaluate alachlor, metolachlor, H-22234 and H-26910 for yellow nutsedge control and ascertain the effect of method of application, rate, and soil type on their activity, (2) to evaluate the activity of these acetanilide herbicides on yellow nutsedge tuber sprouting, sprout viability and shoot development, and (3) to evaluate their persistence and mobility in the soil.

CHAPTER 1

COMPARATIVE EVALUATION OF SEVERAL ACETANILIDE HERBICIDES FOR THE CONTROL OF YELLOW NUTSEDGE (*CYPERUS ESCULENTUS*)

ABSTRACT

The acetanilide compounds alachlor [2-chloro-2',6'-diethyl-*N*-(methoxymethyl) acetanilide], metolachlor [2-chloro-*N*-2-ethyl-6-methly-phenyl)-*N*-(2-methoxyl-methylethyl) acetamide], H-22234 (*N*-chloroacetyl-*N*-(2,6-di ethylphenyl)-glycine ethyl ester] and H-26910 [*N*-chloroacetyl-*N*-(2-methyl-6-ethylphenyl)-glycine isopropyl ester] are selective pre-emergence herbicides for use in corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.). Field studies were initiated in 1975, 1976, and 1977 to comparatively evaluate these acetanilide herbicides for yellow nutsedge (*Cyperus esculentus* L.) control and determine the effect of method of application, rate, and soil type upon their activity. All treatments evaluated reduced number of shoots per m^2 compared to the untreated control 8 weeks after application. Yellow nutsedge shoots emerged, late in the season in all treatments, for one or more locations, during at least one year. The break in control coincided with reduced precipitation for that location and year. Visual control ratings and stand density 8 weeks after application indicated that these herbicides have the following order of activity: metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234,

depending upon location and year. Activity of all treatments on yellow nutsedge was enhanced by incorporation into the soil and by increasing the rate. As soil organic matter and clay content levels increased, the activity of all acetanilide herbicides decreased. After 8 weeks, the yellow nutsedge shoots which received the metolachlor treatments significantly shorter in height than all other treatments. Evaluating shoot dry weight reduction, herbicide activity was of the following order: metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234. All acetanilide herbicide treatments significantly reduced the number of yellow nutsedge shoots and consequently increased soybean yield compared to the untreated control.

INTRODUCTION

Yellow nutsedge ranks as one of the major weed problems in the world (6). Once confined to low wet areas, yellow nutsedge can now be found in upland mineral soils. Within the past 5 years, the acres in corn and soybean infested by yellow nutsedge have significantly increased (2,5). Present agronomic trends toward earlier planting, fewer tillage operations, and reduced competition from annual weeds have contributed to its spread (2).

Yellow nutsedge is a perennial sedge capable of reproducing by seed and tubers. The primary means of propagation in cultivated fields is by tubers formed at the tip of rhizomes (4,10). Tubers developed during the summer lie dormant in the soil until extended cold periods and leaching water break their dormancy. As a tuber germinates, one or more rhizomes elongate from the tuber buds, the rhizome then develops a basal bulb and subsequent parent plant. Each parent plant is capable of producing 40 to 50 daughter plants and 300 to 500 tubers in 16 weeks. In 1 year this tuber has spread to an area containing 1900 plants and approximately 7000 tubers (11).

It has been reported that alachlor controls yellow nutsedge in corn (1,3) and soybean (1,7,9). Preplant incorporated application of alachlor delayed sprouting of tubers and provided 6 to 12 weeks control, but failed to kill tubers (8). Tubers appeared to escape injury by failing to sprout until activity of the herbicide had substantially dissipated (8). Incorporation of alachlor just before planting effectively controlled yellow nutsedge, whereas preemergence applications were dependent upon rainfall and only moderately successful.

Recent advances in acetanilide chemistry have resulted in new herbicides with structures similar to alachlor. The acetanilide compounds alachlor, metolachlor, H-22234, and H-26910 were developed as selective herbicides for use in corn and soybeans. The objectives of this study were to comparatively evaluate the acetanilide herbicides for yellow nutsedge control and ascertain the effect that the method of application, rate, and soil type have on their activity.

MATERIALS AND METHODS

For the comparative evaluation, the acetanilide herbicides alachlor, metolachlor, H-22234, and H-26910 were applied preplant incorporated or preemergence at 3.36 kg/ha and 6.72 kg/ha. Several locations in Michigan were selected for soil texture, soil organic matter content, and degree of yellow nutsedge infestation during 1975, 1976, and 1977 (Table 1). All locations were planted to corn or soybeans (Table 1). Treatments were applied with a tractor mounted sprayed delivering 215 l/ha to 3 by 12 meter plots. Crops were planted with rows spaced 76.2 cm apart with four rows per plot. The preplant incorporated treatments were incorporated within 15 min after application with a spring tooth harrow, twice in opposite directions. Rainfall following herbicide application is shown in Table 2.

A randomized complete block design was utilized with four replications at Location I and three replications at Locations II and III. The major weed species at all locations was yellow nutsedge and the infestations were the result of natural selection. Field plots were hand weeded throughout the growing season to eliminate competitive effects from other weed species.

Visual control ratings were taken 4, 8, and 12 weeks after application on a percentage basis with 0 = no control and 100 = complete control. The two middle rows of each four row plot were rated. Yellow nutsedge stand density was recorded 2, 4, and 8 weeks after application to evaluate the development of the yellow nutsedge population. Stand density counts were taken for 3 m^2 between the two middle rows. Yellow nutsedge shoot height and shoot dry weight were recorded for location I, 8 weeks after treatment. The yellow nutsedge shoots were harvested from 3 m^2 between two middle rows, dried, and weighed. Soybeans from location I were harvested October 3 in 1975, October 5 in 1976, and October 10 in 1977. Six meters of the two middle rows were pulled, thrashed, dried to 13% moisture, and weighed.

RESULTS AND DISCUSSION

Visual control ratings were used as a measure of treatment efficacy. At location I, alachlor and metolachlor provided equal control of yellow nutsedge and were more effective than H-22234 during 1975 (Table 2). In 1976, there was a significant herbicide by method of application interaction. Preplant incorporated metolachlor and alachlor, and preemergence applied metolachlor, were the most effective treatments providing equal control of yellow nutsedge. During 1977, the most effective treatment was metolachlor with 92% control. Visual control ratings for location II during 1976 indicated that metolachlor was the most effective treatment. In 1977, metolachlor and alachlor provided equal yellow nutsedge control, and were more effective than H-26910 or H-22234. At location III, during 1976 and 1977, metolachlor was the most effective treatment, with alachlor being equally effective during 1977. Treatments exhibited a decrease in herbicidal activity from 1976 to 1977 at locations II and III. The drop in yellow nutsedge control during 1977 corresponds to the low levels of rainfall received after application for both locations (Table 2). Evaluating the herbicides within all locations, metolachlor consistently provided the most effective yellow nutsedge control. Alachlor and H-26910 were intermediate in activity, while H-22234 was consistently poor.

A comparison of the main effects for herbicides on stand density supported the conclusion obtained from visual control ratings (Table 3). At location I during 1976 and 1977, treatments that provided equally effective control of yellow nutsedge stand density were metolachlor, alachlor, and H-26910. At location II during 1976, reduction in stand density by the herbicide treatments was in the order: metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234. Metolachlor and alachlor provided equal and effective control during 1977. At location III during 1976 and 1977, the greatest reduction in stand density resulted from metolachlor treatment; alachlor was equally effective during 1977.

The level of organic matter of the soils varied from 2.5% at location I to 6.0% at location III. Clay contents of the soils were 27.8% at location I, and 35.8% at locations II and III. The herbicide's main effect was compared across locations (Table 4). All treatments were more effective at the lowest percent soil organic matter and clay content; effectiveness significantly decreased as the percent organic matter and clay content in the soil increased.

Visual control ratings at location I during 1975 and 1977 showed no significant difference between preplant incorporated or preemergence applications (Table 3). During 1976, there was a significant herbicide by method of application interaction, and it was observed that alachlor, H-26910, and H-22234 exhibited increased yellow nutsedge control when incorporated into the soil. The decrease in herbicide activity for preemergence treatments during 1976 corresponds with the low level of precipitation received 0 to 2 weeks after application (Table 2). At location II there was no significant difference between methods of application during 1976. However, in 1977, the soil incorporated treatments exhibited greater control of yellow nutsedge. The decrease in visual control rating for preemergence treatments during 1977 corresponds with low levels of precipitation received after application. At location III, for both years, evaluated treatments showed increased activity when soil incorporated. Visual control ratings indicated that soil incorporated acetanilide herbicides consistently provided effective control within each location. The preemergence applications provided effective control on soil low in organic matter content, and when rainfall was received after application. Measurement of stand density provided information that reinforced visual observation. Incorporation of the herbicide into the soil increased yellow nutsedge control at all locations during 1976 and 1977.

The visual control ratings indicated a significant increase in yellow nutsedge control from the higher application rates at locations I and II (Table 3). The rate effect was not observed at location III. The stand density measurements indicated a significant rate effect for all locations and years. The 2x rate, 6.72 kg/ha, provided greater yellow nutsedge control than 3.36 kg/ha.

From the visual control ratings and stand density measurements, it appeared that the activity of the acetanilide herbicides on yellow nutsedge was enhanced by soil incorporation, higher application rates, or when the chemicals were applied to soils containing low levels of organic matter and clay.

Yellow nutsedge stand density was monitored during the season to assess population development in the untreated control and to ascertain the effect chemical treatments exert on shoot emergence. The stand density data for the untreated control for all locations and years indicated that yellow nutsedge emerged rapidly during the 2 weeks after application and continued to emerge for the next 8 weeks (Table 5). Therefore, in order to provide effective control, treatments must exert activity throughout this time period. Following statistical analysis and evaluation of significant main effects, it was evident that all herbicide treatments, for all locations and years evaluated, resulted in fewer shoots per m^2 than the untreated control 8 weeks after application (Table 5). Metolachlor exhibited the most effective and consistent control for all locations and years 8 weeks after application. Alachlor activity on yellow nutsedge was $\leq$ metolachlor and $\geq$ H-26910. H-22234 provided the least control of shoot density for all locations and years.

H-22234 at location I during 1976 exhibited a break in activity as evidenced by the increase in number of shoots 2 to 8 weeks after application. During 1977, alachlor and H-22234 at all locations, H-26910 at locations II and III, and metolachlor at location II, lost part of their effectiveness during the evaluation period as shown by the increase in shoots 2 to 8 weeks after treatment. During 1977, the yellow nutsedge population in the untreated controls at all locations exhibited an increase in stand density 4 to 8 weeks after experiment initiation. The herbicide treatments were unable to control this late season shoot emergence. The loss of activity in 1977 at location II and III corresponds with low initial rainfall, which may have facilitated herbicide dissipation.

Yellow nutsedge plant height and shoot dry weight were measured for location I to assess herbicide effect on yellow nutsedge plant growth. During 1976 and 1977, the yellow nutsedge shoots in the metolachlor treatments were significantly shorter in height after 8 weeks, 54 and 56% of control, than all other treatments (Table 6). Shoot dry weight reflected plant height (Table 6). There was a significant herbicide by method of application interaction for shoot dry weight during 1976. The treatments showing the greatest reduction in yellow nutsedge shoot dry weight were preplant incorporated metolachlor and alachlor, and preemergence applied metolachlor. The treatment resulting in the least shoot dry matter during 1977 was metolachlor. Yellow nutsedge plant height and shoot dry weight was significantly reduced when treatments were applied preplant incorporated during 1977 or when applied at higher rates during 1976 and 1977.

Evaluating the acetanilide herbicides with visual ratings, plant height, and shoot dry weight indicated that yellow nutsedge control with metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234, at location I.

The acetanilide herbicides were effective in reducing weed pressure and increasing soybean yield during 1975, 1976, and 1977 (Table 6). During 1976 there was no significant difference in soybean yield among the chemical treatments. However, H-22234, during 1975 and 1976, was less effective in controlling yellow nutsedge as reflected by lower soybean yields. Across the 3 years at location I, it appears that treatments providing $\geq$ 70% visual control of yellow nutsedge consistently increased soybean yield versus the weedy control, and that there was no significant difference among these treatments.

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Table 1. Soil characteristics, crops, and planting dates for the comparative evaluation of acetanilide herbicides at three locations in Michigan.

Location	County	Soil texture	Organic matter (%)	Crop	Variety	Planting date		
						1975	1976	1977
I	Ingham	Sandy clay loam	2.5	Soybean	Swift	5/28	5/26	5/26
II	Clinton	Clay loam	4.1	Soybean	Swift		6/1	5/21
III	Eaton	Sandy clay loam	6.0	Corn	Michigan 396		6/8	5/20

Table 2. Accumulative precipitation (cm) for 8 weeks after herbicide application in 1975, 1976, and 1977.

Location	Year	Weeks after application							
		1	2	3	4	5	6	7	8
		(cm)							
I	1975	1.6	3.8	6.0	7.2	7.2	8.7	9.7	11.4
	1976	1.0	1.0	1.4	4.2	10.6	13.9	14.3	15.6
	1977	0.8	1.3	1.9	5.0	5.0	8.4	8.4	11.2
II	1975	0.3	0.3	4.0	5.3	15.5	15.6	15.9	16.6
	1977	0.0	2.3	4.6	6.2	6.3	9.8	11.0	11.0
III	1976	2.7	3.8	4.3	7.9	8.1	8.5	11.3	12.4
	1977	0.8	0.9	3.8	5.8	7.2	11.0	13.2	13.2

Table 3. Comparative evaluation of several acetanilide herbicides for the control of yellow nutsedge 8 weeks after application.[c]

Main and interaction effects	Location I					Location II				Location III			
	1975	1976		1977		1976		1977		1976		1977	
	Visual[a] control rating	Visual control rating	Stand[b] density	Visual control rating	Stand density	Visual control rating	Stand density	Visual control rating	Stand density	Visual control rating	Stand density	Visual control rating	Stand density
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Herbicide													
Metolachlor	90 b		28 a	92 c	6 a	75 c	25 a	65 b	23 a	59 c	20 a	49 b	49 a
Alachlor	83 b		28 a	79 b	11 a	61 b	33 ab	63 b	22 a	42 b	36 b	35 b	56 a
H-26910			39 a	82 b	9 a	62 ab	41 bc	50 a	33 b	34 ab	35 b	26 a	70 b
H-22234	58 a		56 b	65 a	39 b	53 a	47 c	43 a	46 c	28 a	45 c	23 a	71 b
Application method													
Preplant incorporated	76 a		29 a	81 a	9 b	61 a	31 a	65 b	20 a	57 b	26 a	41 b	43 a
Preemergence	77 a		47 b	78 a	22 b	64 a	41 b	45 a	42 b	27 a	42 b	25 a	80 b
Rate													
3.36 kg/ha	72 a	65 a	42 b	74 a	23 b	56 a	40 b	50 a	38 b	40 a	43 b	28 a	68 b
6.72 kg/ha	82 b	77 b	33 a	86 b	8 a	69 b	33 a	61 b	24 a	45 a	25 a	38 a	55 a
Herbicide x method of application													
Preplant incorporated													
Metolachlor		85 e											
Alachlor		84 e											
H-26910		73 cd											
H-22234		48 a											
Preemergence													
Metolachlor		84 e											
Alachlor		74 d											
H-26910		58 b											
H-22234		65 bc											

[a]Visual ratings are expressed on a percentage basis with 0 = no control and 100 = complete control.

[b]Stand density is expressed shoots/m^2 as a percent of control.

[c]Means within a column and main or interaction effect followed by common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 4. Activity of several acetanilide herbicides on yellow nutsedge at three locations in Michigan 8 weeks after application.

	Percent yellow nutsedge control[ab]		
Treatment	Location I sandy clay loam 2.5% OM	Location II clay loam 4.1% OM	Location III sandy clay loam 6.0% OM
Metolachlor	90 g	71 e	57 d
Alachlor	80 f	62 d	38 b
H-26910	75 ef	55 cd	30 ab
H-22234	61 d	47 c	25 a

[a]Values are mean of two years, two rates, two methods of application.

[b]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 5. Yellow nutsedge stand density, shoots per square meter, 2, 4, and 8 weeks after application for 1976 and 1977.

Location	Treatment	1976 Weeks after application			1977 Weeks after application		
		(shoots/m^2)^{ab}			(shoots/m^2)^{ab}		
I	Metolachlor	126 bcd	139 bcd	85 ab	12 ab	17 bcd	6 a
	Alachlor	91 ab	108 abc	94 ab	16 bc	19 bcd	28 d
	H-26910	157 cde	172 de	110 abc	21 bcd	27 cd	20 bcd
	H-22234	131 bcd	201 e	197 e	21 bcd	58 e	89 f
	Control	250 e	368 f	392 f	55 e	166 g	270 h
II	Metolachlor	125 ab	140 ab	112 a	87 a	102 a	162 b
	Alachlor	140 b	161 b	177 bc	93 a	120 a	201 b
	H-26910	175 bc	205 bc	160 b	95 a	147 h	260 c
	H-22234	180 bc	206 bc	247 c	118 a	148 h	297 c
	Control	293 c	560 d	626 d	271 c	383 cd	695 d
III	Metolachlor	75 abc	33 a	46 a	122 abc	170 bcd	166 bcd
	Alachlor	64 abc	53 abc	81 bc	83 a	101 ab	185 bcd
	H-26910	101 cd	61 abc	70 bc	183 bcd	209 cde	250 e
	H-22234	80 bc	52 abc	89 bcd	165 bcd	178 bcd	316 e
	Control	177 de	140 ef	215 f	132 abc	237 de	552 f

[a] Values are mean of two rates, two methods of application with four replications for location I and three replications for locations II and III.

[b] Means within year and location with common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 6. Effect of several acetanilide herbicides on yellow nutsedge plant height, shoot dry weight, and soybean yield at location I, 8 weeks after application.[a]

Main and interaction effects	1975 Soybean yield	1976 Plant ht	1976 Shoot dry wt	1976 Soybean yield	1977 Plant ht	1977 Shoot dry wt	1977 Soybean yield
	(kg/ha)	(% of control)		(kg/ha)	(% of control)		(kg/ha)
Herbicide							
Metolachlor	2230 c	54 a		1990 b	56 a	2 a	2260 c
Alachlor	2250 c	81 c		1980 b	80 c	15 b	2050 bc
H-26910		71 b		1840 b	70 b	14 b	2060 bc
H-22234	1920 b	83 c		900 a			1700 a
Application method							
Preplant incorporated	1800 a	71 a		1800 a	67 a	12 a	1850 a
Preemergence	1900 a	72 a		1900 a	79 b	19 b	1450 a
Rate							
3.36 kg/ha	1800 a	75 b	32 b	1800 a	77 b	24 b	1500 a
6.72 kg/ha	1900 a	69 a	25 a	2000 a	69 a	8 a	1498 a
Herbicide x method of application							
Preplant incorporated							
Metolachlor			13 a				
Alachlor			17 a				
H-26910			30 b				
H-22234			42 c				

[a]Values within a column and main or interaction effect followed by common letters are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 6. (continued).

Main and interaction effects	1975 Soybean yield	1976 Plant ht	1976 Shoot dry wt	1976 Soybean yield	1977 Plant ht	1977 Shoot dry wt	1977 Soybean yield
	(kg/ha)	(% of control)		(kg/ha)	(% of control)		(kg/ha)
Preemergence							
Metolachlor			17 a				
Alachlor			38 bc				
H-26910			38 bc				
H-22234			34 bc				

CHAPTER 2

ACTIVITY OF FOUR ACETANILIDE HERBICIDES ON YELLOW NUTSEDGE (*CYPERUS ESCULENTUS* L.)

ABSTRACT

The acetanilide herbicides alachlor [2-chloro-2',6'-diethyl-*N*-(methoxymethyl) acetanilide], metolachlor [2-chloro-*N*-ethyl-6-methyl-phenyl)-*N*-(2-methoxy-1-methylethyl) acetamide], H-22234 [*N*-chloroacetyl-*N*-(2,6,-diethylphenyl)-glycine ethyl ester] and H-26910 [*N*-chloroacetyl-*N*-(2-methyl-6-ethylphenyl)-glycine isopropyl ester] at 3.5×10^{-6} M did not inhibit yellow nutsedge (*Cyperus esculentus* L.) tuber sprouting in petri dishes. The herbicides at 3.5×10^{-6} M and 3.5×10^{-7} inhibited growth of newly emerging shoots. The viability of yellow nutsedge sprouts decreased with increased exposure to the acetanilide compounds, however, after 192 h exposure, the tubers were not killed. In petri dish studies, there was no significant difference in activity among alachlor, metolachlor, H-22234, and H-26910 on yellow nutsedge sprouts. Treatments applied to the soil exhibited a significant difference in activity on yellow nutsedge. Metolachlor activity = alachlor $\geq$ H-26910 $\geq$ H-22234, depending on the percent organic matter in the soil. For all herbicides evaluated, activity decreased with increased levels of organic matter in the soil. For acetanilide herbicides to be effective on yellow

nutsedge they must be in the soil zone, above or at the level of the tuber.

INTRODUCTION

Herbicide treatments applied to corn (Zea mays L.) for the control of yellow nutsedge include EPTC (S-ethyl dipropylthiocarbamate] (3), butylate [S-ethyl diidobutylthiocarbamate] (10), atrazine [2-chloro-4-ethylamino)-6-(isopropylamine)-s-triazine] (10), and alachlor [2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide] (2). Herbicides applied to soybean (Glycine max (L.) Merr.) which control yellow nutsedge are vernolate [S-propyl dipropylthiocarbamate] (12), bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-4-(3H)-one 2,2-dioxide] (6,13) and alachlor. Several reports indicate that the thiocarbamates do not inhibit yellow nutsedge sprouting or kill the tuber (7,9). EPTC effectively suppresses and delays shoot emergence, the delay depending upon rate of application (7,9). The herbicide atrazine does not delay sprouting of yellow nutsedge, but kills the shoots after emergence (9). Alachlor inhibits growth of newly emerging shoots, but fails to kill the tuber or inhibit sprouting (2,9).

The placement of a herbicide in the soil has a significant effect upon its activity in the field. Knake and Wax (11) found that EPTC was lethal to green foxtail (Setaria viridis (L.) Beauv.) when placed in the soil shoot zone but not when placed in the root zone. Butylate placed in the tuber zone was effective in suppressing yellow nutsedge shoot growth and tuber sprouting, but was ineffective when incorporated in the soil above or below the tuber (8). Alachlor controlled yellow nutsedge when applied above the tuber (1,8).

The role of soil organic matter on the adsorption and reduction of phytotoxicity of herbicides has been reviewed (14,15). As soil organic matter content increased, higher rates of atrazine were necessary for effective weed control (4,5). Alachlor controlled yellow nutsedge in soil with less than 6% organic matter (2).

Recently, new herbicides with structures similar to alachlor have been introduced. The acetanilide compounds metolachlor, H-22234, and H-26910 were developed as selective herbicides for use in corn and soybeans. The objectives of this study were to evaluate and compare activity of alachlor, metolachlor, H-22234, and H-26910 on yellow nutsedge tuber sprouting, sprout viability, and shoot development, to evaluate the activity of the acetanilide herbicides in the soil, and to determine the effect percent organic matter and soil placement have upon their activity.

MATERIALS AND METHODS

Yellow nutsedge tubers harvested from the field in East Lansing, Michigan were utilized for greenhouse and laboratory studies. The effect of acetanilide herbicides on tuber sprouting was evaluated in the laboratory by placing ten tubers in a petri dish with 20 ml of 3.5×10^{-6} M alachlor, metolachlor, H-22234, and H-26910. Petri dishes were placed in a germination chamber at 22C in complete darkness. Seven days after treatment, tubers were examined for number of emerging shoots and rhizomes. Acetanilide activity on shoot elongation was evaluated by exposing one pre sprouted tuber to 3.5×10^{-6} M, 10^{-7} M, and 10^{-8} M concentrations of alachlor, metolachlor, H-22234, and H-26910 in petri dishes placed in a dark chamber at 22C. Shoot length was recorded after 5 days. The effect of exposure time on sprout viability and shoot development was determined by placing one pre sprouted tuber in a petri dish containing 3.5 x 10^{-6} M alachlor, metolachlor, H-22234, H-26910 for 0, 12, 24, 48, 96, and 192 h. After each exposure period shoot length was recorded; tubers were rinsed for 5 min with distilled water and placed in a petri dish containing only distilled water. Ten days after rinsing, sprout viability and shoot length were recorded. Sprout viability was assessed on the resumption of shoot growth. Treatments were maintained in a dark chamber at 22C throughout the duration of the study.

The effect of percent organic matter in the soil on acetanilide herbicide activity was evaluated in the greenhouse with soil mixtures made with a Conover sandy loam soil 1.7% organic matter, 65.9% sand, 20.6% silt, 13.5% clay, and a muck soil with 81.4% organic matter. Quantities of each soil were mixed in volume ratios to obtain 1.7, 3.2, 5.6, 10.1, and 61.1 percent organic matter. Prior to treating the soil with herbicides, one pre sprouted tuber was planted 3.5 cm below the soil surface. Alachlor, metolachlor, H-22234, and H-26910 were sprayed at 3.36 kg/ha to the soil surface. After herbicide application, all treatments were surface irrigated and maintained in the greenhouse with supplemental flourescent lighting for a 16 h day. Soil placement studies utilized a charcoal barrier to separate herbicide treated soil from untreated soil. Alachlor, metolachlor, H-22234, and H-26910 were sprayed at 3.36 kg/ha on a sandy loam soil and incorporated as a batch mix with a portable cement mixer. One pre sprouted tuber was placed in a 1.5 cm band of charcoal for the above and below tuber herbicide treatments. The charcoal barrier was absent for treatments placing the herbicide at the level of the tuber. Predetermined portions of the treated soil were used to establish a 2.5 cm layer of soil above the tuber, with the tuber, or below the tuber. All treatments were surface irrigated and placed in the greenhouse with supplemental lighting for a 16 h day. Yellow nutsedge plants in the organic matter and soil placement studies were harvested, dried, and weighed 6 weeks after application.

All laboratory and greenhouse studies were in a randomized complete block design with four replications. All values presented are the means of two experiments with four replications each.

RESULTS AND DISCUSSION

Yellow nutsedge tuber sprouting was not significantly affected by 3.5×10^{-6} M concentrations of alachlor, metolachlor, H-22234, or H-26910 (Table 1). Exposure of yellow nutsedge sprouts to 3.5×10^{-6} M, 10^{-7} M, 10^{-8} M concentrations of the acetanilide herbicides caused significant inhibition of shoot elongation (Table 2). A dosage response was evident. Yellow nutsedge sprouts exposed to the acetanilide herbicides from 0 to 192 h showed a decrease in sprout viability with increased exposure time (Table 3). However, after 192 h, more than 20% of the tubers were still alive as evidenced by shoot growth. All herbicide treatments inhibited shoot length after each exposure period (Table 4). However, after rinsing the tubers in distilled water, all treatments resumed growth. The shoot regrowth suggests that yellow nutsedge tubers can withstand exposure to the acetanilide herbicides over an extended period of time. Once chemical pressure was removed, the yellow nutsedge plants were capable of continuing their development. There was a decrease in shoot length for all herbicide treatments as exposure time increased. The reduced shoot length coincided with the lower number of viable sprouts following 192 h exposure (Table 3). There were no significant differences among the acetanilide herbicides with respect to their activity on yellow nutsedge tuber sprouting, viability, or shoot elongation in petri dishes.

All herbicide treatments showed a decrease in yellow nutsedge control as the soil organic matter increased (Figure 1). Metolachlor, alachlor, and H-26910 showed equal activity which was greater than H-22234 on the sandy loam soil with 1.7% and 3.2% organic matter (Table 5). As soil organic matter level increased to 5.6% and 10.1%, acetanilide herbicide activity on yellow nutsedge followed in the order: metolachlor = alachlor > H-26910 > H-22234. Herbicide treatments applied to the soil with 61.1% organic matter had little activity on yellow nutsedge, with metolachlor control ≥ alachlor ≥ H-26910 ≥ H-22234 (Table 5). Treatments applied above or at the level of the tuber controlled yellow nutsedge shoot growth (Figure 2). Herbicide treatments applied below the tuber had no significant effect upon shoot development (Table 6). As the yellow nutsedge tuber sprouted, it sent up a rhizome which formed a basal bulb below the soil surface from which originated vegetative shoots, roots, and rhizomes. During the 6 week period following application, yellow nutsedge roots grew but did not penetrate the treated soil zone (Figure 3). This development pattern for yellow nutsedge provided no intimate contact between plant and herbicide treatments applied below the tuber.

Alachlor, metolachlor, H-22234, and H-26910 did not prevent yellow nutsedge tuber sprouting or kill the tuber. However, they inhibited shoot elongation when in contact with the sprout. To be effective in the field, the acetanilide herbicides must be applied to soils low in organic matter and be present in the soil zone above, or at the level of, the tuber. To successfully inhibit yellow nutsedge shoot development, these herbicides must be present at a phytotoxic concentration for an extended period of time.

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Table 1. Effect of 3.5 x 10^{-6} M acetanilide herbicide on yellow nutsedge tuber sprouting after 7 days exposure.

Treatment	Percent sprouting[a]
Metolachlor	34.0 a
Alachlor	36.3 a
H-26910	40.0 a
H-22234	41.2 a
Control	41.3 a

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 2. Effect of several acetanilide herbicides on yellow nutsedge shoot elongation after 5 days exposure.

Treatment	Herbicide concentration (3.5 x) 10^{-6} M	10^{-7} M	10^{-8} M
		(mm/shoot)[a]	
Metolachlor	3.2 a	12.1 b	28.8 cd
Alachlor	3.6 a	12.3 b	30.9 cd
H-26910	3.2 a	16.3 b	30.5 cd
H-22234	3.6 a	15.3 b	28.1 c
Control	36.4 d	33.0 cd	30.1 cd

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 3. Effect of exposure time of tubers and sprouts to 3.5×10^{-6} M acetanilide herbicides on yellow nutsedge sprout viability.

Treatment	Exposure time (h)					
	0	12	24	48	96	192
			(% viable)[a]			
Metolachlor	100 c	100 c	100 c	50 ab	38 ab	25 a
Alachlor	100 c	100 c	100 c	75 bc	50 ab	23 a
H-26910	100 c	100 c	100 c	50 ab	63 ab	23 a
H-22234	100 c	100 c	100 c	75 bc	37 ab	25 a

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 4. Effect of exposure time of tubers and sprouts to 3.5×10^{-6} M acetanilide herbicides on yellow nutsedge shoot length.

	Exposure time (h)											
	0		12		24		48		96		192	
Treatment	AE[a]	AR[b]	AE	AR	AE	AR	AE	AR	AE	AR	AE	AR
	(mm/shoot)[c]											
Metolachlor	5 a	114 de	9 a	141 e	8 a	138 de	9 a	66 cde	2 a	38 bc	5 a	36 bc
Alachlor	7 a	115 de	8 a	136 de	7 a	125 de	6 a	123 de	7 a	64 cde	4 a	18 b
H-26910	5 a	114 de	7 a	130 de	5 a	144 e	8 a	79 cde	8 a	76 cde	2 a	19 bc
H-22234	8 a	121 de	3 a	136 de	7 a	143 e	5 a	114 de	9 a	50 bcd	6 a	35 bc

[a]AE designates shoot length after 0 to 192 h exposure to the acetanilide herbicides.

[b]AR designates shoot length 10 days after removing tuber from exposure and rinsing in distilled water.

[c]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 5. Dry weight of yellow nutsedge shoots 6 weeks after treatment with 3.36 kg/ha acetanilide herbicides applied to soils with various levels of organic matter.

Treatment	Percent soil organic matter				
	1.7	3.2	5.6	10.1	61.1
	(shoot dry wt. expressed as % of control)[a]				
Metolachlor	0 a	0.7 ab	3.8 c	11.2 d	71.0 g
Alachlor	0 a	0.5 ab	5.5 c	11.2 d	77.0 gh
H-26910	0 a	0.8 ab	18.0 de	26.7 e	92.5 hi
H-22234	2.2 bc	12.0 d	47.2 f	86.5 ghi	100.0 i

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Table 6. Yellow nutsedge shoot dry weight 6 weeks after treatment, when exposed to 3.36 kg/ha acetanilide herbicide at varied placement in the soil.

Treatment	Herbicide placement		
	Above tuber	On tuber	Below tuber
		(gm/plant)[a]	
Metolachlor	0.0 a	0.0 a	1.1 b
Alachlor	0.0 a	0.0 a	1.0 b
H-26910	0.0 a	0.0 a	0.9 b
H-22234	0.1 a	0.2 a	0.9 b
Control	1.4 b	1.4 b	1.4 b

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Figure 1. Yellow nutsedge shoot development, 6 weeks after treatment with 3.36 kg/ha (B) alachlor, (C) metolachlor, (D) H-26910, (E) H-22234, applied to soils with various levels of organic matter.

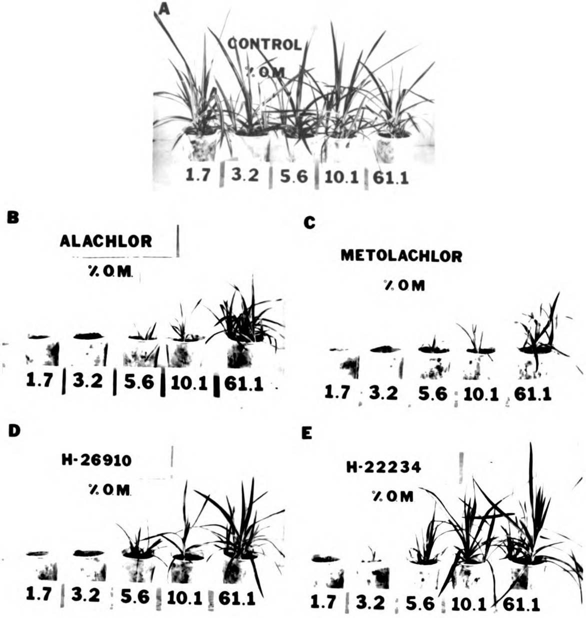
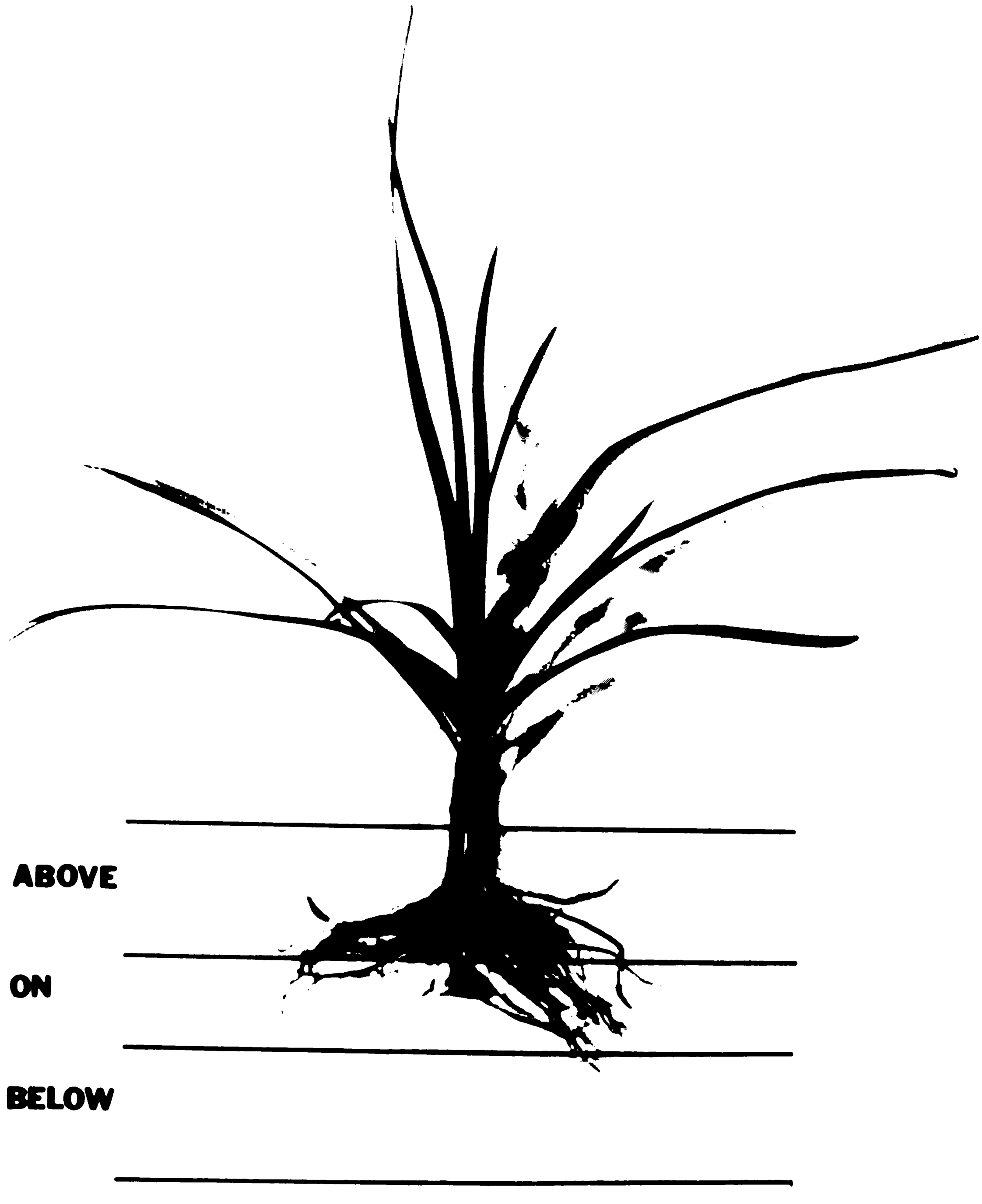

A
CONTROL
% O.M.
1.7
3.2
5.6
10.1
61.1
B
ALACHLOR
% O.M.
1.7
3.2
5.6
10.1
61.1
C
METOLACHLOR
% O.M.
1.7
3.2
5.6
10.1
61.1
D
H-26910
% O.M.
1.7
3.2
5.6
10.1
61.1
E
H-22234
% O.M.
1.7
3.2
5.6
10.1
61.1

Figure 2. Yellow nutsedge development, 6 weeks after treatment with 3.36 kg/ha acetanilide herbicide applied to soil above the tuber, on the tuber, or below the tuber.

ABOVE | ON BELOW

Figure 3. Yellow nutsedge shoot, root, and rhizome development in the soil, 6 weeks after tuber germination.


ABOVE
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CHAPTER 3

PERSISTENCE AND MOBILITY OF SEVERAL ACETANILIDE HERBICIDES IN THREE MICHIGAN SOILS.

ABSTRACT

The acetanilide herbicides alachlor [2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide], metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide], H-22234 [N-chloroacetyl-N-(2,6,-diethylphenyl-glycine ethyl ester], and H-26910 [N-chloroacetyl-N-(2-methyl-6-ethylphenyl)-glycine isopropyl ester] were applied preplant incorporated or preemergence at 3.36 kg/ha and 6.72 kg/ha at three locations in Michigan. The rate of dissipation in the 0 to 8 cm soil depth for the herbicides indicated the half life of metolachlor ≥ H-26910 ≥ H-22234 ≥ alachlor. The greatest soil persistence 8 weeks after application was exhibited by metolachlor and H-26910 for all years and locations evaluated. Significant interactions for method of application indicated that the rate of dissipation was slower and persistence was longer for soil incorporated treatments. The concentration of herbicide applied to the soil did not effect dissipation rate. However, for all dates sampled, greater residues were detected in the treatments receiving 6.72 kg/ha. Trace amounts of herbicide were detected at the 8 to 16 cm soil depth. Movement of the acetanilide chemicals on silica gel plates

indicated increased adsorption and lower water solubility for H-22234 as compared to the other herbicides. Mobility on soil thin layer chromatography plates was as follows: metolachlor = alachlor > H-22234. All treatments exhibited a decrease in mobility as soil organic matter and clay content increased. There was no significant difference amont treatments with respect to their lateral diffusion on soil thin layer chromatography plates.

INTRODUCTION

The acetanilide herbicides alachlor, metolachlor, H-22234, and H-26910 were developed as selective preemergence herbicides for use in corn (Zea mays L.) and soybean (Glycine max (L.) Merr.). It has been reported that these compounds provide yellow nutsedge (Cyperus esculentus L.) control (1,3,8,13,19). Keely and Thullen (14) report that alachlor delayed sprouting of yellow nutsedge tubers and provided 6 to 12 weeks control, but failed to kill tubers. Tubers appears to escape injury by failing to sprout until activity of the herbicide had substantially dissipated. Alachlor inhibited shoot development; however, when its pressure was removed, shoots resumed growth (1,14).

Knowledge of persistence and distribution of a herbicide in the soil is desirable for predicting its effectiveness. Herbicides should have sufficient residual activity to maintain weed control, then decompose to harmless products. The movement of chemicals in the soil is important because it results in their placement in the soil horizon. Movement of a herbicide in the soil may result in enhanced or diminished weed control, depending upon the nature of its movement. Soil applied herbicides should have sufficient mobility to move into the soil, around germinating weeds.

The acetanilide herbicides are used extensively in the United States, their effectiveness on yellow nutsedge being dependent on their presence in the soil (14). In the laboratory, alachlor degradation in the soil by microbial (4,5,6,16,17) and physical (9) mechanisms has been evaluated. Chou (6,7) and Beestman and Deming (4) report the half life of alachlor to be 2 to 14 days. Information available on the persistence and mobility of the acetanilide herbicides in the field is limited. The objectives of this study were to evaluate the persistence and mobility of alachlor, metolachlor, H-22234, and H-26910 in the field and to compare their movement in the same soil under controlled laboratory conditions.

MATERIALS AND METHODS

Field studies were designed to evaluate the persistence and mobility of several acetanilide herbicides in the soil. Alachlor, metolachlor, H-22234, and H-26910 were applied preplant incorporated or preemergence at 3.36 kg/ha and 6.72 kg/ha. Several locations in Michigan were selected for soil texture, soil organic matter content, and degree of yellow nutsedge infestation during 1976 and 1977 (Table 1). Location I, in Ingham county, was planted to 'Swift' soybeans and treatments applied May 26 during 1976 and 1977. Location II, in Clinton county, was planted to 'Swift' soybeans and treatments applied June 1 in 1976 and May 21 in 1977. Location III, in Eaton county, was planted to 'Michigan 396' corn and treatments applied June 8 in 1976 and May 20 in 1977. Treatments were applied with a tractor mounted sprayer delivering 215 l/ha to 3 by 12 meter plots. Crops were planted with rows spaced 76.2 cm apart with

4 rows per plot. The preplant incorporated treatments were incorporated, within 15 min after application, with a spring tooth harrow, twice in opposite directions. Precipitation data following application is provided in Table 2. A randomized block design with three replications was utilized at all locations.

Soil samples were taken from the 0 to 8 cm depth, 0, 2, 4, and 8 weeks after application. Fifteen samples per plot were taken between the two middle rows. Soil samples were prepared for extraction by thoroughly mixing and passing through a 2 mm screen. One hundred gram samples of soil were moistened with water to form a slurry and let equilibrate 12 h. Acetanilide residues were extracted by vigorous shaking for 30 min with 50 ml of hexane:acetone (9:1, v/v). After allowing the soil to settle, soil and extract was dried with 10 g of anhydrous Na_2SO_4, decanted, and evaporated to 1 ml. Metolachlor samples for location III required additional cleanup through an alumina column according to procedures received from the CIBA GEIGY Corporation. Gas liquid chromatography (glc) was done with a Tracor 560 gas chromatograph equipped with a flame ionization detector. Operating temperatures for injector, column, and detector were 210, 200, 230 C, respectively. Carrier gas flow rate was 40 ml/min. The column used was 2 m by 2 mm (i.d.) glass, packed with 3% OV-1 on 100 to 120 mesh Gas Chrom Q. Recovery from soil, after 30 min equilibration in the dark, for all acetanilide herbicides was greater than 85%. Detection limit in the soil was 0.03 ppm.

Acetanilide mobility in three soils was determined according to the soil thin layer chromatography procedure described by Helling (10,11). The soils evaluated were the same as in the residue study (Table 1).

Soil thin layer plates 20 cm by 20 cm were coated with 500 μ thick layer of each of the soils using a thin layer chromatographic spreader. The plates were air dried then spotted 2 cm from the bottom with 0.2 μCi/spot and 0.02 mg/spot of ^{14}C-alachlor, ^{14}C-metolachlor, ^{14}C-H-22234. Herbicide mobility was evaluated on a weight-weight and count-count basis to account for differences in specific activity among the chemicals (alachlor 1.7 mCi/mM, metolachlor 4.6 mCi/mM, H-22234 1.2 mCi/mM). The plates were chromatographed ascendingly 15 cm above the origin with distilled water. The plates were air dried for 24 h and radioautographed. The R_F value was measured at the front of the corresponding spot or streak shown on the radioautogram. R_S values, as described by Rhodes (15), were determined as the distance moved by the bottom of the spot divided by the distance traveled by the eluant. Lateral diffusion of the herbicides was obtained by dividing the width of the spot at its widest point by width of the applied spot (14). ^{14}C-labeled herbicides were spotted on silica gel GF plates, 0.2 μCi/spot, and eluted with distilled water ascendingly. All thin layer chromatography studies were replicated four times and repeated twice.

RESULTS AND DISCUSSION

Soils at locations I, II, and III examined for herbicide residues at the 0 to 8 cm depth exhibited significant date by herbicide interactions during 1976 and 1977 (Tables 3, 4, 5). Acetanilide herbicide residues in the soil decreased from 0 to 8 weeks after application. The rate of dissipation, expressed as half life, varied amont treatments. At location I, metolachlor and H-22234 for both years, and H-26910 in 1976, exhibited half lives of 2 to 4 weeks (Table 3). Alachlor for both years, and H-26910 during 1977, exhibited half lives of 0 to 2 weeks. At location II, the half life of metolachlor was 4 to 8 weeks during 1976, and 2 to 4 weeks during 1977 (Table 4). H-26910 and H-22234 exhibited 0 to 2 week and 2 to 4 week half lives during 1976 and 1977, respectively. Alachlor showed rapid degradation during both years with a half life of 0 to 2 weeks. For location III, metolachlor and H-26910 during both years, and H-22234 in 1977, exhibited half lives of 2 to 4 weeks (Table 5). Alachlor for both years, and H-22234 during 1976, had 0 to 2 weeks (Table 5). Alachlor for both years, and H-22234 during 1976, had 0 to 2 week half lives. These results agree with laboratory results by Chou (6,7) and Beestman and Deming (4), who determined alachlor half life to be 2 to 14 days. There was little change in rate of dissipation between locations as soil type changes and organic matter increased. This supports the findings by Chou that organic matter additions fail to increase rate of alachlor degradation.

Herbicide persistence in the soil was expressed as residue remaining in the soil 8 weeks after application. The most persistent compounds for all locations and years were metolachlor and H-26910 (Tables 3, 4, 5). Residues in the soil greater than 1.2 μg/g at location 1, 0.6 μg/g at location II, and 1.6 μg/g at location III were detected for metolachlor and H-26910. Although the half life of H-22234 was comparable to metolachlor and H-26910, the residue after 8 weeks was significantly less. The low levels detected for alachlor at the 0 to 8 cm depth 8 weeks after application corresponds to its rapid dissipation rate.

There was a significant date by method of application interaction for all locations during 1976 and 1977 (Tables 3, 4, 5). Residue samples taken immediately after application indicated that acetanilide residues were greater in the 0 to 8 cm soil depth when applied preemergence. Incorporation served to distribute the herbicide below 8 cm, thus reducing concentration in the 0 to 8 depth immediately after application. Regardless of method of application, all treatments for all years and locations showed a decrease in residue 0 to 8 weeks after application. The rate of dissipation between methods of application was not equal. Preplant incorporated treatments exhibited a 4 to 8 week half life for all locations during 1977, and location III in 1976. The half life for incorporated treatments was 2 to 4 weeks and 0 to 2 weeks at locations I and II, respectively, during 1976. Preemergence treatments for both years at locations I and III exhibited half lives of 0 to 2 weeks. Location II preemergence application showed a 0 to 2 week and 2 to 4 week half life during 1976 and 1977, respectively. The slower dissipation rate for preplant incorporated treatments is reflected in a longer half life and greater residue 8 weeks after application. For all locations and years, the acetanilide herbicides exhibited greater persistence in the soil when incorporated. The increased dissipation rate and decreased persistence for preemergence treatments was the result of their exposure to environmental influences on the soil surface.

There was a significant date by herbicide rate interaction during 1976 and 1977 for all locations (Tables 3, 4, 5). Treatment rates of 3.36 kg/ha and 6.72 kg/ha showed a decrease in soil residue 0 to 8 weeks after application. However, for each sample date, soil residues were greater for the 6.72 kg/ha rate. Eight weeks after application for all locations and years, the most persistent treatment was 6.72 kg/ha. Herbicide dissipation rate in the soil was not affected by herbicide rate. The half lives for 3.36 kg/ha and 6.72 kg/ha were the same within each year and location.

Persistence of the acetanilide herbicides was evaluated at the 8 to 16 cm soil depth for three locations. There was no significant difference in residue level among metolachlor, alachlor, H-26910, and H-22234. However, for all locations, there was a significant main effect for weeks after application and herbicide rate (Table 6). All locations during 1976 and 1977 exhibited a decrease in soil residue 2 to 8 weeks after application. The acetanilide herbicides were present in the 8 to 16 cm soil depth for all sample dates in trace amounts. The low residue level detected at this depth correlates with low levels of precipitation received for all locations during 1976 and 1977 (Table 2). The significant rate main effect at 8 to 16 cm indicated greater residues for the 6.72 kg/ha treatments.

The leaching of herbicides through the soil results in the placement of the chemical and may determine its efficacy (18). Adsorption strongly influences movement while the depth of movement is dependent upon soil properties and rainfall received (12). Adsorption governs movement, whereas organic matter, clay, and pH effect adsorption. Increased solubility appears to correlate with decreased adsorption (12). The acetanilide herbicides were spotted on silica gel thin layer chromatography plates and eluted with distilled water. The polysilicic gel was capable of hydrogen bonding and cation exchange. Movement of the herbicides on the silica gel provided information regarding structural differences and water solubility.

Chemical movement on silica gel is primarily an adsorption-desorption process. There were substantial differences in mobility among the herbicides evaluated (Figure 1). H-22234 exhibited the smallest R_F and R_S values (Table 7). Evaluating the structure of H-22234, an ester group is evidenced in the R-2 position (Figure 2). This additional carbonyl facilitated increased adsorption to the silica gel. Water competes with the chemicals for active sites on the silica. H-22234 was adsorbed the greatest and had the lowest water solubility, therefore, water did not displace it readily. This resulted in extensive tailing for the chemical on silica gel, as evidenced by a zero R_S. Metolachlor exhibited the greatest mobility and least tailing on silica plates. The increased movement was the result of decreased adsorption. Therefore, this compound was displaced readily by water and moved as a compact band with the eluant. Alachlor has an ether group at the R-2 position, therefore, it will be adsorbed less tightly than H-22234. However, alachlor does not have methyl groups protecting its ether as does metolachlor. The R_F value for alachlor was equal to metolachlor and greater than H-22234, while its R_S value was intermediate between the two herbicides.

Helling (10,11) and Rhodes (15) utilized soil thin layer chromatography plates as a quantitative indication of herbicide mobility. The R_F value is a measure of the maximum distance a chemical will move through the soil, when a given amount of water is applied. The mobility of a herbicide in the soil is governed by its adsorption. Metolachlor and alachlor exhibited greater mobility than H-22234, in all soils evaluated (Table 8). The soil R_F values of metolachlor = alachlor > H-22234 agree with the results obtained on silica gel. The carbonyl group, for H-22234, in the R-2 position, increases its adsorptive capacity to soil, subsequently decreasing its mobility in the soil. All of the herbicides exhibited substantial tailing, as evidenced by a zero R_S (Figure 1). This distribution pattern in the soil was the result of herbicide adsorption to the organic matter and clay fractions. It has been reported that soil organic matter and clay content positively correlate with herbicide adsorption (12,18). All acetanilide treatments exhibited a decrease in mobility as the soil organic matter and clay content increased. Increasing the clay content or organic matter level in the soil increased the number of adsorptive sites. thereby decreasing herbicide mobility.

Herbicides should have sufficient residual activity to accomplish control, then decompose to innocous products. Compounds with the greatest persistence are capable of affecting germinating weeds over an extended period of time. The movement of chemicals in the soil results in their placement in the soil and availability to germinating weeds. These studies indicate that metolachlor had the greatest persistence and mobility of the acetanilide herbicides evaluated. The effectiveness of metolachlor on yellow nutsedge was enhanced by the combination of greater persistence and greater mobility. H-26910 exhibited substantial persistence in the soil 8 weeks after application. The mobility of H-26910 in the soil was not evaluated, however, based on its low water solubility and ester group at the R-2 position, its movement is suspected to be comparable to H-22234 (Table 7). Alachlor did not exhibit great persistence in soil, however, it was among the most mobile compounds in the soil. H-26910 and alachlor exhibited only one of the qualities of persistence or mobility, which may explain their effective but erratic activity on yellow nutsedge in the field. H-22234 did not exhibit either persistence or mobility in the soil, and provided poor yellow nutsedge control.

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Table 1. Characteristics of soils taken from the Ap horizon, 0 to 16 cm, at three locations in Michigan for soil residue studies.

Location	Soil texture	Organic matter	Mechanical analysis			pH
			Sand	Silt	Clay	
		(%)		(%)		
I	Sandy clay loam	2.5	60.2	12.0	27.8	6.3
II	Clay loam	4.1	40.2	24.0	35.8	6.6
III	Sandy clay loam	6.0	46.2	18.0	35.8	6.7

Table 2. Accumulative precipitation for 8 weeks after herbicide application during 1976 and 1977.

Location	Year	Weeks after application							
		1	2	3	4	5	6	7	8
		(cm)							
I	1976	1.0	1.0	1.4	4.2	10.6	13.9	14.3	15.6
	1977	0.8	1.3	1.9	5.0	5.0	8.4	8.4	11.2
II	1976	0.3	0.3	4.0	5.3	15.5	15.6	15.9	16.6
	1977	0.0	2.3	4.6	6.2	6.3	9.8	11.0	11.0
III	1976	2.7	3.8	4.3	7.9	8.1	8.5	11.3	12.4
	1977	0.8	0.9	3.8	5.8	7.2	11.0	13.2	13.2

Table 3. Persistence of several acetanilide herbicides 0 to 8 cm in a sandy clay loam soil 2.5% organic matter, location I, 8 weeks after treatment.

Main and interaction effect	1976				1977			
	Weeks after application				Weeks after application			
	0	2	4	8	0	2	4	8
	($\mu g/g$)[a]				($\mu g/g$)[a]			
Date x Herbicide[b]								
Metolachlor	3.99 g	2.73 fg	1.17 cd	1.27 d	6.17 jk	3.34 h	2.89 gh	1.68 c
H-26910	2.93 g	2.35 f	1.00 bcd	1.21 cd	5.06 ij	2.43 efg	1.84 cd	1.24 b
H-22234	3.15 g	1.64 e	0.82 b	0.39 a	4.71 ij	2.67 fg	2.09 cde	0.58 a
Alachlor	2.87 fg	1.18 cd	0.91 cd	0.33 a	5.81 jk	2.26 def	1.17 b	0.40 a
Date x Method of Application[c]								
Preplant incorporated	1.92 c	2.29 d	0.96 b	0.95 b	2.90 e	2.49 de	2.17 d	1.17 b
Preemergence	4.56 e	1.66 c	0.98 c	0.65 a	7.98 f	2.86 e	1.81 c	0.78 a
Date x Herbicide Rate[d]								
3.36 kg/ha	2.27 f	1.35 e	0.70 b	0.54 a	3.47 f	1.80 d	1.29 b	0.60 a
6.72 kg/ha	4.21 h	2.60 g	1.25 d	1.06 c	7.41 g	3.55 f	2.70 e	1.35 c

[a]Values followed by the same letter within year and main effect are not significantly different at the 5% level by Duncan's Multiple Range Test.

[b]Values are the mean of two rates, two methods of application, three replications.

[c]Values are the mean of four chemicals, two rates, three replications.

[d]Values are the mean of four chemicals, two methods of application, three replications.

Table 4. Persistence of several acetanilide herbicides 0 to 8 cm in a clay loam soil 4.1% organic matter, location II, 8 weeks after treatment.

Main and interaction effect	1976 Weeks after application				1977 Weeks after application			
	0	2	4	8	0	2	4	8
		(µg/g)[a]				(µg/g)[a]		
Date x Herbicide[b]								
Metolachlor	3.86 g	2.43 f	2.07 ef	0.94 cd	4.08 f	2.35 de	1.76 cd	0.89 b
H-26910	4.57 g	1.67 e	1.15 d	0.62 bc	4.80 f	2.66 e	2.19 de	0.88 b
H-22234	3.69 g	1.20 e	1.00 d	0.25 a	4.70 f	2.51 de	1.45 c	0.47 a
Alachlor	3.38 g	0.78 bcd	0.56 b	0.11 a	4.63 f	2.22 de	1.43 c	0.36 a
Date x Method of Application[c]								
Preplant incorporated	3.70 e	1.70 d	1.40 d	0.58 b	3.97 f	2.05 d	2.04 d	0.81 b
Preemergence	4.00 e	1.41 d	0.96 c	0.38 a	5.13 g	2.82 e	1.38 c	0.49 a
Date x Herbicide Rate[d]								
3.36 kg/ha	2.67 f	1.07 d	0.79 c	0.29 a	3.01 f	1.64 d	1.11 c	0.39 a
6.72 kg/ha	5.08 g	1.97 e	0.60 e	0.67 b	6.10 h	3.24 g	2.31 e	0.91 b

[a]Values followed by the same letter within year and main effect are not significantly different at the 5% level by Duncan's Multiple Range Test.

[b]Values are the mean of two rates, two methods of application, three replications.

[c]Values are the mean of four chemicals, two rates, three replications.

[d]Values are the mean of four chemicals, two methods of application, three replications.

Table 5. Persistence of several acetanilide herbicides 0 to 8 cm in a sandy clay loam soil 6.0% organic matter, location III, 8 weeks after treatment.

Main and interaction effect	1976				1977			
	Weeks after application				Weeks after application			
	0	2	4	8	0	2	4	8
	($\mu g/g$)[a]				($\mu g/g$)[a]			
Date x Herbicide[b]								
Metolachlor	4.66 fg	2.94 de	1.81 bcd	1.53 bc	5.38 de	3.45 c	2.60 bc	1.59 b
H-26910	5.18 g	3.85 ef	1.82 bcd	1.63 bc	5.72 e	4.05 cd	3.02 bc	1.65 b
H-22334	5.77 g	2.71 cde	1.19 ab	0.77 a	5.02 de	3.03 bc	1.78 b	0.75 a
Alachlor	4.76 fg	1.95 bcd	1.04 ab	0.31 a	6.83 e	2.65 bc	1.55 ab	0.66 a
Date x Method of Application[c]								
Preplant incorporated	2.83 c	3.13 c	1.52 b	1.25 b	4.29 d	3.23 c	2.87 c	1.39 b
Preemergence	7.35 d	2.59 c	1.41 b	0.87 a	6.68 e	3.37 cd	1.60 b	0.94 a
Date x Herbicide Rate[d]								
3.36 kg/ha	4.04 g	2.18 e	1.02 b	0.72 a	3.58 e	2.25 c	1.48 b	0.84 a
6.72 kg/ha	6.15 h	3.54 f	1.91 d	1.40 c	7.34 g	4.34 f	3.00 d	1.52 b

[a]Values followed by the same letter within year and main effect are not significantly different at the 5% level by Duncan's Multiple Range Test.

[b]Values are the mean of two rates, two methods of application, three replications.

[c]Values are the mean of four chemicals, two rates, three replications.

[d]Values are the mean of four chemicals, two methods of application, three replications.

Table 6. Herbicide persistence at the 8 to 16 cm soil depth, 8 weeks after application for three locations in Michigan during 1976 and 1977, averaged over four acetanilide herbicides.

Main and interaction effect	Location I		Location II		Location III	
	1976	1977	1976	1977	1976	1977
Weeks after application	(μg/g)[a]		(μg/g)[a]		(μg/g)[a]	
2	0.06 c	0.07 b	0.06 b	0.96 b	0.10 b	0.10 b
4	0.03 b	0.08 b	ND a	0.05 b	ND a	0.10 b
8	ND[d] a	ND a	ND a	ND a	ND a	ND a
Herbicide rate[c]						
3.36 kg/ha	ND a	0.04 a	ND a	0.03 a	ND a	0.05 a
6.72 kg/ha	0.05 b	0.08 b	0.03 b	0.05 b	0.05 b	0.09 b

[a]Values followed by the same letter within year and main effect are not significantly different at the 5% level by Duncan's Multiple Range Test.

[b]Values are the mean of four chemicals, two methods of application, two rates and three replications.

[c]Values are the mean of four chemicals, two methods of application, two dates and three replications.

[d]ND designates non-detectable residue.

Table 7. ^{14}C-acetanilide herbicide mobility on silica gel GF thin layer chromatography plates.[a]

Treatment	R_F[b]	R_S[c]
Metolachlor	0.79 b	0.55 c
Alachlor	0.79 b	0.34 b
H-22234	0.70 a	0.00 a

[a]Values followed by the same letter within a column are significantly different at the 5% level by Duncan's Multiple Range Test.

[b]R_F value was measured at the front of the spot on the radioautogram.

[c]R_S value was measured at the bottom of the spot on the radioautogram.

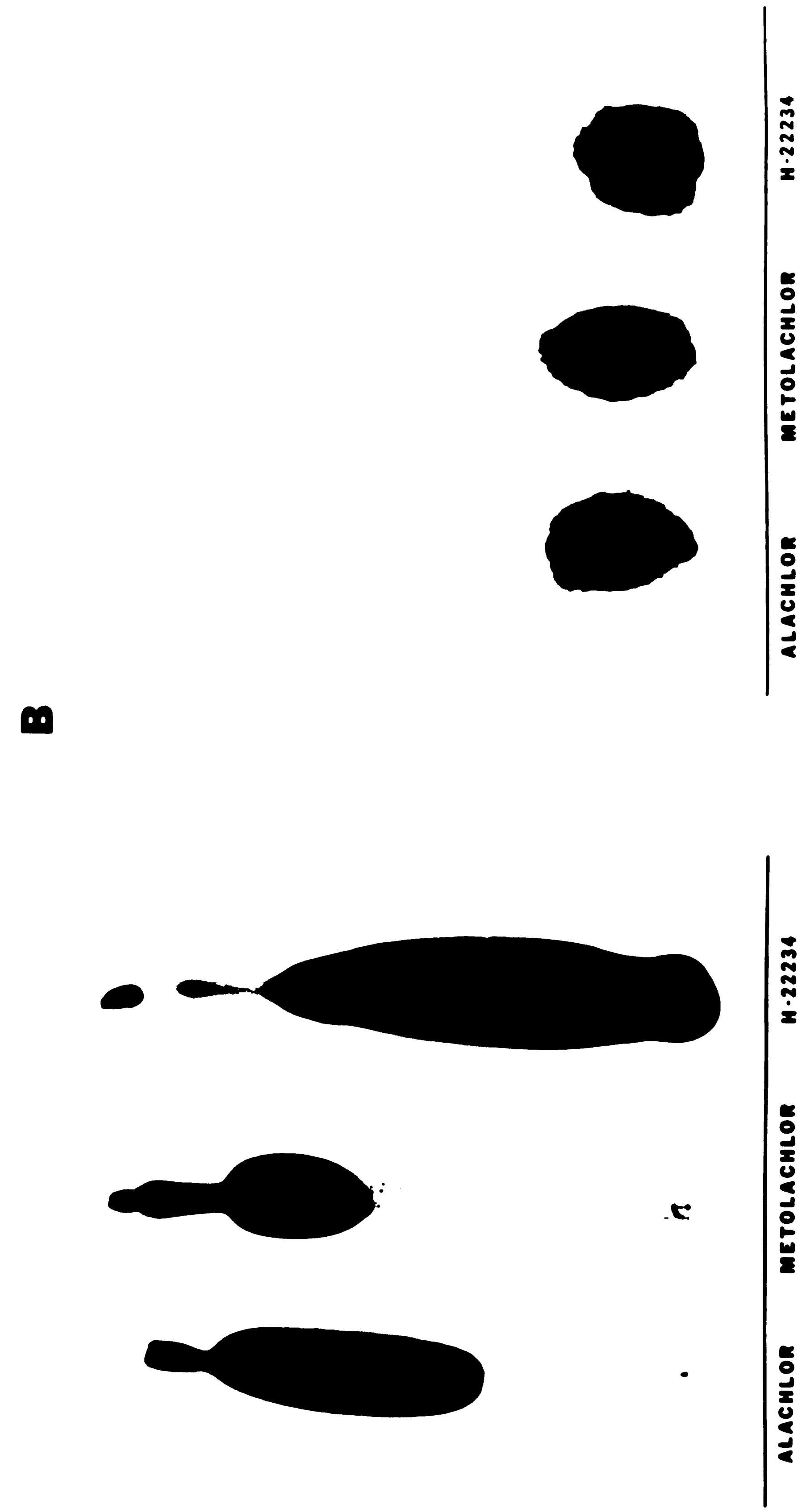
Table 8. ^{14}C-acetanilide mobility on soil thin layer chromatography plates.[a]

Treatment	Soil texture and organic matter: sandy clay loam 2.5% OM	clay loam 4.1% OM	sandy clay loam 6.0% OM
		(R_F)[b]	
Metolachlor	0.30 f	0.27 e	0.23 d
Alachlor	0.29 f	0.27 e	0.21 cd
H-22234	0.20 c	0.19 b	0.14 a

[a]Values followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

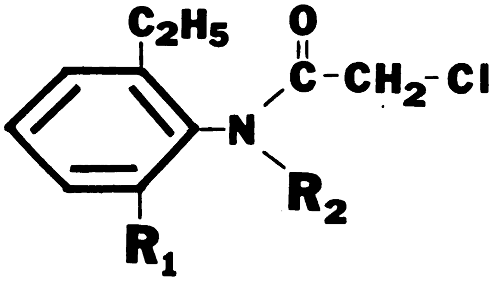
[b]R_F value was measured at the front of the spot on the radioautogram.

Figure 1. Radioautograph of ^{14}C-alachlor, ^{14}C-metolachlor, ^{14}C-H-22234, movement on (A) silica gel GF, and (B) soil, thin layer chromatography plates, eluted with water.



A
ALACHLOR
METOLACHLOR
H-22234
B
ALACHLOR
METOLACHLOR
H-22234

Figure 2. Molecular structure and water solubility of alachlor, metolachlor, H-22234, and H-26910.



	R_1	R_2	SOLUBILITY in H_2O (ppm/C)
ALACHLOR	$-C_2H_5$	$-CH_2-O-CH_3$	242/25
METOLACHLOR	$-CH_3$	$-CH(CH_3)-CH_2-O-CH_3$	530/20
HERC-22234	$-C_2H_5$	$-CH_2-C(=O)-O-CH_2-CH_3$	105/25
HERC-26910	$-CH_3$	$-CH_2-C(=O)-O-CH(CH_3)-CH_3$	89/25

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CHAPTER 4

SUMMARY AND CONCLUSIONS

Studies were conducted in the field, greenhouse, and laboratory to comparatively evaluate the herbicides alachlor, metolachlor, H-22234, and H-26910 for yellow nutsedge control, and ascertain the effect that method of application, rate, soil organic matter, and placement in the soil have on their activity. Herbicide persistence and mobility in the soil and its relationship to weed control was determined. Growth chamber studies were initiated to determine the activity of the acetanilide herbicides on yellow nutsedge tuber sprouting, sprout viability, and shoot development.

Visual control ratings and stand density measurements, taken in the field, indicate that the herbicides control yellow nutsedge in the order: metolachlor $\geq$ alachlor $\geq$ H-26910 $\geq$ H-22234. Activity for all treatments was enhanced by incorporation into the soil and by increasing the rate. As soil organic matter increased, the activity of all acetanilide herbicides decreased. Placement of the chemical in the soil has a significant effect upon its activity. For the acetanilide herbicides to be effective on yellow nutsedge, they must be in the soil zone, above or at the level of the tuber. Treatments providing $\geq$ 70% visual control of yellow nutsedge consistently increased soybean yield compared to the untreated check.

Alachlor, metolachlor, H-22234, and H-26910 did not prevent yellow nutsedge tuber sprouting or kill the tubers. However, they did inhibit shoot elongation when in contact with the sprout. Once chemical pressure was removed, the yellow nutsedge plants were capable of resuming development. There was no significant difference among the acetanilide herbicides with respect to their activity on yellow nutsedge tuber sprouting, sprout viability, or shoot elongation in petri dish studies.

To be effective in the field, the acetanilide herbicides must be applied to soils low in organic matter and be present in the soil zone above or at the level of the tuber. To effectively inhibit yellow nutsedge shoot development, these herbicides must be present at a phytotoxic concentration for an extended period of time.

Differences in weed control among treatments, exhibited in the field and not in petri dish studies, are the result of chemical-soil interactions. The rate of dissipation in the 0 to 8 cm soil depth for the herbicides indicates the half life of metolachlor $\geq$ H-26910 $\geq$ H-22234 $\geq$ alachlor. The chemicals exhibiting the greatest soil persistence were metolachlor and H-26910.

Metolachlor and alachlor exhibited greater mobility than H-22234 in all soils evaluated. Movement of the herbicides on silica gel and soil thin layer chromatography plates indicates increased adsorption and decreased mobility for H-22234.

Herbicides with the greatest persistence are capable of affecting germinating weeds over an extended period of time. The mobility of chemicals in the soil is a function of their adsorption to the soil. Increased adsorption results in decreased availability of herbicides to germinating weeds. Metolachlor provided the most consistent weed control across all locations and years. The effectiveness of metolachlor on yellow nutsedge is enhanced by its combination of persistence and mobility in the soil. H-26910 exhibited substantial persistence in the soil, however, its mobility is suspected to be low. Alachlor did not exhibit great soil persistence, however, it was among the most mobile compounds in the soil. H-26910 and alachlor exhibited only one of the qualities of persistence or mobility, which may explain their effective but erratic activity on yellow nutsedge in the field. H-22234 did not exhibit either persistence or mobility in the soil and provided poor yellow nutsedge control.

Weed control for all herbicides in the field was enhanced by soil incorporation and higher application rates. Greater herbicide persistence for these treatments supports their increased activity on yellow nutsedge.

Yellow nutsedge is among the most serious weed problems in Michigan. However, through our understanding of factors affecting herbicide activity, effective weed control programs may be designed. Selected acetanilide herbicides, when applied preplant incorporated at a higher use rate to soils low in clay and organic matter, will assist Michigan growers in controlling yellow nutsedge.

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APPENDICES

APPENDIX A

Table A-1. Visual control rating of several acetanilide herbicides on yellow nutsedge 8 weeks after application.

Treatment	Location I			Location II		Location III	
	1975	1976	1977	1976	1977	1976	1977
				(% of control)[a]			
Preplant incorporated 3.36 kg/ha							
Metolachlor	89	81	89	75	80	73	60
Alachlor	78	78	78	60	70	60	50
H-26910		70	79	53	48	53	30
H-22234	50	33	58	33	47	23	20
Preemergence 3.36 kg/ha							
Metolachlor	90	83	91	60	47	27	20
Alachlor	80	65	71	50	47	13	10
H-26910		60	71	60	40	23	33
H-22234	48	53	53	63	27	13	10
Preplant incorporated 6.72 kg/ha							
Metolachlor	90	89	96	78	73	83	60
Alachlor	85	91	86	65	80	70	53
H-26910		75	88	70	67	37	30
H-22234	68	64	76	53	60	57	27

[a]Visual ratings are expressed on a percentage basis with 0 = no control and 100 = complete control.

Table A-1 (continued).

Treatment	Location I			Location II		Location II	
	1975	1976	1977	1976	1976	1976	1977
				(% of control)[a]			
Preemergence							
6.72 kg/ha							
Metolachlor	93	85	94	87	60	53	57
Alachlor	88	83	81	70	57	23	27
H-26910		63	90	63	47	25	20
H-22234	68	70	74	63	40	13	33

[a]Visual ratings are expressed on a percentage basis with 0 = no control and 100 = complete control.

APPENDIX B

Table B-1. Effect of acetanilide herbicides on yellow nutsedge shoot density 8 weeks after application.

Treatment	Location I		Location II		Location III	
	1976	1977	1976	1977	1976	1977
			(% of control)			
Preplant incorporated 3.36 kg/ha						
Metolachlor	23	3	23	12	20	27
Alachlor	21	9	36	14	31	22
H-26910	32	6	31	36	40	57
H-22234	61	37	55	52	62	64
Preemergence 3.36 kg/ha						
Metolachlor	34	18	28	48	25	89
Alachlor	38	22	37	41	54	94
H-26910	50	22	56	46	54	94
H-22234	76	77	53	57	61	92
Preplant incorporated 6.72 kg/ha						
Metolachlor	14	1	14	7	9	31
Alachlor	9	2	20	3	16	32
H-26910	33	2	34	14	11	57
H-22234	34	12	37	25	20	52

[a]Shoot density is expressed as percent of the untreated control.

Table B-1 (continued).

Treatment	Location I		Location II		Location III	
	1976	1977	1976	1977	1976	1977
			(% of control)			
Preemergence						
6.72 kg/ha						
Metolachlor	40	1	33	25	28	48
Alachlor	45	9	39	30	41	76
H-26910	42	7	41	37	36	74
H-22234	52	31	43	49	38	75

[a]Shoot density is expressed as percent of the untreated control.

APPENDIX C

Table C-1. Yellow nutsedge stand density 2, 4, 8 weeks after application on a sandy clay loam soil 2.5% organic matter.

Treatment	1976 Weeks after application			1977 Weeks after application		
	2	4	8	2	4	8
	($shoots/m^2$)[a]					
Preplant incorporated 3.36 kg/ha						
Metolachlor	67	96	49	2	6	7
Alachlor	33	59	40	2	5	26
H-26910	73	105	61	2	7	20
H-22234	122	218	216	8	28	59
Control	218	385	406	55	166	270
Preemergence 3.36 kg/ha						
Metolachlor	196	197	99	23	45	13
Alachlor	129	154	117	40	52	65
H-26910	235	254	183	53	68	45
H-22234	188	287	272	49	139	196
Control	281	352	394	55	166	270
Preplant incorporated 6.72 kg/ha						
Metolachlor	30	55	26	1	2	2
Alachlor	15	22	23	1	2	6
H-26910	49	88	55	1	4	3
H-22234	61	131	125	2	12	27
Control	218	385	406	55	166	270

[a]Values are the mean of 4 replications.

Table C-1 (continued).

Treatment	1976 Weeks after application 2	4	8	1977 Weeks after application 2	4	8
			(shoots/m^2)[a]			
Preemergence						
6.72 kg/ha						
Metolachlor	213	207	126	24	17	2
Alachlor	187	199	195	21	16	15
H-26910	257	240	142	30	30	13
H-22234	155	169	174	25	48	49
Control	281	352	394	55	166	270

[a]Values are the mean of 4 replications.

APPENDIX D

Table D-1. Yellow nutsedge stand density 2, 4, 8 weeks after application on a clay loam soil 4.1% organic matter.

Treatment	1976 Weeks after application			1977 Weeks after application		
	2	4	8	2	4	8
	(shoots/m^2)[a]					
Preplant incorporated 3.36 kg/ha						
Metolachlor	115	132	104	15	21	87
Alachlor	174	194	159	16	28	103
H-26910	164	214	116	69	113	217
H-22234	229	249	277	64	95	227
Control	267	518	617	246	323	505
Preemergence 3.36 kg/ha						
Metolachlor	172	187	146	180	205	260
Alachlor	180	200	272	191	239	292
H-26910	250	261	277	113	219	343
H-22234	192	213	331	189	238	407
Control	320	602	636	295	403	885
Preplant incorporated 6.72 kg/ha						
Metolachlor	68	83	80	51	57	101
Alachlor	82	102	101	47	63	161
H-26910	126	156	87	58	95	173
H-22234	128	158	183	46	67	222
Control	267	518	617	246	323	505

[a]Values are the mean of three replications.

Table D-1 (continued).

Treatment	1976 Weeks after application 2	4	8	1977 Weeks after application 2	4	8
			(shoots/m^2)[a]			
Preemergence						
6.72 kg/ha						
Metolachlor	144	160	117	101	123	208
Alachlor	128	148	175	117	148	247
H-26910	160	190	161	140	162	307
H-22234	184	204	196	172	188	336
Control	320	602	636	295	403	885

[a]Values are the mean of three replications.

APPENDIX E

Table E-1. Yellow nutsedge stand density 2, 4, 8 weeks after application on a sandy clay loam soil 6.0% organic matter.

Treatment	1976 Weeks after application			1977 Weeks after application		
	2	4	8	2	4	8
	(shoots/m^2)[a]					
Preplant incorporated 3.36 kg/ha						
Metolachlor	33	21	16	40	48	31
Alachlor	40	33	52	30	22	51
H-26910	41	17	22	150	160	169
H-22234	43	51	89	131	119	207
Control	141	131	194	84	224	547
Preemergence 3.36 kg/ha						
Metolachlor	108	32	56	245	308	420
Alachlor	102	109	130	133	148	396
H-26910	145	75	102	276	438	475
H-22234	137	74	148	279	300	530
Control	213	148	236	179	250	557
Preplant incorporated 6.72 kg/ha						
Metolachlor	18	13	17	63	92	53
Alachlor	14	9	20	6	6	31
H-26910	46	51	29	82	62	62
H-22234	26	13	28	64	72	92
Control	141	131	194	84	224	547

[a]Values are the mean of three replications.

Table E-1 (continued).

Treatment	1976 Weeks after application 2	4	8	1977 Weeks after application 2	4	8
			$(shoots/m^2)$[a]			
Preemergence						
6.72 kg/ha						
Metolachlor	142	65	95	139	232	162
Alachlor	100	62	121	162	232	260
H-26910	171	102	127	223	175	298
H-22234	114	68	89	186	222	433
Control	213	148	236	179	250	557

[a]Values are the mean of three replications.

APPENDIX F

Table F-1. Effect of several acetanilide herbicides on yellow nutsedge plant height 8 weeks after application.

Treatment	Plant Height 1976	Plant Height 1977
	(% of control)[a]	
Preplant incorporated 3.36 kg/ha		
Metolachlor	62	52
H-26910	74	69
Alachlor	79	73
H-22234	89	80
Preemergence 3.36 kg/ha		
Metolachlor	56	61
H-26910	73	78
Alachlor	85	99
H-22234	86	99
Preplant incorporated 6.72 kg/ha		
Metolachlor	46	53
H-26910	70	63
Alachlor	79	69
H-22234	77	66
Preemergence 6.72 kg/ha		
Metolachlor	51	54
H-26910	68	71
Alachlor	83	77
H-22234	79	86

[a]Values are the mean of four replications.

APPENDIX G

Table G-1. Effect of several acetanilide herbicides on yellow nutsedge shoot dry weight 8 weeks after application.

Treatment	Shoot Dry Weight 1976	Shoot Dry Weight 1977
	(% of control)[a]	
Preplant incorporated		
3.36 kg/ha		
Metolachlor	17	2
Alachlor	27	12
H-26910	30	6
H-22234	53	44
Preemergence		
3.36 kg/ha		
Metolachlor	17	3
Alachlor	38	33
H-26910	38	39
H-22234	41	45
Preplant incorporated		
6.72 kg/ha		
Metolachlor	10	1
Alachlor	8	4
H-26910	29	3
H-22234	33	25
Preemergence		
6.72 kg/ha		
Metolachlor	18	1
Alachlor	39	10
H-26910	39	8
H-22234	28	12

[a]Values are the mean of four replications.

APPENDIX H

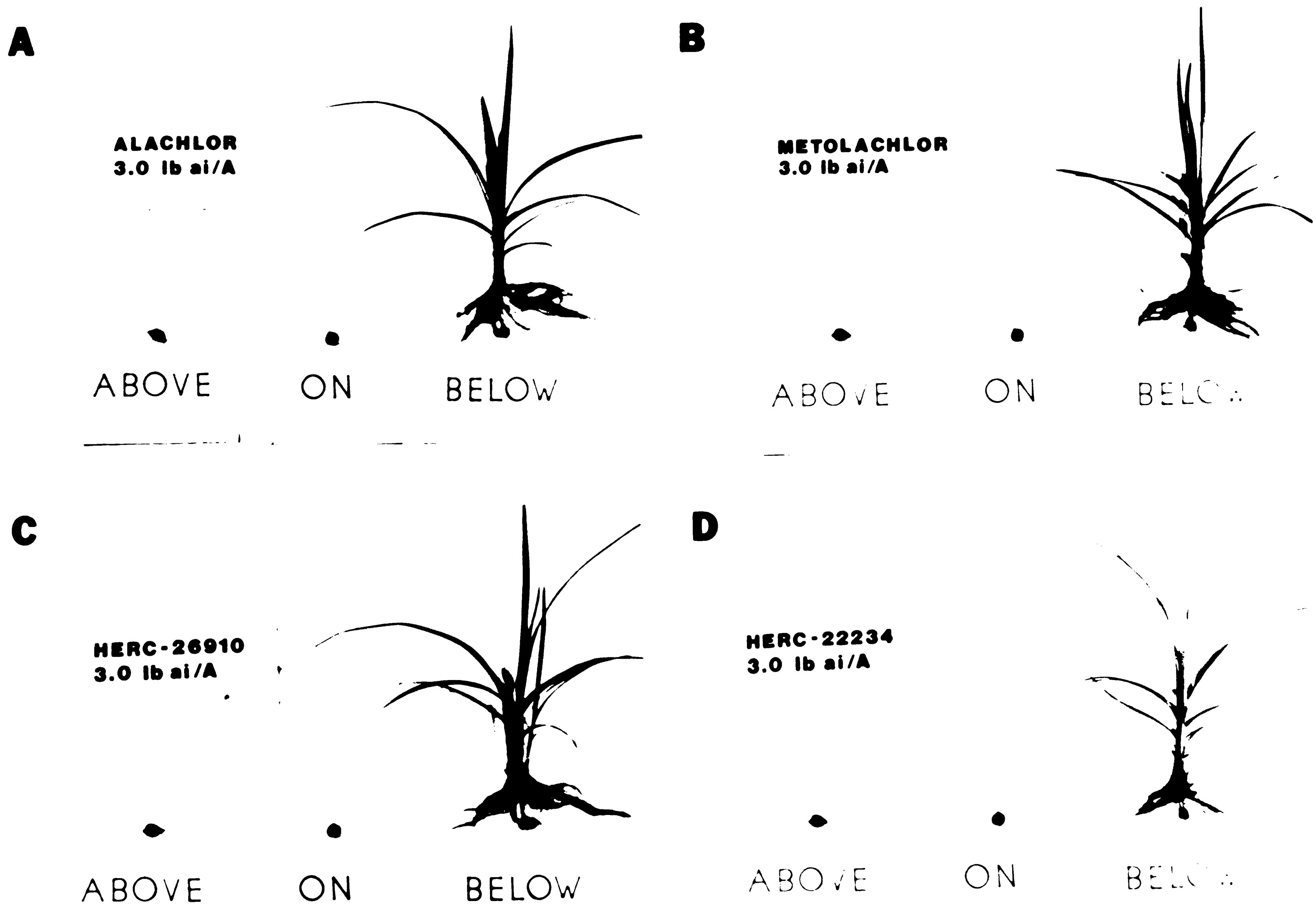
Table H-1. Effect of several acetanilide herbicides on soybean yield on a sandy clay loam soil 2.5% organic matter.

Treatment	Soybean Yield 1975	1976	1977
	(kg/ha x 1000)[a]		
Preplant incorporated			
3.36 kg/ha			
Metolachlor	2.21	2.22	2.48
Alachlor	2.04	2.15	2.12
H-26910		1.93	1.75
H-22234	1.66	2.10	1.83
Control	1.09	0.90	1.58
Preemergence			
3.36 kg/ha			
Metolachlor	2.27	1.81	1.95
Alachlor	2.31	1.78	2.07
H-26910		1.69	2.24
H-22234	1.57	1.74	2.03
Control	1.08	0.89	1.82
Preplant incorporated			
6.72 kg/ha			
Metolachlor	2.16	2.01	2.07
Alachlor	2.17	2.30	2.01
H-26910		1.98	2.05
H-22234	2.02	2.03	1.75
Control	1.09	0.90	1.58
Preemergence			
6.72 kg/ha			
Metolachlor	2.27	1.84	2.53
Alachlor	2.46	1.75	2.02
H-26910		1.76	2.21
H-22234	2.44	1.50	2.11
Control	1.08	0.89	1.82

[a]Values are the mean of four replications.

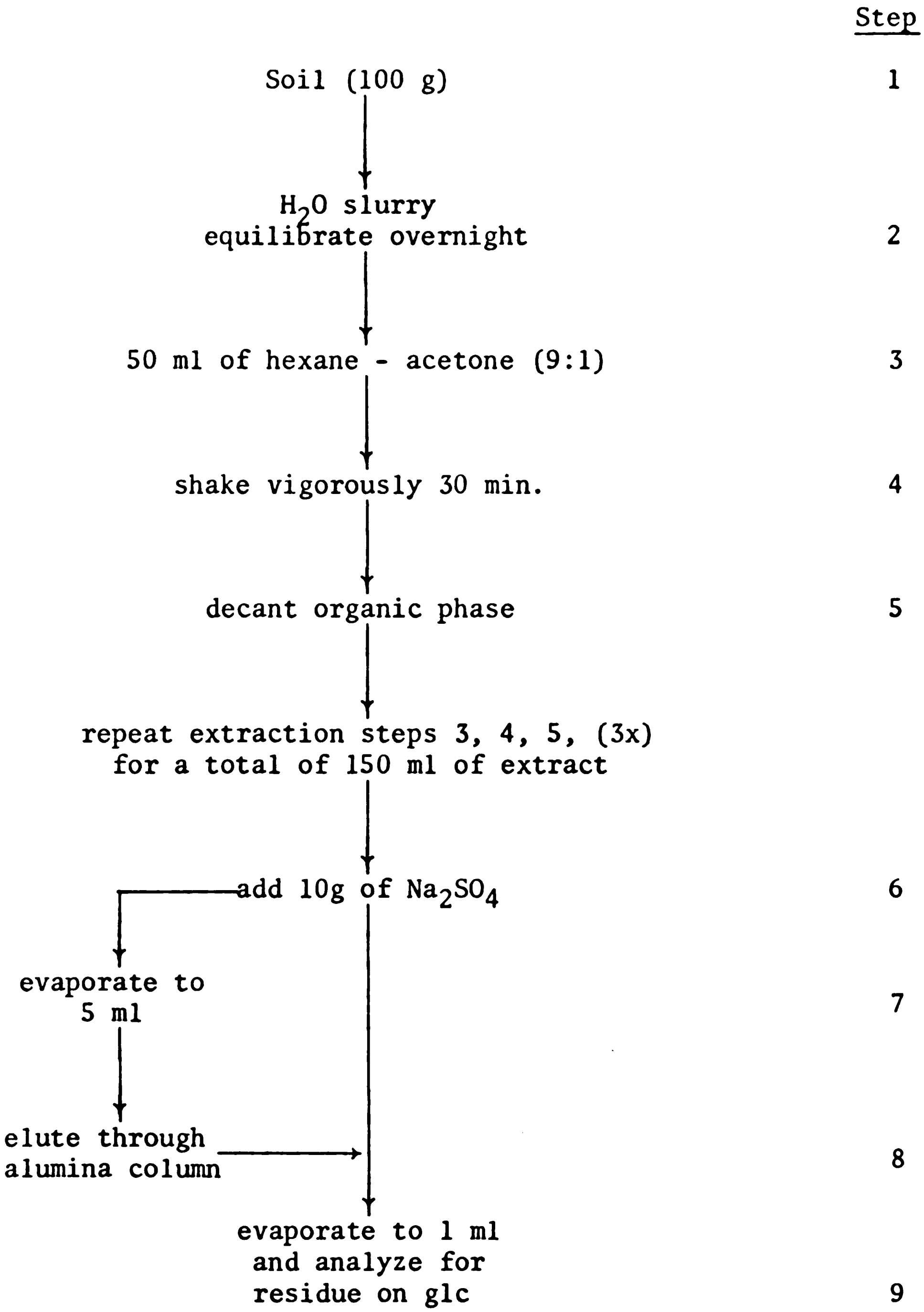
APPENDIX I

Figure I-1. Yellow nutsedge development, 6 weeks after treatment with 3.36 kg/ha (A) alachlor, (B) metolachlor, (C) H-26910, (D) H-22234, applied to soil above the tuber, on the tuber, or below the tuber.


A
ALACHLOR
3.0 lb ai/A
ABOVE
ON
BELOW
B
METOLACHLOR
3.0 lb ai/A
ABOVE
ON
C
HERC-26910
3.0 lb ai/A
ABOVE
ON
BELOW
D
HERC-22234
3.0 lb ai/A
ON

APPENDIX J

Figure J-1. Flow diagram of the analytical procedure for the determination of alachlor, metolachlor, H-22234, H-26910 parent residue in the soil.



[a]Alumina column cleanup is required for some samples. Procedures utilized were provided by the CIBA - GEIGY Corporation.

APPENDIX K

Table K-1. Acetanilide herbicide percent recovery from untreated soil after 30 minutes equilibration.

	Location I sandy clay loam 2.5% OM	Location II clay loam 4.1% OM	Location III sandy clay loam 6.0% OM
		(%)	
Alachlor	85	88	84
Metolachlor	85	91	88
H-22234	93	85	87
H-26910	95	91	85

APPENDIX L

Table L-1. Gas chromatographic conditions.

Instrument	Tracor 560 equipped with flame ionization detector
Column Packing	3% OV-1 on Gas Chrom Q (100/120 mesh)
Column	pyrex 2m x 2mm (i.d.)
Temperatures	
Injector	210°C
Column	200°C
Dector	230°C
Gas Flow	
N_2 carrier	40 ml/min
H_2	30 ml/min
air	350 ml/min
Minimum Detection Limit	15 nanograms
Volume Injected	5 µl
Chart Speed	1/2 inch/min

APPENDIX M

Table M-1. Typical standard curve for acetanilide herbicides by flame ionization detection.

Treatment	Amount of acetanilide herbicide injected (ng)				
	25	50	125	250	500
	Peak Height (cm)				
Alachlor	1.0	2.1	5.0	11.0	19.9
Metolachlor	0.7	1.3	3.3	6.7	13.5
H-22234	0.9	1.9	4.7	9.4	18.9
H-26910	0.5	0.9	2.2	4.5	9.0

APPENDIX N

Table N-1. Soil persistence of several acetanilide herbicides 0 - 8 cm depth on a sandy clay loam soil 2.5% organic matter, 8 weeks after application.

	1976				1977			
	Weeks after application				Weeks after application			
Treatment	0	2	4	8	0	2	4	8
	(μg/g)[a]				(μg/g)[a]			
Preplant incorporated 3.36 kg/ha								
Metolachlor	1.22	2.75	1.24	1.27	1.79	2.26	2.34	1.39
H-26910	1.18	1.88	0.75	0.99	1.89	1.71	1.19	0.73
H-22234	1.22	1.24	0.39	0.14	1.94	1.32	0.96	0.24
Alachlor	1.30	0.72	0.65	0.14	1.94	1.32	0.96	0.24
Preemergence 3.36 kg/ha								
Metolachlor	4.39	1.20	0.72	0.57	5.05	2.26	1.49	0.88
H-26910	2.94	1.39	0.90	0.59	4.91	1.88	1.34	0.62
H-22234	2.98	0.92	0.57	0.24	4.66	2.12	1.22	0.33
Alachlor	2.94	0.71	0.36	0.11	6.27	1.53	0.60	0.10
Preplant incorporated 6.72 kg/ha								
Metolachlor	3.70	3.95	1.42	1.76	4.97	4.28	4.61	2.41
H-26910	2.16	3.74	0.87	1.90	3.70	2.50	2.48	2.16
H-22234	2.19	2.25	1.17	0.38	3.51	3.50	3.07	1.10
Alachlor	2.39	1.85	1.23	0.71	4.14	3.00	1.57	0.85
Preemergence 6.72 kg/ha								
Metolachlor	6.67	3.01	1.29	1.50	12.87	4.58	3.08	2.03
H-26910	5.45	2.41	1.49	1.38	9.76	3.63	2.35	1.43
H-22234	6.24	2.16	1.14	0.48	9.43	3.71	2.91	0.41
Alachlor	4.85	1.44	1.39	0.37	10.90	3.19	1.54	0.42

[a]Values are the mean of three replications.

APPENDIX O

Table O-1. Soil persistence of several acetanilide herbicides 0 - 8 cm depth on a clay loam soil 4.1% organic matter, 8 weeks after application.

Treatment	1976 Weeks after application				1977 Weeks after application			
	0	2	4	8	0	2	4	8
	(µg/g)[a]				(µg/g)[a]			
Preplant incorporated 3.36 kg/ha								
Metolachlor	2.79	2.13	1.46	0.76	2.78	1.31	1.87	0.81
H-26910	3.53	1.13	1.21	0.42	2.59	1.47	1.39	0.50
H-22234	2.65	0.74	0.81	0.13	2.55	1.24	1.19	0.39
Alachlor	2.24	0.62	0.27	.01	2.27	1.80	1.09	0.12
Preemergence 3.36 kg/ha								
Metolachlor	2.22	1.26	1.25	0.46	3.78	2.01	0.98	0.45
H-26910	3.20	1.01	0.52	0.33	2.82	2.07	1.13	0.43
H-22234	2.77	1.11	0.58	0.17	3.45	1.99	0.55	0.27
Alachlor	1.96	0.59	0.22	0.04	3.81	1.19	0.64	0.15
Preplant incorporated 6.72 kg/ha								
Metolachlor	4.75	3.92	3.71	1.58	4.90	2.45	2.24	1.57
H-26910	5.10	2.46	1.66	1.11	5.37	3.05	3.83	1.62
H-22234	4.88	1.68	1.64	0.40	4.63	2.35	2.02	0.63
Alachlor	3.77	0.63	0.70	0.22	6.70	2.75	2.65	0.80
Preemergence 6.72 kg/ha								
Metolachlor	5.68	2.40	1.85	0.96	4.86	3.67	1.94	0.71
H-26910	6.45	2.08	1.20	0.63	8.42	4.07	2.40	0.98
H-22234	4.45	1.27	0.99	0.30	8.16	4.44	2.03	0.59
Alachlor	5.55	1.28	1.06	0.19	5.73	3.12	1.35	0.35

[a]Values are the mean of three replications.

APPENDIX P

Table P-1. Soil persistence of several acetanilide herbicides 0 - 8 cm depth on a sandy clay loam soil 6.0% organic matter, 8 weeks after application.

Treatment	1976 Weeks after application				1976 Weeks after application			
	0	2	4	8	0	2	4	8
	(μg/g)[a]				(μg/g)[a]			
Preplant incorporated 3.36 kg/ha								
Metolachlor	3.05	2.24	2.04	1.55	2.43	2.21	2.58	1.42
H-26910	2.18	3.20	1.71	1.08	2.37	2.27	2.59	1.53
H-22234	1.89	2.62	0.75	0.57	2.10	1.94	1.68	0.73
Alachlor	2.16	2.70	0.52	0.29	2.15	1.04	1.32	0.61
Preemergence 3.36 kg/ha								
Metolachlor	5.60	1.85	1.05	0.72	4.80	3.10	1.02	0.88
H-26910	7.49	2.33	0.91	1.11	5.33	2.63	1.47	0.92
H-22234	5.69	1.58	0.87	0.31	4.90	3.05	0.57	0.37
Alachlor	4.27	0.74	0.30	0.12	4.58	1.79	0.60	0.24
Preplant incorporated 6.72 kg/ha								
Metolachlor	2.83	3.48	2.00	2.12	5.91	4.01	4.33	2.25
H-26910	3.52	4.95	2.25	2.73	6.09	5.82	4.83	2.31
H-22234	4.60	3.31	1.52	1.13	5.58	4.35	3.04	1.06
Alachlor	2.46	2.35	1.39	0.51	7.23	4.15	2.61	1.19
Preemergence 6.72 kg/ha								
Metolachlor	7.17	4.01	2.14	1.74	8.39	4.46	2.48	1.82
H-26910	7.55	4.90	2.41	1.59	9.07	5.48	3.19	1.85
H-22234	10.89	3.33	1.64	1.07	7.52	2.79	1.84	0.85
Alachlor	10.16	2.00	1.94	0.32	8.89	3.62	1.67	0.60

[a]Values are the mean of three replications.

APPENDIX Q

Table Q-1. Half life (t 1/2) of four acetanilide herbicides, applied at 2 methods of application, 2 rates, at 3 locations, over 2 years.

Main and interaction effect	Location I sandy clay loam 2.5% OM		Location II clay loam 4.1% OM		Location III sandy clay loam 6.0% OM	
	1976	1977	1976	1977	1976	1977
			(t 1/2 days)			
Date x Herbicide						
Metolachlor	19	24	31	22	21	28
H-26910	22	13	10	21	22	32
H-22234	16	21	8	17	13	19
Alachlor	11	10	7	14	10	12
Date x Method of Application						
Preplant incorporation	28	45	13	29	41	40
Preemergence	10	9	9	16	10	14
Date x Herbicide Rate						
3.36 kg/ha	18	17	11	16	15	22
6.72 kg/ha	18	13	10	16	17	20

[a]Values were plotted on a semilog scale with herbicide concentration on the log axis and date after application on the linear axis.

APPENDIX R

Table R-1. Soil persistence of several acetanilide herbicides 8 - 16 cm depth on a sandy clay loam soil 2.5% organic matter, 8 weeks after application.

Treatment	1976 Weeks after application 2	1976 4	1976 8	1977 Weeks after application 2	1977 4	1977 8
		(μg/g)[a]			(μg/g)[a]	
Preplant incorporated 3.36 kg/ha						
Metolachlor	0.05	ND	ND	0.03	0.08	ND
H-26910	0.06	ND	ND	0.04	0.09	ND
H-22234	0.05	ND	ND	0.01	0.04	ND
Alachlor	0.04	ND	ND	0.04	0.06	ND
Preemergence 3.36 kg/ha						
Metolachlor	0.04	ND	ND	0.03	0.04	ND
H-26910	0.06	0.03	ND	0.06	0.07	ND
H-22234	0.05	0.03	ND	0.08	0.06	ND
Alachlor	0.03	ND	ND	0.06	0.03	ND
Preplant incorporated 6.72 kg/ha						
Metolachlor	0.11	0.04	0.03	0.12	0.08	0.05
H-26910	0.06	0.03	ND	0.07	0.06	0.03
H-22234	0.10	0.03	ND	0.09	0.12	ND
Alachlor	0.07	0.04	ND	0.06	0.10	0.04
Preemergence 6.72 kg/ha						
Metolachlor	0.08	0.05	ND	0.16	0.10	0.04
H-26910	0.07	0.05	ND	0.12	0.15	0.03
H-22234	0.09	0.05	ND	0.09	0.12	ND
Alachlor	0.07	0.03	ND	0.13	0.08	ND

[a]Values are the mean of three replications.

[b]ND designates non-detectable residue.

APPENDIX S

Table S-1. Soil persistence of several acetanilide herbicides 8 - 16 cm depth on a clay loam soil 4.1% organic matter, 8 weeks after application.

Treatment	1976 Weeks after application			1977 Weeks after application		
	2	4	8	2	4	8
		(μg/g)[a]			(μg/g)[a]	
Preplant incorporated 3.36 kg/ha						
Metolachlor	0.07	ND	ND	0.05	0.03	ND
H-26910	0.08	ND	ND	0.04	0.05	0.03
H-22234	ND	ND	ND	0.03	ND	ND
Alachlor	ND	ND	ND	0.04	0.04	ND
Preemergence 3.36 kg/ha						
Metolachlor	ND	ND	ND	0.05	ND	ND
H-26910	0.03	ND	ND	0.05	0.06	0.03
H-22234	0.03	ND	ND	0.04	0.03	ND
Alachlor	ND	ND	ND	0.07	0.05	ND
Preplant incorporated 6.72 kg/ha						
Metolachlor	0.10	ND	ND	0.05	0.04	0.03
H-26910	0.08	0.03	ND	0.09	0.06	0.04
H-22234	0.07	ND	ND	0.05	0.03	ND
Alachlor	0.04	ND	ND	0.05	0.09	0.03
Preemergence 6.72 kg/ha						
Metolachlor	0.07	ND	ND	0.10	0.05	0.05
H-26910	0.08	ND	ND	0.07	0.07	0.03
H-22234	0.07	ND	ND	0.05	0.03	ND
Alachlor	0.10	ND	ND	0.06	0.08	0.04

[a]Values are the mean of three replications.

[b]ND designates non-detectable residue.

APPENDIX T

Table T-1. Soil persistence of several acetanilide herbicides 8 - 16 cm depth on a sandy clay loam soil 6.0% organic matter, 8 weeks after application.

Treatment	1976			1977		
	Weeks after application			Weeks after application		
	2	4	8	2	4	8
		($\mu g/g$)[a]			($\mu g/g$)[a]	
Preplant incorporated 3.36 kg/ha						
Metolachlor	0.04	ND	ND	0.08	0.10	ND
H-26910	0.04	ND	ND	0.05	0.09	ND
H-22234	0.05	ND	ND	0.05	0.06	ND
Alachlor	0.06	ND	ND	0.06	0.10	ND
Preemergence 3.36 kg/ha						
Metolachlor	0.06	ND	ND	0.07	0.06	ND
H-26910	0.06	ND	ND	0.09	0.06	0.03
H-22234	0.06	ND	ND	0.04	ND	ND
Alachlor	0.05	ND	ND	0.07	0.04	ND
Preplant incorporated 6.72 kg/ha						
Metolachlor	0.12	ND	ND	0.18	0.14	ND
H-26910	0.15	ND	ND	0.16	0.10	ND
H-22234	0.13	ND	ND	0.13	0.16	ND
Alachlor	0.16	ND	ND	0.19	0.15	ND
Preemergence 6.72 kg/ha						
Metolachlor	0.12	ND	ND	0.08	0.15	ND
H-26910	0.11	ND	ND	0.11	0.11	0.03
H-22234	0.19	ND	ND	0.12	0.11	0.04
Alachlor	0.13	0.03	ND	0.12	0.15	ND

[a]Values are the mean of three replications.

[b]ND designates non-detectable residue.

APPENDIX U

Table U-1. ^{14}C-acetanilide herbicide lateral diffusion on soil thin layer chromatography plates.

Treatment	Soil texture and organic matter		
	sandy clay loam 2.5% OM	clay loam 4.1% OM	sandy clay loam 6.0% OM
		(mm)	
Metolachlor	24	27	26
Alachlor	25	26	26
H-22234	26	28	28