AN ABSTRACT OF THE THESIS OF

Raouf Cherif for the degree of Master of Science

in Crop Science presented on December 18, 1985

Title: Cuphea wrightii Tolerance To Selected Herbicides

Abstract approved: Redacted for Privacy

Larry C. Burrill

The medium-chain triglyceride (MCT) oils, capric, caprylic, and lauric are important to the chemical industry as raw material for the production of surface-active agents, plasticizers, perfumes, and flavors. Species of the genus Cuphea synthesize in their seeds relatively high amounts of these oils. The present sources of medium-chain triglycerides are copra and palm kernels which are extracted from perennial crops. These perennial crops are grown in the tropics, especially Southeast Asia. Fluctuations in the production of copra and palm kernels due to weather conditions and bad harvesting years cause these products to be an unreliable source of MCT oils.

Because some species in the genus Cuphea have annual growth habits, there has been speculation that commercial production is feasible. Plant breeding studies are underway in an attempt to modify some of the undesirable

characteristics common to species of Cuphea. Concurrently, agronomic research is being conducted to learn how to grow the cuphea and to identify the most obvious production problems.

Cuphea wrightii is one of the promising species. Field studies were conducted in 1983, 1984, and 1985 to investigate Cuphea wrightii tolerance to selected herbicides and identify herbicides that could be used in cuphea research and commercial plantings without affecting seed production. Greenhouse experiments were conducted in 1984 to supplement field data.

Under greenhouse and field conditions, benefin, diclofop, fluazifop, sethoxydim, haloxyfop, and bromoxynil consistently caused little or no injury to cuphea. Benefin and propham were the only soil-applied herbicides that were safe on cuphea in the field studies, although propham caused serious injury in the greenhouse.

Several postemergence herbicides appeared to be safe on cuphea. Diclofop, fluazifop, sethoxydim, and haloxyfop are known to control many grass weeds. Only minor and temporary symptoms were observed on cuphea when these herbicides were used at rates two or three times normal field rates.

Bromoxynil was the only postemergence herbicide effective against broadleaf weeds with apparent safety on cuphea. In the 1985 field studies, bromoxynil seemed to cause a delay in flowering so further testing is recommended.

Results with desmedipham were inconsistent. Cuphea injury in the field trials was never more than 20%, but in the greenhouse experiments, cuphea injury was much greater. Because desmedipham is active against many broadleaf weeds, it probably should receive more testing.

Ethalfluralin, EPTC, trifluralin, chloramben, ethofumesate, and DCPA consistently caused too much cuphea injury to be considered as promising candidates for use on this crop.

The combination of bromoxynil or desmedipham with each of the grass control herbicides caused low to moderate cuphea injury 1 week after treatment, but by the end of the growing season, all cuphea plants recovered and had similar growth to that of the check. Caution is advised when using these herbicide combinations. Further research is needed to assess the extent of their safety on cuphea.

The field results left no doubt that atrazine, diuron, metribuzin, alachlor, napropamide, oxadiazon, oxyfluorfen, pronamide, simazine, terbacil, oryzalin, bentazon, 2,4-D, dalapon, glyphosate, paraquat, propanil, pendimethalin, dinoseb, dichlobenil, and chlorpropham are toxic to cuphea.

This research indicates that several herbicides with adequate safety on *Cuphea wrightii* are available. When two or more of these herbicides are used, many grass and broadleaf weeds will be controlled. It is equally certain that some weeds will not be controlled by these herbicides. The use of mechanical and cultural methods should be anticipated. As other promising species of cuphea are identified, they should be tested for tolerance to the promising herbicides identified in this work.

Cuphea wrightii TOLERANCE TO SELECTED HERBICIDES

by

Raouf Cherif

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Master of Science

Completed December 18, 1985

Commencement June 1986

APPROVED:

Redacted for Privacy

Assistant Professor of Crop Science in charge of Major

Redacted for Privacy

Head of Department of Crop Science

Redacted for Privacy

Dean of Graduate School

Date thesis is presented December 18, 1985

Typed by Raouf Cherif

ACKNOWLEDGMENTS

I thank my major professor, Larry C Burrill, for his help and guidance throughout the course of my graduate program. Also, I thank my other committee members Drs. Arnold P Appleby, Ray D William, and Thomas E Bedell for their time and suggestions about this thesis.

Special thanks to the Tunisia Agricultural Technology Transfer Project for the guidance and for providing the valuable opportunity to me to come to the USA and pursue my education.

TABLE OF CONTENTS

LIST OF APPENDIX TABLES

LIST OF TABLES

CUPHEA WRIGHTII TOLERANCE TO SELECTED HERBICIDES

INTRODUCTION

Cuphea wrightii of the family Lythraceae is native to tropical and subtropical areas of Central and South America. Seeds of the *Cuphea* genus contain a high level of medium-chain triglyceride (MCT) oils which are used in the production of detergents and dietetics. The only commercial source of MCT oils is from members of the Palmae (Arecaceae) family which are perennials grown in Southeast Asia. The annual growth habit and high MCT content of their oil have caused an increased interest in members of the *Cuphea* genus, most of which are wild.

Agronomic and breeding studies were started in 1975 to domesticate cuphea. Good field research cannot be conducted on a slow-growing plant like cuphea unless interference by weeds is eliminated. If cuphea is to be grown commercially, good weed control is essential.

Little is known about the effect of herbicides on members of the *Cuphea* genus. The research reported here was conducted on *Cuphea wrightii* to determine the reaction of that species to several commercial herbicides and to select herbicides that could be used in cuphea research and commercial plantations without jeopardizing seed production.

LITERATURE REVIEW

CUPHEA

Cuphea of the family Lythraceae is a diverse genus. More than 300 species have been described taxonomically, many of them by Koehne (1880). In 1963, Graham (1963) started systematic studies of the genus Cuphea and identified many new species in Mexico, Brazil, and the southern part of the United States.

Cuphea is native to tropical and subtropical areas of South and Central America. Varieties of Cuphea ignea (cigar flower) and Cuphea llavea Lex. (cinnabar cuphea) are popular ornamentals in warm areas of the United States (Miller et al. 1964).

Wilson et al. (1960) and Miller et al. (1964) discovered that oil from cuphea seeds contains a high concentration of medium-chain triglycerides. These were the first reports of a high concentration of these acids in seed-oil of a herbaceous plant. The high proportion of fatty acids with carbon-chain length of 12, 10, and 8 carbon atoms in cuphea seeds is unique among plant genera studied to date (Graham et al. 1981). These acids of medium-chain length, lauric (12:0),capric (10:0), caprylic (8:0), are important to the chemical industry as raw material for the production of surface-active agents, plasticizers, perfumes, flavors, and physiologically active compounds.

The present sources of medium-chain fatty acids are coconut copra and palm kernels which are produced in the tropics, especially Southeast Asia. Fluctuations in the production of these products, because of weather conditions and bad harvesting years, cause copra and palm kernels to be an unreliable source (Miller et al, 1964; and Robbelen and Hirsinger,1982).

Miller et al (1964) reported that in 1962 the United States imported 807 million pounds (366 million kilograms) of lauric acid oils, 90% of which came from coconuts. A domestic source of medium-chain fatty acids would be strategically important and would be helpful to the chemical industry if sufficiently economical. The annual life-cycle and relatively high content of mediuum-chain triglycerides in the seed lipids of Cuphea spp. have led to strong interest in this genus.

Breeding studies and agronomic research began in 1975 to determine the feasibility of modifying cuphea and growing it as a commercial crop. Strong interest and financial support by chemical companies resulted in studies being started at the University of Gottingen, West Germany, and later continued at the University of California at Davis. In 1983, the USDA, Procter and Gamble Company, and Oregon State University initiated an agronomic research and development program on cuphea as a potential new crop for the United States. During the first years of research, wild strains of different origin representing many *Cuphea* species were grown and studied.

Cuphea wrightii, *Cuphea laminuligera*, and *Cuphea leptopoda* were found to be promising as they have good seed quality, sufficient plant height, and high yield (Hirsinger, 1982). However, all *Cuphea* species exhibit wild plant characteristics which impede their agricultural utilization. These include dormancy caused by hard seed coats, viscid glandular hairs on flowers and stems, indeterminate inflorescence, and premature shattering of the seed conditioned by a genus-specific zygomorphy of the flower (Hirsinger, 1981; and Thompson, 1984).

Successful field research and crop production depend on adequate control of weeds. This is especially true for a slow-growing crop such as cuphea.

The first attempts to control weeds in cuphea plantations were in West Germany where the first agronomic research was done. Desiccating-herbicides like paraquat were applied to weeds just before cuphea emergence. A soil disinfectant, dazomet, was tried, too. It was successful when applied 3 weeks before planting, but it is expensive (Hirsinger, 1981)

At the University of California, Davis, a screening trial was conducted in which trifluralin at 0.84 kg/ha, EPTC at 3.36 kg/ha, and alachlor at 3.36 kg/ha were applied before planting and incorporated into the soil. Pendimethalin, DCPA, and napropamide at 1.12, 8.96, and 2.24 kg/ha respectively were surface sprayed before plant emergence. Promising results with trifluralin, EPTC, and DCPA with 20%, 20%, and 10% injury, respectively, were reported (Hirsinger, 1982).

Based on those results, trifluralin was used on large research blocks in Davis, California, at 0.56 kg/ha and Corvallis, Oregon, at 0.48 kg/ha. A slight decrease in the yield was suspected to be due to trifluralin use (Hirsinger, 1983).

At the Southern Oregon Research Station near Medford, screening of herbicides was conducted in the greenhouse on a Central Point sandy loam soil. Trifluralin and EPTC, at 0.84 and 3.36 kg/ha, respectively, were applied pre-plant and incorporated into the soil. DCPA at 6.72 kg/ha, and nitrofen, chlorpropham and propachlor at 4.48 kg/ha each were sprayed on the soil surface prior to crop emergence. Oxyfluorfen, chloroxuron, chlorpropham, and DCPA at 0.56, 3.36, 4.48, and 6.72 kg/ha, respectively, were applied on the cuphea foliage after emergence. Only trifluralin and DCPA were reported to be promising (Yungen, 1984).

PROPERTIES OF SELECTED HERBICIDES USED IN THIS STUDY

Common names, trade names, and chemical names of chemicals discussed or used in this study are in Appendix Table 44.

BENEFIN

Benefin belongs to the dinitrobenzeneamine (or dinitroaniline) herbicide family . It is a yellow liquid with a high vapor pressure. This means that benefin is volatile enough to require mechanical incorporation into the soil to prevent chemical loss. Application and incorporation can be pre-plant or postplant (WSSA handbook, 1983). It is formulated as an emulsifiable concentrate or as granules.

Benefin controls a wide range of grass and broadleaf weeds, including annual bluegrass (*Poa annua* L.), foxtails (*Setaria* spp.), common lambsquarters (*Chenopodium album* L.), and pigweeds (*Amaranthus* spp.). It is commonly used to control weeds in lettuce (*Lactuca biennis* (Moench.) Fern.), alfalfa (*Medicago sativa* L.), clover (*Trifolium* spp.), peanut (*Arachis hypogea* L.), and established turfgrasses. It is normally used at 1.3 to 1.7 kg/ha for adequate control of annual grass and broadleaf weeds.

Benefin is not translocated in plants, but burns the emerging seedlings (WSSA handbook 1983).

PROPHAM

Propham belongs to the carbamate family of herbicides. It has high vapor pressure and sublimes slowly at room temperature. It acts as a selective pre-planting, preemergence, and postemergence herbicide. Applied postemergence, propham has limited efficacy, so it is almost exclusively applied through the soil (Ashton and Crafts, 1981). In warm and moist soils, propham is rapidly degraded by soil microorganisms. Because of this and its highly volatile nature, propham has proved most useful in cool-season crops and in cool-weather areas.

Propham effectively controls many annual grass weeds and certain broadleaf weeds: Italian ryegrass (*Lolium multiflorum* Lam.), downy brome (*Bromus tectorum* L.), annual bluegrass, wild oats (*Avena* spp.), canarygrass (*Phalaris arundinacea* L.). Broadleaf weeds controlled include field dodder (*Cuscuta campestris* Yunck.), seedlings of curly dock (*Rumex crispus* L.) and red sorrel (*Rumex acetosella* L.), and purslane (*Portulaca oleracea* L.). Crabgrass (*Digitaria sanguinalis* (L.) Scop.), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv,), yellow foxtail (*Setaria lutescens* (Weigel.) Hubb), and giant foxtail (*Setaria faberii* Herrm.) are tolerant (WSSA handbook, 1983). Propham has been widely used to control grasses in tolerant crops such as sugarbeets (*Beta vulgaris* ,L.) soybeans (*Glycine max* (L.)Merr.), flax

(Linum usitatissimum L.), sunflower (Helianthus annuus L.), rape (Brassica napus L.), onion (Allium cepa L.), garlic (Allium sativum L.), and mustard (Brassica spp). Established perennial grasses grown for seed are generally tolerant. Wheat (Triticum aestivum L.) is tolerant only at low levels of application. Propham is toxic to oats, barley (Hordeum vulgare L.), rice (Oryza sativa L.), corn (Zea mays L.), fescue (Festuca spp.), and quackgrass (Agropyron repens (L.) Beauv).

Propham acts on the plants through the roots and emerging shoots. Weed control is enhanced by rainfall or irrigation soon after application to move the herbicide into the root zone. It is absorbed through cut surfaces of leaves of emerging grass seedlings and to a lesser degree by the roots of plants. Intact surfaces did not absorb an appreciable amount of propham. Once absorbed by the roots, a portion of propham is translocated to the shoot apoplastically and the rest is metabolized in the roots (Ashton and Crafts, 1981).

At the cellular level, propham disrupts normal cell division, inhibits protein and amylase synthesis, inhibits photolytic activity of isolated chloroplasts, and affects activity of messenger RNA (WSSA handbook, 1983).

GRASS CONTROL HERBICIDES

Diclofop, fluazifop, sethoxydim, and haloxyfop belong to the new group of herbicides known to be active on many grass species and safe on broadleaf plants.

Diclofop belongs to the diphenyl ether herbicide family (Ashton and Crafts, 1981). It is similar to sethoxydim and haloxyfop in that it kills many grasses, but differs by being safe on wheat and barley which makes it useful to control grass weeds in these crops.

Diclofop is widely used for control of wild oats, Italian ryegrass , green foxtail (*Setaria viridis* (L.) Beauv.), and barnyardgrass in wheat and barley.

It is commonly applied early postemergence for control of weeds, but is also effective as a preemergence or pre-plant incorporated treatment. Diclofop should be incorporated into the soil to give adequate control of members of the *Bromus* genus.

Fluazifop and sethoxydim are not safe on wheat and barley, but they are safe on all broadleaf crops and weeds tested (WSSA handbook 1983). They are now registered for use in soybeans and cotton (*Gossypium* sp.). They are applied postemergence to the crop and the weeds and control most annual grasses and some perennials including perennial bluegrass (*Poa pratensis* L.). Some fine-leaf fescues including red fescue (*Festuca rubra* L.)

and rattail fescue (<u>Vulpia</u> <u>myuros</u> (L.)K.C. Gmel.) have been found conspicuously tolerant to sethoxydim.

The mode of action of this group of herbicides is still under study, but they seem to inhibit the meristimatic activity by degradation of the chloroplast membrane (WSSA handbook 1983).

<u>DESMEDIPHAM AND PHENMEDIPHAM</u>

Desmedipham and phenmedipham have similar herbicidal properties, and they both belong to the family of carbamate herbicides.

Desmedipham controls many broadleaf weeds including redroot pigweed (<u>Amaranthus</u> <u>retroflexus</u> L.), mustards (<u>Brassica</u> spp.), common lambsquarters, and nightshades (<u>Solanum</u> spp.). Phenmedipham is active against many annual weeds such as foxtails, dogfennel (<u>Anthemis</u> <u>cotula</u> L.), and common purslane, but unlike desmedipham it does not control pigweed.

Desmedipham and phenmedipham are widely used to control weeds in sugarbeets. They are applied postemergence to the crop and weed. They are absorbed by the leaves and act by blocking the Hill-reaction in the photosynthetic process.

Because they are both used on sugarbeets and have similar properties, they are often mixed in a 1:1 ratio to control a wider range of weeds. The mixture is marketed under the trade name Betamix. It is formulated as an emulsifiable concentrate and contains 0.16 kg/ha of chemical/l (WSSA handbook, 1983).

BROMOXYNIL

Bromoxynil belongs to the nitrile family of herbicides. It is used postemergence for control of broadleaf weeds in grass crops such as oats (Avena sativa L.), rye (Secale cereale L.), flax, wheat, and barley, at the rates of 0.56 to 1.12 kg/ha. It is mainly used to control broadleaf weeds that do not respond to the phenoxy herbicides, e.g. fiddleneck (Amsinckia intermedia Fisch and Mey.) and wild buckwheat (Polygonum convolvulus L.). The stage of growth of the crop and the weed, as well as spray volume, are critical for crop safety (Ashton and Crafts, 1981).

Bromoxynil is formulated as an emulsifiable concentrate. It is absorbed into the leaves and not translocated in the plant (Audus, 1976). It acts as a photosynthetic and respiratory inhibitor.

FIELD RESEARCH

General Materials and Methods

Field experiments were conducted during 1983, 1984, and 1985 at the Oregon State University Hyslop Research Farm, located 11 km NE of Corvallis. The soil was a Woodburn silt loam, a member of the fine, silty, mesic family of Aquultic Argixerolls. Prior to planting, 224 Kg/ha of 16:20:0(N:P:K) fertilizer was mixed into the seedbed.

Planting was done in 1983 and 1984 with "Planet Jr" seeders mounted on a tractor tool bar, and with an "Oyjord" seeder in 1985. Seeds were placed in the soil about 0.5 cm deep.

Herbicides were applied uniformly with a hand-pushed sprayer with a 1 m boom for the 1983 trial and a 2 m boom for the 1984 and 1985 trials. "Tee Jet" 8004 flat fan nozzles were used.

The experiments were irrigated with sprinklers as needed.

HERBICIDE SCREENING 1983

Materials and Methods

Twenty-four commercial herbicides were tested to determine their level of activity on cuphea. Herbicides were applied at three rates, with the middle being a normal commercial rate for other crops. The pre-plant treatments were sprayed and mechanically incorporated into the soil just before seeding cuphea on June 22, 1983. Preemergence treatments were applied on June 24, and postemergence treatments were sprayed on July 17, when a few plants had started to bloom. Treatments were replicated twice in a randomized complete block design. Each plot was 7 by 1.5 m and contained four rows of cuphea each 25 cm apart. A spray volume of 280 l/ha was used at a pressure of 172 kPa.

Frequent visual estimates of cuphea injury were recorded.

Results

Cuphea response to the herbicides was from complete mortality to no effect. EPTC and trifluralin caused obvious injury symptoms at the lowest rates tested; 1.68 and 0.56 kg/ha respectively (Table 1), even though they had been reported to be safe on cuphea.

Among the preemergence herbicides tested, only propham did not cause visible symptoms on cuphea. The other preemergence herbicides caused unacceptable injury to cuphea, at the tested rates (Table 1).

Table 1. Average percent injury of cuphea 4 weeks and 12 weeks after treatment with pre-plant incorporated and preemergence herbicides, at three rates in 1983.

Herbicides	Rates	Cuphea injury 4 weeks	Cuphea injury 12 weeks
	(kg/ha)	(%)	(%)
Pre-plant			
EPTC	1.68	85	50
	3.36	85	80
	6.72	85	80
Trifluralin	0.56	90	55
	1.12	90	75
	1.68	90	85
Preemergence			
Atrazine	1.12	100	100
	2.24	100	100
	4.48	100	100
Diuron	1.12	100	100
	2.24	100	100
	4.48	100	100
Alachlor	2.24	100	85
	4.48	100	100
	6.72	100	100
Metribuzin	0.56	100	100
	1.12	100	100
	2.24	100	100
Napropamide	1.12	95	75
	2.24	95	85
	4.48	95	95
Oxadiazon	2.24	100	100
	4.48	100	100
	6.72	100	100

(continued on next page)

Table 1. (continued)

Herbicides	Rates	Cuphea injury 4 weeks	Cuphea injury 12 weeks
	(kg/ha)	(%)	
Oxyfluorfen	1.12	100	100
	2.24	100	100
	3.36	100	100
Pronamide	2.24	100	100
	4.48	100	100
	6.72	100	100
Propham	2.24	0	0
	4.48	0	0
	6.72	0	0
Simazine	1.12	100	100
	2.24	100	100
	4.48	100	100
Terbacil	0.56	100	100
	1.12	100	100
	2.24	100	100
Oryzalin	0.56	97	70
	1.12	97	85
	2.24	97	100
Check	----	0	0

The postemergence grass killers: fluazifop, diclofop, and sethoxydim had no noticeable effect on cuphea at the highest rates used; 1.12, 1.12, and 2.24 kg/ha, respectively.

Cuphea was also tolerant to bromoxynil and desmedipham at the highest rates used; 1.12 and 2.24 kg/ha, respectively, applied as postemergence treatments (Table 2).

Table 2. Average percent injury of cuphea 2 weeks and 8 weeks after the postemergence herbicides application at three rates in 1983.

		Cuphea injury	
Herbicides	Rates	2 weeks	8 weeks
	(kg/ha)	(%)	
Bentazon	1.12	35	50
	2.24	60	70
	4.48	95	100
Bromoxynil	0.28	0	0
	0.56	0	0
	1.12	0	0
2,4-D	0.28	30	90
	0.56	40	90
	1.12	50	90
Dalapon	2.80	20	40
	5.60	30	60
	11.20	90	90
Glyphosate	0.56	90	90
	1.12	100	100
	2.24	100	100
Paraquat	0.28	20	55
	0.56	30	50
	1.12	40	70
Sethoxydim	0.28	0	0
	0.56	0	0
	1.12	0	0
Fluazifop	0.28	0	0
	0.56	0	0
	1.12	0	0
Desmedipham	0.56	0	0
	1.12	0	0
	2.24	0	10
Diclofop	0.56	0	0
	1.12	0	0
	2.24	0	0
Check	----	0	0

HERBICIDE SCREENING 1984

Materials and Methods

Seven herbicides from the 1983 screening trial and 11 additional herbicides were included in the 1984 screening trial (Tables 3 and 4). Plots were 2.7 by 1.8 m and contained four rows of cuphea 40 cm apart. Treatments were replicated two times and arranged in a randomized complete block design. Two rates of each herbicide were applied. The pre-plant incorporated and preemergence treatments were applied on the day of seeding, June 14, 1984. Postemergence treatments were sprayed on August 3, which was 7 weeks after seeding.

A spray volume of 350 l/ha was used, at a pressure of 276 kPa.

Cuphea injury in comparison to an untreated check was estimated at three dates. The height of plants not killed by herbicides was recorded 15 weeks after application of the soil-active herbicides and 8 weeks after the foliage-active treatments were sprayed. Before the postemergence treatments were applied and because of pigweed infestation, the plots were weeded and kept free of weeds by frequent hand weeding.

Results

As in the 1983 screening trial, EPTC and trifluralin reduced growth of cuphea seedlings and the surviving plants did not grow normally. Ethalfluralin caused an initial effect similar to trifluralin, but the cuphea made better recovery and the top growth was normal (Table 3).

Of the nine herbicides applied to the soil prior to cuphea emergence, only propham and benefin did not cause injury symptoms at rates required for adequate weed control. Chloramben at 2.24 kg/ha, ethofumesate at 1.68 kg/ha, and DCPA at 5.6 kg/ha caused no more than 20% injury to cuphea. Each of these treatment rates would normally be expected to give adequate control of susceptible weeds. When the rate of these herbicides was doubled, cuphea injury was high (Table 3).

Sethoxydim, fluazifop, diclofop and haloxyfop did not cause serious injury to cuphea. Bromoxynil did not injure cuphea at 1.12 kg/ha, but caused serious injury at 2.24 kg/ha (Table 4).

Table 3. Average percent injury of cuphea 6 weeks and 15 weeks after application of three pre-plant incorporated and nine preemergence herbicides in the 1984 screening trial.

		Cuphea injury	
Herbicides	Rates	6 weeks	15 weeks
	(kg/ha)	(%)	
Pre-plant			
Ethalfluralin	0.56	35	20
	1.12	30	15
EPTC	1.68	30	25
	3.36	60	80
Trifluralin	0.56	30	35
	1.12	85	65
Preemergence			
Benefin	1.12	0	0
	2.24	0	0
Chloramben	2.24	65	15
	4.48	100	90
Chlorpropham	4.48	80	70
	6.72	75	50
Dichlobenil	2.24	100	100
	4.48	100	100
Dinoseb	3.36	65	50
	6.72	100	100
Ethofumesate	1.68	55	15
	3.36	55	20
Pendimethalin	0.56	55	35
	1.12	100	100
DCPA	5.60	40	15
	11.20	45	30
Propham	2.24	0	5
	4.48	0	5
Check	----	0	0

Table 4. Average percent injury of cuphea 2 weeks and 8 weeks after application of seven postemergence herbicides in the 1984 screening trial.

		Cuphea injury	
Herbicides	Rates	2 weeks	8 weeks
	(kg/ha)	------------(%)-----------	
Haloxyfop	0.28	5	0
	0.56	25	0
Propanil	2.24	100	90
	4.48	100	100
Bromoxynil	1.12	15	10
	2.24	45	40
Sethoxydim	0.56	20	0
	1.12	5	0
Fluazifop	0.56	30	0
	1.12	0	0
Desmedipham + phenmedipham	1.12	90	10
	2.24	95	45
Diclofop	1.12	15	0
	2.24	30	0
Check	----	0	0

HERBICIDE COMBINATION TRIAL 1984

Materials and Methods

The promising postemergence herbicides from the 1983 screening trial were used in a test designed to produce data on cuphea seed yield. Each herbicide was applied at a single rate alone, and in selected combinations. The herbicide combinations were considered to be important because the herbicides were known to be most effective on either grass weeds or on broadleaf weeds. Desmedipham was used in the 1983 screening trial and did not injure cuphea. In the 1984 herbicide combination trial, a combination of desmedipham and phenmedipham was used as a single herbicide. These closely related herbicides are often combined to control a wider range of weeds in sugar beets.

Cuphea was planted in rows 60 cm apart with four rows in each 2.7 by 2.4 m plot. All treatments were sprayed on August 3, 1984 which was 7 weeks after planting. A randomized complete block design with three replications was used. A pressure of 276 kPa was used to produce a spray volume of 350 l/ha.

Soon after cuphea emergence, it became obvious that a dense population of pigweed would soon dominate the crop. Because the effect of herbicide on the cuphea was the objective of the experiment, weeds were removed from the experiment by hand, and plots were kept relatively weed-free for the duration of the experiment.

Injury from the treatments compared to the untreated check were recorded by visual estimates. Plant heights were measured 8 weeks after the treatments were applied.

Eleven weeks after the postemergence treatments were applied, the experiment was terminated and cuphea samples were taken from the two middle rows of each plot for fresh weight and dry weight measurements. Each row was divided into three equal sections and all of the plants in one randomly selected section in each row were harvested. The two samples were combined and weight of the fresh material was determined. After 4 days of drying at 65 C, the weights of the dry samples were recorded.

Results

Diclofop and fluazifop did not cause any injury to cuphea when used alone. The combination of each of them with bromoxynil or desmedipham/phenmedipham caused serious injury to cuphea. Since the desmedipham/ phenmedipham treatment caused serious injury to cuphea, the injury occurring when these chemicals were combined with diclofop or fluazifop was no surprise. But bromoxynil did not cause serious injury to the crop when used alone. Cosequently, injury resulting from the bromoxynil combination with diclofop or fluazifop was not expected (Table 5).

There were no significant differences in plant heights among treatments. (Appendix Table 11).

Measuring grain yield, which was the objective of this trial, was not possible because of the irregularity of emergence, the delay in planting, and especially because of the problem of seed shattering before full maturity. To have an indication of potential seed yield, the inflorescence length was measured. There were no differences between means of inflorescence length (Appendix Table 12).

Dry-matter weights of cuphea reflected the visible injury levels of the different treatments.

Table 5. Average percent injury, dry weigt, and percent dry weight change of cuphea after postemergence herbicides application, in the herbicide combination trial in 1984.

Herbicides	Rates	Cuphea inj[a] 2 wks	Cuphea inj[a] 8 wks	D.W[b]	D.W.chg[c]
	(kg/ha)	----(%)----		--(g)--	--(%)--
Bromoxynil	0.28	5	5	175 abcd	- 5
Desmedipham + phenmedipham	0.56 0.56	85	45	100 cde	- 46
Diclofop	0.56	0	0	195 ab	+ 5
Fluazifop	0.28	0	0	225 a	+ 22
Bromoxynil + diclofop	0.28 0.56	40	30	135 a-e	- 27
Bromoxynil + fluazifop	0.28 0.28	40	30	130 bcde	- 30
Desmed/phenmed + diclofop	0.56 0.56	80	60	75 e	- 59
Desmed/phenmed + fluazifop	0.56 0.28	90	45	85 cde	- 54
Check	----	0	0	185 abc	0

a Cuphea injury at 2 weeks and 8 weeks

b Average Dry Weight of cuphea. Values having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

c Dry Weight change as a percentage of the check.

SCREENING TRIAL 1985

Materials and Methods

Eight herbicides from the 1984 screening trial were tested in this experiment for further assessment of their effect on cuphea. Plots were 5 by 2.5 m. A commercial rate of each herbicide was used. Treatments were replicated three times and arranged in a randomized complete block design.

Of the herbicides used, two were applied pre-plant and incorporated into the soil just before planting on June 13, 1985. On June 17, 1985, the preemergence herbicides were sprayed. Asulam was applied on July 23, 1985, which was 6 weeks after seeding. A spray volume of 350 l/ha was used at a pressure of 276 kPa.

Plots were kept weed free by frequent hoeing and injury levels were recorded throughout the crop season.

Results

Applied pre-plant and incorporated into the soil or on the soil surface preemergence to the plants, benefin caused no visible injury to cuphea. Propham caused 10% injury. Asulam, ethalfluralin, chloramben, ethofumesate, and DCPA caused nonacceptable levels of injury to cuphea (Table 6).

Table 6. Average percent injury of cuphea 2 weeks and 10 weeks after treatment, in the 1985 screening trial.

Herbicides	Rates	Cuphea injury 2 weeks	Cuphea injury 10 weeks
	(kg/ha)	(%)	
Pre-plant			
Ethalfluralin	1.12	60	40
Benefin	1.68	5	3
Preemergence			
Benefin	1.68	3	3
Chloramben	3.36	95	95
Ethofumesate	2.80	85	90
DCPA	8.40	50	50
Propham	5.04	15	10
Postemergence			
Asulam[a]	2.80	--	70
Check	----	0	0

a Asulam was not sprayed at that time.

HERBICIDE COMBINATION TRIAL 1985

Materials and Methods

Testing of the most promising postemergence herbicides was continued in 1985. Also, to broaden the spectrum of weed control in future cuphea plantings, the broadleaf killers bromoxynil and desmedipham, and the grass killers diclofop, fluazifop, sethoxydim, and haloxyfop were used in combinations at two rates.

Cuphea was planted on June 13, 1985, in 5 by 2.5 m plots, with 4 rows per plot. Treatments were replicated three times in a randomized complete block design. The herbicides were sprayed on July 23, 1985, which was about 6 weeks after seeding. A spray volume of 350 l/ha at a pressure of 276 kPa was used.

Plots were kept weed free during the season by frequent hand weeding. Visual estimates of injury were recorded. At the end of the cropping season, plant heights were measured.

For indications of treatment effect on grain yield, visual estimates of flower reduction compared to the check were recorded at the end of the season, and inflorescence length were measured.

Samples for dry weight measurement were taken from each plot at the end of the season. All of the plants were cut from 6 feet of each of the two middle rows. These samples were dried at 65 C for 4 days and dry weights per plot were recorded.

Results

One week after spraying, all the combination treatments caused injury ranging from 20 to 70%, at the low and high rates used (Appendix Table 16). This injury consisted of bleaching symptoms on the leaves of cuphea plants and sometimes necrosis of some leaf margins. One week later, the injury symptoms tended to disappear slowly and were covered by new growth material. By the end of the season, plants in all treatments had recovered from these early injuries (Table 7 and Appendix Tables 17 and 18).

When applied alone, phenmedipham caused 25% injury at both rates used. Desmedipham and bromoxynil caused 20% and 15% injury, respectively, at the high rate used. They did not cause any visible injury at the lower rate. These injuries were noticed 1 week after spraying and the cuphea recovered from these injuries by the end of the season.

Again this year, none of the grass killers tried caused any noticeable injury to cuphea at any time during the cropping season.

At the end of the season, there were no differences between treatment means in plant height (Appendix Table 19), inflorescence length (Appendix Table 20), or dry weight (Table 7 and Appendix Table 22) of cuphea plants. There were no significant differences in flower reduction between treatment means (Table 7 and Appendix Table 21).

Table 7. Average percent injury, flower reduction, and dry weight of cuphea in the 1985 herbicide combination trial.

Herbicides	Rates	Cuphea inj[a] 1 wk	6 wks	Flr Red[b]	D.W[c]
	(Kg/ha)	----(%)----		--(%)--	-(g)--
Bromoxynil	0.56	3	0	0	638 ns
	1.12	15	3	3	521
Sethoxydim	0.56	0	0	0	642
	1.12	0	0	0	561
Fluazifop	0.14	3	3	0	566
	0.56	0	0	0	636
Diclofop	0.84	0	0	0	447
	1.40	3	3	0	536
Haloxyfop	0.28	3	3	0	537
	0.56	0	0	0	695
Bromoxynil + diclofop	0.56 + 0.84	7	3	0	501
	1.12 + 1.40	20	7	7	507
Bromoxynil + fluazifop	0.56 + 0.14	3	3	0	626
	1.12 + 0.56	40	10	10	480
Bromoxynil + sethoxydim	0.56 + 0.56	20	6	3	479
	1.12 + 1.12	50	15	7	475
Bromoxynil + haloxyfop	0.56 + 0.28	20	7	0	560
	1.12 + 0.56	40	13	7	491
Desmedipham	0.84	10	2	0	554
	1.40	20	8	0	400
Phenmedipham	1.12	25	0	0	482
	1.68	25	3	0	533

(continued on next page)

a cuphea injury at 1 week and 6 weeks.

b Average percent flower reduction of cuphea comparing to the chek, 6 weeks after treatment.

c Dry Weight: Values in this column are not significantly different as determined by Duncans multiple range test at the 5% level.

Table 7. (continued)

Herbicides	Rates	Cuphea inj[a] 1 wk	6 wks	Flr Red[b]	D.W[c]
	(Kg/ha)	----(%)----		--(%)--	-(g)--
Desmedipham + phenmedipham	0.84 + 0.84	50	10	0	453 ns
	1.40 + 1.40	70	10	7	460
Desmedipham + diclofop	0.84 + 0.84	25	0	0	587
	1.40 + 1.40	50	7	0	478
Desmedipham + fluazifop	0.84 + 0.14	20	3	0	635
	1.40 + 0.56	30	5	0	503
Desmedipham + sethoxydim	0.84 + 0.56	25	3	0	503
	1.40 + 1.12	30	10	3	408
Desmedipham + haloxyfop	0.84 + 0.28	20	3	0	606
	1.40 + 0.56	20	0	0	637
Check + Oil	----	0	0	0	727
Check	----	0	0	0	629

a cuphea injury at 1 week and 6 weeks.

b Average percent flower reduction of cuphea comparing to the chek, 6 weeks after treatment.

c Dry Weight: Values in this column are not significantly different as determined by Duncans multiple range test at the 5% level.

GREENHOUSE RESEARCH

In 1984, studies were conducted in the greenhouse to confirm field data on cuphea tolerance to selected herbicides.

General Methods and Materials

In all greenhouse experiments, plants were grown in 7.5 by 7.5 cm plastic pots. The soil was a standard greenhouse mix containing equal parts by volume of loam, sand, and peat. The cuphea seeds were planted in three rows, 3 cm apart in each pot. Two weeks after germination, all but six plants were removed from each pot. Subirrigation was given as needed.

Herbicides were applied uniformly to the plants and soil with a "Tee Jet" 8004 flat-fan nozzle on a track-mounted sprayer moved across the pots by a motor driven chain. Compressed air at a pressure of 276 kPa was used to provide a spray volume of 350 l/ha.

Experiment I was conducted in the summer, so 3 weeks after cuphea germination the pots were taken outdoors to encourage hardiness of the plants. The pots were out of the greenhouse 1 week prior to spraying and for 1 week after spraying. Two weeks after the postemergence herbicides were applied, plant heights were measured and visual estimates of cuphea injury were recorded. On the same day, the above-ground plant material was harvested and dry weight of all samples was recorded after 3 days of drying at 40 C.

EXPERIMENT I

Materials and Methods

Seventeen herbicides tested in the field trials were also tested in the greenhouse to supplement information on cuphea tolerance. Four rates of each herbicide were used. At least two rates were higher than normally required to give good control of susceptible weeds.

The pre-plant treatments were sprayed and incorporated into the soil a few minutes before seeding on August 9, 1984. Preemergence treatments were sprayed the same day. Postemergence treatments were sprayed on September 10, 1984.

All treatments were replicated twice and arranged in a randomized complete block design. The pots of each replication were placed in a separate greenhouse tray.

Results

In contrast to results of the field research at the same rates, trifluralin and ethalfluralin killed the cuphea in this greenhouse experiment. Propham also was more toxic to cuphea under greenhouse conditions than in the field experiments. It did not cause injury at 1.12 kg/ha, but at higher rates the plants were stunted about 50% compared to untreated plants. There was little or no injury at these rates in the field experiments. Benefin gave results consistent with performance in the field research by causing no visible symptoms in the greenhouse.

The postemergence herbicides, bromoxynil, sethoxydim, fluazifop, diclofop, and haloxyfop apparently caused minor injury to cuphea. Visual ratings consistently indicated more injury at the low rates than at the high rates for reasons that are not understood. Plant heights were not reduced by these treatments.

When bromoxynil was combined with either diclofop, fluazifop, sethoxydim, or haloxyfop, phytotoxicity was increased. At rates normally used to control susceptible weeds, injury ratings were consistently below 10% (Table 8 and Appendix Table 23). In spite of obvious injury symptoms, the plant heights were not reduced by these treatments (Appendix Tables 24 and 25).

Asulam caused no more than 15% injury at 1.12 or 1.68 kg/ha, but injury increased to 25 and 33% at 3.92 and 7.84 kg/ha, respectively. Plant heights and dry weights were not reduced.

Desmedipham which caused no injury to cuphea in the 1983 field trial, caused injury greater than 65% in the greenhouse experiment at the same range of rates (Table 8 and Appendix Table 23). Plant heights were not reduced but dry weights were (Appendix Tables 24 and 25).

Weights of the dried cuphea supported results of visual evaluations. Sethoxydim, fluazifop, diclofop, haloxyfop, and bromoxynil did not reduce dry weights compared to the check. Asulam did not reduce the weight of the dried plant material though injury symptoms were apparent when plants were treated with rates as high as 7.84 kg/ha.

Based on visual symptoms, when bromoxynil was combined with any of the four postemergence grass herbicides, sethoxydim, fluazifop, diclofop, and haloxyfop, there was more injury to cuphea than when the herbicides were used alone. At two times the rates normally required for grass control, only sethoxydim or haloxyfop combinations with bromoxynil caused serious injury to cuphea. Approximately four times the normal use rates of diclofop and bromoxynil or fluazifop and bromoxynil were required to cause serious injury. The dry weights of plants receiving these treatments did not reflect the visible injury symptoms (Appendix Table 25).

Table 8. Average percent injury and dry weight of cuphea 6 weeks after planting in greenhouse experiment I.

Herbicides	Rates	Percent injury	Dry weight[a]
	(Kg/ha)	----(%)----	----(mg)----
Pre-plant			
Trifluralin	0.28	100	0
	0.56	100	0
	1.12	100	0
	1.68	100	0
Ethalfluralin	0.28	100	0
	0.56	100	0
	1.12	100	0
	1.68	100	0
Preemergence			
Benefin	1.12	0	25 a-f
	1.40	0	18 d-j
	1.68	0	22 c-i
	2.24	5	19 d-j
Propham	1.12	0	23 c-h
	4.48	50	17 e-j
	6.72	55	18 d-j
	8.96	55	15 g-j
Postemergence			
Bromoxynil	0.56	5	22 c-i
	1.12	5	21 c-j
	1.68	5	19 d-j
	2.24	10	24 b-g
Sethoxydim	0.11	15	24 b-g
	0.56	10	33 ab
	1.12	10	23 c-h
	2.24	10	18 d-j
Fluazifop	0.14	0	27 a-d
	0.56	5	21 c-j
	1.12	0	25 a-f
	2.24	0	26 a-e
Diclofop	0.84	5	20 c-j
	1.12	5	20 c-j
	1.40	10	19 d-j
	3.36	0	23 c-h

(continued on next page)

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

Table 8. (continued)

Herbicides	Rates	Percent injury	Dry weight[a]
	(Kg/ha)	----(%)-----	----(mg)----
Haloxyfop	0.28	5	23 c-h
	0.56	10	20 c-j
	1.12	0	26 a-e
	2.24	10	20 c-j
Bromoxynil + diclofop	0.56 + 0.84	5	20 c-j
	1.12 + 1.12	10	15 g-j
	1.68 + 1.40	10	21 c-j
	2.24 + 3.36	35	15 g-j
Bromoxynil + fluazifop	0.56 + 0.14	0	17 e-j
	1.12 + 0.56	0	28 a-d
	1.68 + 1.12	10	21 c-j
	2.24 + 2.24	80	20 c-j
Bromoxynil + sethoxydim	0.56 + 0.11	5	20 c-j
	1.12 + 0.56	25	16 f-j
	1.68 + 1.12	50	17 e-j
	2.24 + 2.24	50	15 g-j
Bromoxynil + haloxyfop	0.56 + 0.28	10	18 d-j
	1.12 + 0.56	45	12 j
	1.68 + 1.12	50	17 c-j
	2.24 + 2.24	50	16 f-j
Desmedipham	0.56	65	15 g-j
	0.84	80	16 f-j
	1.40	80	19 d-j
	2.24	95	13 ij
Phenmedipham	1.12	85	15 g-j
	1.40	90	16 f-j
	1.68	90	18 d-j
	3.36	95	16 f-j
Asulam	1.12	10	23 c-h
	1.68	15	34 a
	3.92	25	29 abc
	7.84	30	26 a-e
Desmedipham + phenmedipham	0.56 + 0.56	85	17 e-j
	1.12 + 1.12	90	16 f-j
	2.24 + 2.24	100	13 ij
	3.36 + 3.36	100	14 hij
Check	----	0	21 c-j

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

EXPERIMENT II

Materials and Methods

Benefin is a herbicide that can be applied pre-plant or preemergence to the crop. It should normally be incorporated into the soil within 6 hours of application. Benefin was used in the 1984 field-screening trial as a preemergence treatment but without incorporation. To determine if cuphea tolerance to benefin is affected by incorporation into the soil, a small greenhouse experiment was conducted.

Cuphea was planted on September 11, 1984. On the same day, benefin was applied to the soil at the rates of 1.12, 1.40, 1.68, and 2.24 kg/ha and either incorporated into the soil or left on the soil surface.

Treatments were replicated three times, arranged in a randomized complete block design, and placed in a greenhouse tray. Six weeks after planting, visual estimates of injury were recorded. Plant heights were measured, and the plants were harvested at soil level. The dry weight was measured after 3 days of drying at 40 C.

Results

When applied before planting and incorporated into the soil or applied before cuphea emergence without incorporation, benefin caused no visible injury to cuphea. Nor did it reduce plant heights or dry matter weights (Table 9 and Appendix Tables 26, 27, and 28).

Higher rates will be necessary to determine if there is a difference in cuphea tolerance depending on placement of the herbicide. The rates used were high enough to control susceptible weeds, so based on these results, cuphea tolerance will not be affected by either a pre-plant incorporated or preemergence application of benefin. A comparison of weed control efficiency by benefin when mixed with the soil or applied on the soil surface will probably determine the best way to use this herbicide.

Table 9. Average percent injury and dry weight of cuphea 6 weeks after herbicides application, in the greenhouse experiment II.

Herbicides	Rates	Percent injury	Dry weight
	(Kg/ha)	-----(%)------	---(mg)----
Pre-plant			
Benefin	1.12	0	24 ns
	1.40	0	21
	1.68	0	22
	2.24	0	17
Preemergence			
Benefin	1.12	0	25
	1.40	0	26
	1.68	0	22
	2.24	0	18
Check	----	0	23

EXPERIMENT III

Materials and Methods

After visual evaluations of greenhouse experiments I and II, treatments causing obvious injury to cuphea were discarded. Only the nine most promising herbicides were kept. These herbicides were used in a greenhouse experiment for another test of crop tolerance. Three dosage levels of each herbicide were tested.

On November 11, 1984, the pre-plant-incorporated and preemergence treatments were applied, and the cuphea was seeded. At that time, day length was short and light intensity passing through the greenhouse glass was low. Cuphea needs high light intensity, so high intensity inflorescent lamps were placed above the cuphea plants 4 weeks after germination started to enhance growth and reduce etiolation of the plants. The lights were set at a sequence of 16 hours of light and 8 hours of darkness, until harvest time.

Five weeks after germination, the postemergence treatments were sprayed. An untreated check and a check treated with just a phytobland oil in water at a dose of 1.1 l/ha were used. All treatments were replicated three times in a randomized complete block design. Pots from each replication were set in separate greenhouse trays.

The experiment was terminated 2 weeks after the postemergence treatments were applied. Visual estimates of herbicide injury and plant height measurements were recorded. After drying the plant material at 40 C for 3 days, weights of the dry matter were recorded.

Results

Consistent with results in the field and in earlier greenhouse experiments, benefin did not cause any injury or decrease in dry weight of cuphea compared to the check, at rates as high as 2.24 kg/ha (Table 10 and Appendix Tables 29 and 31).

Ethalfluralin did not cause visible injury to cuphea at rates of 0.28 and 0.56 kg/ha, but when compared to untreated plants, it caused 63% injury at 1.68 kg/ha and decreased dry weights by 28% at 0.56 kg/ha. This was in contrast to results in experiment I where ethalfluralin completely killed the cuphea at these rates (Table 10 and Appendix Table 31).

Propham caused injury of 25 to 95%, depending on the rate which ranged from 1.12 to 8.96 kg/ha.

Fluazifop caused no injury at rates as high as 2.24 kg/ha. Sethoxydim, diclofop, haloxyfop, desmedipham, and bromoxynil did not cause injury to cuphea at the respective rates of 0.56, 1.12, 0.56, 0.56, and 0.56 kg/ha. At higher rates, these herbicides caused injury to cuphea (Table 10). At these same rates, only bromoxynil and desmedipham caused a decrease in the dry weight of the plant material compared to the check. Bromoxynil caused 32 to 52% decrease in dry weight of the plant material at rates of 0.56 to 2.24 kg/ha and desmedipham caused 48% decrease in dry weight of the plant material at rates as low as 0.56 kg/ha (Appendix Table 31).

Excluding propham, which stunted the plants, there were no differences in plant height between treatments (Appendix Table 30).

This experiment contained a check treated with phytobland oil, which caused no obvious effect on cuphea.

Table 10. Average percent injury and dry weight of cuphea 6 weeks after planting, in the greenhouse experiment III, in 1984.

Herbicides	Rates	Dry weight[a]	Percent injury
	(Kg/ha)	-----(mg)----	------(%)----
Pre-plant			
Ethalfluralin	0.28	22 def	0
	0.56	18 hi	3
	1.68	7 m	65
Preemergence			
Benefin	1.12	27 ab	0
	1.40	24 cd	0
	2.24	24 cd	0
Propham	1.12	13 kl	25
	4.48	1 n	95
	8.96	1 n	95
Postemergence			
Bromoxynil	0.56	17 ij	5
	1.12	15 jk	20
	2.24	12 l	85
Sethoxydim	0.11	25 bc	0
	0.56	22 def	3
	2.24	9 m	85
Fluazifop	0.14	29 a	0
	0.56	25 bc	0
	2.24	21 efg	3
Diclofop	0.84	20 fgh	3
	1.12	23 cde	0
	3.36	22 def	20
Haloxyfop	0.28	25 bc	0
	0.56	21 efg	0
	2.24	15 jk	20
Desmedipham	0.56	13 kl	15
	0.84	13 kl	20
	2.24	13 kl	40
Check + oil	----	24 cd	0
Check	----	25 bc	0

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

DISCUSSION

There were differences between the field experiments conducted in 1983, 1984, and 1985 which should be considered when comparing results. In the 1983 screening trial, a high percentage of cuphea emerged, and subsequent growth was uniform. There were relatively few weeds at this site to interfere with growth of cuphea or evaluations of herbicidal effects on the crop.

In contrast, the 1984 screening trial and herbicide combination trial were plagued by poor cuphea emergence and a dense population of weeds before weeding of the plots was started. The predominant weed species was pigweed, a fast-growing, competitive species compared to cuphea which is slow growing and has a long vegetative stage.

The weeds were removed by hoeing and pulling but not before some damage had been done to the cuphea. These problems and physical disturbance of cuphea seedlings during the weeding process led to an uneven population and uneven growth of cuphea in the plots.

In 1985, cuphea emergence was satisfactory and hand weeding started early, leading to a uniform stand of cuphea throughout the season.

Based on the 3 years of study, certain results were obvious enough to allow conclusions to be arrived at with confidence although research conditions in the field experiments were not always uniform.

Benefin was not included in the 1983 trial, but in the 1984 and 1985 screening trials, it caused no injury to cuphea at rates as high as 2.24 kg/ha. This rate is double that normally required to give control of susceptible weeds. Benefin was the only soil-applied herbicide that did not injure cuphea in the greenhouse experiments. This is evidence that cuphea tolerance may be, at least partially, biochemical in nature and thus independent of environmental conditions.

Benefin is often incorporated into the soil by mechanical means, but this was not done in the 1984 field trial. Because more consistent weed control will probably result if the herbicide is incorporated, even when sprinkler irrigation is available, benefin was tested with and without incorporation into the soil in the 1985 field trial and in the greenhouse. Cuphea tolerance was adequate when benefin was applied preemergence or incorporated into the soil before planting, in the 1985 field experiment and in the greenhouse research.

Propham, at twice the rate normally required for good weed control, caused no visible injury in the field experiments (Tables 3 and 6 and Appendix Tables 5, 7, 14 and 15). But in the greenhouse experiments, stunting of the cuphea was obvious at rates higher than 1.12 kg/ha (Tables 8 and 10, amd Appendix Tables 23 , 24, 29, and 30). Even though peat moss was added to the soil used in the greenhouse experiments, the total adsorptive capacity perhaps was not as high as that of the silt-loam soil at Hyslop farm. In addition, the roots of plants grown in the small pots have less opportunity to grow out of the herbicide-treated soil. For these reasons, the cuphea injury by propham in the greenhouse should only be considered as a warning that cuphea tolerance is not absolute. Further field testing should be done to find the limits of cuphea tolerance under different conditions. Propham does not normally control all of the weed species common to the Willamette Valley of Oregon, especially in spring and early summer. The need for additional herbicides or other control methods should be anticipated.

Ethalfluralin was tested in 1984 and in 1985. In the field, it caused about 30% decrease in seedling emergence but the plants that recovered had normal growth at the end of the season. In the greenhouse at the same rates, all of the cuphea was killed by ethalfluralin in experiment I. In the third experiment, injury was observed only at the high rate (Table 10, and Appendix Table 29). It is common for plants to be more sensitive under greenhouse conditions, but in this case injury was severe enough to indicate careful testing in the field should be done before ethalfluralin is used on cuphea. EPTC and trifluralin consistently caused enough injury to discourage further testing.

Chloramben, ethofumesate, and DCPA were tested in the 1984 field trial and caused minor injury to cuphea at normal rates but severe injury when those rates were doubled. They were tested again in 1985 at normal rates and caused unacceptable levels of injury.

Several herbicides that are normally sprayed on the foliage of the weeds were consistently safe to cuphea in the field and greenhouse experiments. Four of the herbicides belong to a group of new grass control herbicides. Data from the 1984 field experiments indicate that reduction in cuphea vigor occurred when the plants were treated with haloxyfop, sethoxydim, fluazifop, or diclofop. Because the data indicate more injury at low rates than at high rates, these data may reflect competition from weeds and damage to, or removal of, cuphea plants when the weeds were removed by hand.

Of these four herbicides, only fluazifop and diclofop were included in the 1984 field trial intended to produce yield data. Heights of cuphea plants and length of inflorescence did not differ from the untreated plants. Weight of dry matter was not reduced when fluazifop and diclofop were sprayed alone, but decrease in dry matter occurred when each of them was combined with bromoxynil or desmedipham/phenmedipham.

In the 1985 field trial and in the greenhouse experiments, the grass control herbicides had little if any visible effect on cuphea at rates several times higher than required to control weeds. Based on results of field and greenhouse tests, any of these herbicides should be considered as good candidates for further testing and as weed control tools for field research. These herbicides control only grasses. If used alone, fluazifop, diclofop, haloxyfop, or sethoxydim will leave the broadleaf weeds.

Of the herbicides tested in this research, bromoxynil was the safest herbicide that controls a wide array of broadleaf weeds. All of the visual evaluations and objective measurements indicate that bromoxynil is safe on cuphea at twice the rate normally required to give good control of susceptible weeds. Only at higher rates (2.24 kg/ha), was injury to cuphea apparent. Further testing should be done to verify these indications that bromoxynil will be a safe and useful herbicide for use on cuphea.

Results of research with desmedipham were inconsistent. In the 1983 screening trial, desmedipham was safe on cuphea at 1.12 kg/ha which is a normal use rate. Slight (10%) injury to cuphea was noted when desmedipham was used at 2.24 kg/ha. In the greenhouse, desmedipham caused severe injury to cuphea (Table 10). Since only one other postemergence herbicide known to be active on broadleaf weeds was identified, further field testing with desmedipham was conducted in 1985. One week after application, injury levels of 10% at 0.84 kg/ha and 20% at 1.40 kg/ha were recorded. Five weeks later the symptoms were nearly gone.

Because desmedipham is commonly mixed with a closely related herbicide, phenmedipham; the mixture was used in all of the 1984 research with the assumption that phenmedipham was no more toxic to cuphea than desmedipham. At the lowest rate used, 0.56 kg/ha of each herbicide, an injury level of 90% 2 weeks after treatment had decreased to 10% injury 6 weeks later. When the rate was doubled, cuphea injury was still 45% 6 weeks after treatment. Toxicity was even higher in the greenhouse trials.

The 1985 results with desmedipham and phenmedipham did little to clarify the previous results. Injury levels between 10 and 25% after 1 week had decreased to less than 10% after 5 weeks. The anticipated need for additional control measures for broadleaf weeds is probably reason enough to test both of these herbicides again.

Field and greenhouse tests with asulam on cuphea were not encouraging. Unacceptable levels of injury occurred even though weights of dry matter from greenhouse experiments did not reflect this injury.

In the 1984 trials, injury attributed to the grass control herbicides may have been due to weed competition and physical damage. If so, any moderate herbicide injury would be difficult to quantify. Cuphea was injured more when bromoxynil was combined with diclofop or fluazifop than when the herbicides were used alone. A similar result was noted in the first greenhouse experiment.

To substantiate 1983 and 1984 data, research was conducted in 1985 with bromoxynil and desmedipham applied alone and in combination with each of the promising grass control herbicides. Moderate crop injury was obvious after application of most of the combinations, but by the end of the season there was no noticeable injury when the herbicides were used alone, or in combinations at low rate. There was only slight injury at the high rate. At the end of the season, there were no differences in plant height, inflorescence length, flowering, or dry weight when the treatments were compared with the check.

The field experiments left no doubt that atrazine, diuron, alachlor, metribuzin, napropamide, oxadiazon, oxyfluorfen, pronamide, simazine, terbacil, oryzalin, bentazon, 2,4-D, dalapon, glyphosate, paraquat, propanil, pendimethalin, dinoseb, dichlobenil, and chlorpropham are toxic to cuphea at rates required for weed control.

In conclusion, this three-year-study under field and greenhouse conditions demonstrated that the following herbicides are promising for selective use on *Cuphea wrightii*:

(a) Benefin at 1.12 to 2.24 kg/ha.

(b) Propham at 1.12 to 6.72 kg/ha.

(c) Fluazifop at 0.14 to 1.12 kg/ha.

(d) Diclofop at 0.56 to 1.40 kg/ha.

(e) Haloxyfop at 0.28 to o.56 kg/ha.

(f) Sethoxydim at 0.11 to 1.12 kg/ha.

(g) Bromoxynil at 0.28 to 1.12 kg/ha.

(h) Desmedipham at 0.84 to 1.40 kg/ha

None of the herbicides on this list control a broad spectrum of weeds. A combination of herbicides may be needed for satisfactory weed control. A combination of bromoxynil or desmedipham with any of the grass control herbicides might be used with caution. Non-herbicidal control methods should not be overlooked. Crop rotation and cultivation should be used whenever appropriate.

None of the conclusions stated here are based on cuphea seed yield. Research to acquire seed yield data should be done before extensive use of any of these herbicides on cuphea.

LITERATURE CITED

1. Ashton, F.M. and A.S. Crafts. 1981. Mode of Action of Herbicides. 2nd Ed. Wiely-Interscience Publ. New York. 525 pp.

2. Audus, L.J. 1976. Herbicides, Physiology, Biochemistry, Ecology. 2nd Ed. Academic Press Publ. London. 608 pp.

3. Graham, S.A. 1963. Systematic studies in the genus Cuphea (Lythraceae). Diss. Univ. Michigan 1963. 235 pp.

4. Graham, S.A. 1968. History of the generic name Cuphea (Lythraceae). Taxon 17:535-536.

5. Graham, S.A.,F. Hirsinger, and G. Robbelen. 1981. Fatty acids of Cuphea seed lipids and their systematic significance. Am. J. of Bot. 68:908-917.

6. Hirsinger, F. 1980. Studies to estimate the performance of a new MCT. Oil crop Cuphea (Lythraceae). Part I: Natural variability in taxonomic and agronomic traits of Cuphea species. Angew. Botanik 54:157-177.

7. Hirsinger, F. 1981. Cuphea the first oil crop for the production of Medium-chain Triglycerides (MCT). from a report on Cuphea presented at the APAG meeting, Chester, U.K. in May 1981.

8. Hirsinger, F. 1983. Cuphea information. Ann. Rep.for New Crops 1983. pp. 350-351. Crop Science Dpt. Or. St. Univ.

9. Hirsinger, F. 1984. Agronomic potential and seed composition of Cuphea, an annual crop for lauric and capric acid oils. J. Am. Oil Chem. Soc. 62:76-80.

10. Hirsinger, F. and G. Robbelen. 1980. Studies on the agronomical value of a new MCT oil crop, Cuphea (Lythraceae). 3. Chemical mutagenesis in C. lanceolata and C. procumbens, and general evaluations. Z. Pflanzenzuchtg. 85:275-286.

11. Koehne, E. 1880. Lythraceae monographice describuntur. Bot. Jahrb. 1:142-178.

12. Miller, R.W., F.R. Earle., I.A. Wolff., and Q. Jones. 1964. Search for new industrial oils. IX, Cuphea, a versatile source of fatty acids. J. Am. Oil Chem. Soc. 41:279-280.

13. Robbelen, G. and F. Hirsinger. 1982. Cuphea, the first annual oil crop for the production of medium-chain

14. Thompson, A.E. 1984. Cuphea - a potential new crop. Hort. Sci. 19:362-354.

15. Wilson, T.L., T.K. Miwa., and C.R. Smith. 1960. Cuphea llavea seed oil, good source of capric acid. J. Am. Oil Chem. Soc. 37:675-676.

16. Herbicide Handbook of the Weed Science Society of America. 1983 pp. 37-40, 43-47, 168-176, 233-234, 375-378, and 413-419.

APPENDIX

Appendix Table 1. Visual estimate of cuphea injury 4 weeks after application of pre-plant incorporated and preemergence herbicides, at three rates in 1983.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	-------------	(%)	-----------
Pre-plant				
EPTC	1.68	85	85	85
	3.36	85	85	85
	6.72	85	85	85
Trifluralin	0.56	90	90	90
	1.12	90	90	90
	1.68	90	90	90
Preemergence				
Atrazine	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Diuron	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Alachlor	2.24	100	100	100
	4.48	100	100	100
	6.72	100	100	100
Metribuzin	0.56	100	100	100
	1.12	100	100	100
	2.24	100	100	100
Napropamide	1.12	95	95	95
	2.24	95	95	95
	4.48	95	95	95
Oxadiazon	2.24	100	100	100
	4.48	100	100	100
	6.72	100	100	100
Oxyfluorfen	1.12	100	100	100
	2.24	100	100	100
	3.36	100	100	100
Pronamide	2.24	100	100	100
	4.48	100	100	100
	6.72	100	100	100

(continued on next page)

Appendix Table 1. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	-----------(%)-----------		
Propham	2.24	0	0	0
	4.48	0	0	0
	6.72	0	0	0
Simazine	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Terbacil	0.56	100	100	100
	1.12	100	100	100
	2.24	100	100	100
Oryzalin	0.56	97	97	97
	1.12	97	97	97
	2.24	97	97	97
Check	----	0	0	0

Appendix Table 2. Visual estimate of cuphea injury 2 weeks after postemergence herbicides application at three rates in 1983.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	------------(%)------------		
Bentazon	1.12	50	20	35
	2.24	60	60	60
	4.48	90	100	95
Bromoxynil	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
2,4-D	0.28	30	30	30
	0.56	40	40	40
	1.12	50	50	50
Dalapon	2.80	20	20	20
	5.60	30	30	30
	11.20	90	90	90
Glyphosate	0.56	90	90	90
	1.12	100	100	100
	2.24	100	100	100
Paraquat	0.28	20	20	20
	0.56	30	30	30
	1.12	40	40	40
Sethoxydim	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
Fluazifop	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
Desmedipham	0.56	0	0	0
	1.12	0	0	0
	2.24	0	0	0
Diclofop	0.56	0	0	0
	1.12	0	0	0
	2.24	0	0	0
Check	----	0	0	0

Appendix Table 3. Visual estimate of cuphea injury 12 weeks after application of pre-plant incorporated and preemergence herbicides, at three rates in 1983.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	(%)		
Pre-plant				
EPTC	1.68	60	40	50
	3.36	95	65	80
	6.72	80	80	80
Trifluralin	0.56	70	40	55
	1.12	85	65	75
	1.68	85	85	85
Preemergence				
Atrazine	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Diuron	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Alachlor	2.24	85	85	85
	4.48	100	100	100
	6.72	100	100	100
Metribuzin	0.56	100	100	100
	1.12	100	100	100
	2.24	100	100	100
Napropamide	1.12	80	70	75
	2.24	85	85	85
	4.48	90	100	95
Oxadiazon	2.24	100	100	100
	4.48	100	100	100
	6.72	100	100	100
Oxyfluorfen	1.12	100	100	100
	2.24	100	100	100
	3.36	100	100	100
Pronamide	2.24	100	100	100
	4.48	100	100	100
	6.72	100	100	100

(continued on next page)

Appendix Table 3. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)		(%)	
Propham	2.24	0	0	0
	4.48	0	0	0
	6.72	0	0	0
Simazine	1.12	100	100	100
	2.24	100	100	100
	4.48	100	100	100
Terbacil	0.56	100	100	100
	1.12	100	100	100
	2.24	100	100	100
Oryzalin	0.56	70	70	70
	1.12	85	85	85
	2.24	100	100	100
Check	----	0	0	0

Appendix Table 4. Visual estimate of cuphea injury 8 weeks after postemergence herbicides application at three rates in 1983.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)		(%)	
Bentazon	1.12	50	50	50
	2.24	70	70	70
	4.48	100	100	100
Bromoxynil	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
2,4-D	0.28	100	80	90
	0.56	100	80	90
	1.12	100	80	90
Dalapon	2.80	50	30	40
	5.60	70	50	60
	11.20	100	80	90
Glyphosate	0.56	100	80	90
	1.12	100	100	100
	2.24	100	100	100
Paraquat	0.28	80	30	55
	0.56	70	30	50
	1.12	70	70	70
Sethoxydim	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
Fluazifop	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
Desmedipham	0.56	0	0	0
	1.12	0	0	0
	2.24	10	10	10
Diclofop	0.56	0	0	0
	1.12	0	0	0
	2.24	0	0	0
Check	----	0	0	0

Appendix Table 5. Visual estimate of cuphea injury 6 weeks after pre-plant incorporated and preemergence herbicides application, at two rates in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	------------	(%)	------------
Pre-plant				
Ethalfluralin	0.56	5	65	35
	1.12	10	50	30
EPTC	1.68	20	40	30
	3.36	60	80	60
Trifluralin	0.56	50	10	30
	1.12	95	65	85
Preemergence				
Benefin	1.12	0	0	0
	2.24	0	0	0
Chloramben	2.24	50	60	65
	4.48	100	100	100
Chlorpropham	4.48	90	70	80
	6.72	65	85	75
Dichlobenil	2.24	100	100	100
	4.48	100	100	100
Dinoseb	3.36	90	40	65
	6.72	100	100	100
Ethofumesate	1.68	40	70	55
	3.36	50	60	55
Pendimethalin	0.56	60	50	55
	1.12	100	100	100
DCPA	5.60	40	40	40
	11.20	50	40	45
Propham	2.24	0	0	0
	4.48	0	0	0
Check	----	0	0	0

Appendix Table 6. Visual estimate of cuphea injury 2 weeks after postemergence herbicides application, at two rates in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)		(%)	
Postemergence				
Haloxyfop	0.28	10	0	5
	0.56	30	20	25
Propanil	2.24	100	100	100
	4.48	100	100	100
Bromoxynil	1.12	10	20	15
	2.24	10	80	45
Sethoxydim	0.56	20	20	20
	1.12	10	0	5
Fluazifop	0.56	10	50	30
	1.12	0	0	0
Desmed/phenmed	1.12	90	90	90
	2.24	95	95	95
Diclofop	1.12	20	10	15
	2.24	30	30	30
Check	----	0	0	0

Appendix Table 7. Visual estimate of cuphea injury 15 weeks after application of pre-plant incorporated herbicides and 8 weeks after application of postemergence herbicides, in the 1984 screening trial.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)		(%)	
Pre-plant				
Ethalfluralin	0.56	10	30	20
	1.12	10	20	15
EPTC	1.68	10	40	25
	3.36	80	80	80
Trifluralin	0.56	60	10	35
	1.12	100	30	65
Preemergence				
Benefin	1.12	0	0	0
	2.24	0	0	0
Chloramben	2.24	10	20	15
	4.48	80	100	90
Chlorpropham	4.48	80	60	70
	6.72	30	70	50
Dichlobenil	2.24	100	100	100
	4.48	100	100	100
Dinoseb	3.36	70	30	50
	6.72	100	100	100
Ethofumesate	1.68	10	20	15
	3.36	10	30	20
Pendimethalin	0.56	30	40	35
	1.12	0	0	0
DCPA	5.60	20	10	15
	11.20	30	30	30
Propham	2.24	10	0	5
	4.48	0	10	5

(continued on next page)

Appendix Table 7. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)		(%)	
Haloxyfop	0.28	0	0	0
	0.56	0	0	0
Propanil	2.24	100	80	90
	4.48	100	100	100
Bromoxynil	1.12	10	10	10
	2.24	70	10	40
Sethoxydim	0.56	0	0	0
	1.12	0	0	0
Fluazifop	0.56	0	0	0
	1.12	0	0	0
Desmed/phenmed	1.12	0	20	10
	2.24	10	80	45
Diclofop	1.12	0	0	0
	2.24	0	0	0
Check	----	0	0	0

Appendix Table 8 . Cuphea height 15 weeks after pre-plant incorporated and preemergence herbicides application and 8 weeks after postemergence herbicides application, in the screening trial in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	(cm)		
Pre-plant				
Ethalfluralin	0.56	18	20	19 ns
	1.12	19	19	19
EPTC	1.68	19	17	18
	3.36	5	17	11
Trifluralin	0.56	17	17	17
	1.12	12	18	15
Preemergence				
Benefin	1.12	18	18	18
	2.24	19	19	19
Chloramben	2.24	18	18	18
	4.48	16	0	8
Chlorpropham	4.48	13	13	13
	6.72	16	18	17
Dichlobenil	2.24	0	0	0
	4.48	0	0	0
Dinoseb	3.36	18	18	18
	6.72	0	0	0
Ethofumesate	1.68	18	16	17
	3.36	19	15	17
Pendimethalin	0.56	16	18	17
	1.12	0	0	0
DCPA	5.60	14	18	16
	11.20	14	18	16
Propham	2.24	18	18	18
	4.48	18	18	18

(continued on next page)

Appendix Table 8. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(kg/ha)	(cm)		
Postemergence				
Haloxyfop	0.28	18	18	18 ns
	0.56	17	17	17
Propanil	2.24	13	13	13
	4.48	0	0	0
Bromoxynil	1.12	18	18	18
	2.24	14	14	14
Sethoxydim	0.56	17	19	18
	1.12	16	18	17
Fluazifop	0.56	18	18	18
	1.12	19	19	19
Desmedipham + phenmedipham	1.12	17	17	17
	2.24	14	14	14
Diclofop	1.12	17	17	17
	2.24	16	18	17
Check	----	18	18	18

Appendix table 9. Visual estimate of cuphea injury 2 weeks after postemergence herbicides application, in the herbicide combination trial in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	(%)			
Bromoxynil	0.28	0	5	10	5
Desmedipham + phenmedipham	0.56 0.56	85	100	70	85
Diclofop	0.56	0	0	0	0
Fluazifop	0.28	0	0	0	0
Bromoxynil + diclofop	0.28 0.56	40	40	40	40
Bromoxynil + fluazifop	0.28 0.28	50	40	30	40
Desmed/phenmed + diclofop	0.56 0.56	75	75	90	80
Desmed/phenmed + fluazifop	0.56 0.28	90	90	90	90
Check	----	0	0	0	0

Appendix Table 10. Visual estimate of cuphea injury 8 weeks after postemergence herbicides application, in the herbicide combination trial in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	(%)			
Bromoxynil	0.28	5	5	5	5
Desmedipham + phenmedipham	0.56 0.56	35	75	25	45
Diclofop	0.56	0	0	0	0
Fluazifop	0.28	0	0	0	0
Bromoxynil + diclofop	0.28 0.56	30	30	30	30
Bromoxynil + fluazifop	0.28 0.28	40	30	20	30
Desmed/phenmed + diclofop	0.56 0.56	70	30	80	60
Desmed/phenmed + fluazifop	0.56 0.28	80	30	25	45
Check	----	0	0	0	0

Appendix Table 11. Cuphea height 8 weeks after treatment, in the herbicide combination trial in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	(cm)			
Bromoxynil	0.28	20	18	16	18 ns
Desmedipham + phenmedipham	0.56 0.56	17	15	19	17
Diclofop	0.56	20	19	18	19
Fluazifop	0.28	21	19	20	20
Bromoxynil + diclofop	0.28 0.56	18	17	19	18
Bromoxynil + fluazifop	0.28 0.28	15	18	18	17
Desmed/phenmed + diclofop	0.56 0.56	14	18	16	16
Desmed/phenmed + fluazifop	0.56 0.28	15	17	16	16
Check	----	19	20	18	19

Appendix Table 12. Cuphea inflorescence length 8 weeks after treatment, in the herbicide combination trial in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	(cm)			
Bromoxynil	0.28	9	7	5	7 ns
Desmedipham + phenmedipham	0.56 0.56	4	4	7	5
Diclofop	0.56	8	10	6	8
Fluazifop	0.28	9	5	16	10
Bromoxynil + diclofop	0.28 0.56	2	8	5	5
Bromoxynil + fluazifop	0.28 0.28	2	5	8	5
Desmed/phenmed + diclofop	0.56 0.56	2	6	4	4
Desmed/phenmed + fluazifop	0.56 0.28	2	3	4	3
Check	----	6	7	11	8

Appendix Table 13. Dry weight of cuphea 8 weeks after treatment, in the herbicide combination trial in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg[a]
	(kg/ha)	(g)			
Bromoxynil	0.28	205	140	180	175 abcd
Desmedipham + phenmedipham	0.56 0.56	110	30	160	100 cde
Diclofop	0.56	235	150	200	195 ab
Fluazifop	0.28	210	195	270	225 a
Bromoxynil + diclofop	0.28 0.56	140	110	155	135 a-e
Bromoxynil + fluazifop	0.28 0.28	80	145	165	130 bcde
Desmed/phenmed + diclofop	0.56 0.56	35	170	20	75 e
Desmed/phenmed + fluazifop	0.56 0.28	35	100	120	85 cde
Check	----	185	170	200	185 abc

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

Appendix Table 14 Visual estimate of cuphea injury 2 weeks after application of several herbicides, in the 1985 screening trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	------------	------------	(%) ------------	------------
Pre-plant					
Ethalfluralin	1.12	60	50	70	60
Benefin	1.68	10	0	5	5
Preemergence					
Benefin	1.68	9	0	0	3
Chloramben	3.36	85	90	95	95
Ethofumesate	2.80	85	85	85	85
DCPA	8.40	30	60	60	50
Propham	5.04	20	15	10	15
Postemergence					
Asulam[a]	2.80	—	—	—	—
Check	----	0	0	0	0

Appendix Table 15. Visual estimate of cuphea injury 10 weeks after application of several herbicides, in the 1985 screening trial

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(kg/ha)	------------	------------	(%) ------------	------------
Pre-plant					
Ethalfluralin	1.12	50	20	50	40
Benefin	1.68	9	0	0	3
Preemergence					
Benefin	1.68	9	0	0	3
Chloramben	3.36	95	95	95	95
Ethofumesate	2.80	95	85	90	90
DCPA	8.40	60	60	30	50
Propham	5.04	20	10	0	10
Postemergence					
Asulam	2.80	60	80	70	70
Check	----	0	0	0	0

a Asulam was not sprayed at that time.

Appendix Table 16. Estimate of cuphea injury 1 week after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)			(%)	
Bromoxynil	0.56	9	0	0	3
	1.12	20	15	10	15
Sethoxydim	0.56	0	0	0	0
	1.12	0	0	0	0
Fluazifop	0.14	0	0	9	3
	0.56	0	0	0	0
Diclofop	0.84	0	0	0	0
	1.40	9	0	0	3
Haloxyfop	0.28	0	0	9	3
	0.56	0	0	0	0
Bromoxynil +	0.56 + 0.84	0	10	11	7
diclofop	1.12 + 1.40	20	20	20	20
Bromoxynil +	0.56 + 0.14	9	0	0	3
fluazifop	1.12 + 0.56	40	40	40	40
Bromoxynil +	0.56 + 0.56	20	20	20	20
sethoxydim	1.12 + 1.12	50	40	60	50
Bromoxynil +	0.56 + 0.28	20	20	20	20
haloxyfop	1.12 + 0.56	50	40	30	40
Desmedipham	0.84	10	10	10	10
	1.40	20	20	20	20
Phenmedipham	1.12	25	30	20	25
	1.68	25	20	30	25
Desmedipham +	0.84 + 0.84	50	70	30	50
phenmedipham	1.40 + 1.40	70	70	70	70
Desmedipham +	0.84 + 0.84	25	20	30	25
diclofop	1.40 + 1.40	60	50	40	50
Desmedipham +	0.84 + 0.14	30	20	10	20
fluazifop	1.40 + 0.56	50	30	10	30
Desmedipham +	0.84 + 0.56	25	25	25	25
sethoxydim	1.40 + 1.12	30	30	30	30
Desmedipham +	0.84 + 0.28	25	20	15	20
haloxyfop	1.40 + 0.56	20	20	20	20

Appendix Table 17. Estimate of cuphea injury 2 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	-----------(%)-----------			
Bromoxynil	0.56	6	0	0	2
	1.12	15	10	5	10
Sethoxydim	0.56	0	0	0	0
	1.12	0	0	0	0
Fluazifop	0.14	0	0	9	3
	0.56	0	0	0	0
Diclofop	0.84	0	0	0	0
	1.40	9	0	0	3
Haloxyfop	0.28	0	0	9	3
	0.56	0	0	0	0
Bromoxynil +	0.56 + 0.84	0	5	10	5
diclofop	1.12 + 1.40	20	10	0	10
Bromoxynil +	0.56 + 0.14	9	0	0	3
fluazifop	1.12 + 0.56	25	15	20	20
Bromoxynil +	0.56 + 0.56	10	10	10	10
sethoxydim	1.12 + 1.12	40	10	40	40
Bromoxynil +	0.56 + 0.28	10	10	10	10
haloxyfop	1.12 + 0.56	15	15	15	15
Desmedipham	0.84	5	5	5	5
	1.40	15	15	15	15
Phenmedipham	1.12	20	15	10	15
	1.68	10	10	10	10
Desmedipham +	0.84 + 0.84	20	30	25	25
phenmedipham	1.40 + 1.40	35	50	50	45
Desmedipham +	0.84 + 0.84	10	5	15	10
diclofop	1.40 + 1.40	25	20	15	20
Desmedipham +	0.84 + 0.14	5	5	5	5
fluazifop	1.40 + 0.56	10	10	10	10
Desmedipham +	0.84 + 0.56	10	10	10	10
sethoxydim	1.40 + 1.12	20	20	20	20
Desmedipham +	0.84 + 0.28	15	10	5	10
haloxyfop	1.40 + 0.56	10	10	10	10

Appendix Table 18. Estimate of cuphea injury 6 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)		(%)		
Bromoxynil	0.56	0	0	0	0
	1.12	9	0	0	3
Sethoxydim	0.56	0	0	0	0
	1.12	0	0	0	0
Fluazifop	0.14	0	0	9	3
	0.56	0	0	0	0
Diclofop	0.84	0	0	0	0
	1.40	9	0	0	3
Haloxyfop	0.28	0	0	9	3
	0.56	0	0	0	0
Bromoxynil +	0.56 + 0.84	0	0	9	3
diclofop	1.12 + 1.40	21	0	0	7
Bromoxynil +	0.56 + 0.14	9	0	0	3
fluazifop	1.12 + 0.56	10	10	10	10
Bromoxynil +	0.56 + 0.56	18	0	0	6
sethoxydim	1.12 + 1.12	20	0	25	15
Bromoxynil +	0.56 + 0.28	10	0	11	7
haloxyfop	1.12 + 0.56	10	10	19	13
Desmedipham	0.84	6	0	0	2
	1.40	5	10	9	8
Phenmedipham	1.12	0	0	0	0
	1.68	9	0	0	3
Desmedipham +	0.84 + 0.84	10	10	10	10
phenmedipham	1.40 + 1.40	10	10	10	10
Desmedipham +	0.84 + 0.84	0	0	0	0
diclofop	1.40 + 1.40	10	0	11	7
Desmedipham +	0.84 + 0.14	9	0	0	3
fluazifop	1.40 + 0.56	15	0	0	5
Desmedipham +	0.84 + 0.56	9	0	0	3
sethoxydim	1.40 + 1.12	10	10	10	10
Desmedipham +	0.84 + 0.28	9	0	0	3
haloxyfop	1.40 + 0.56	0	0	0	0

Appendix Table 19. Cuphea height 6 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	----------(cm)----------			
Bromoxynil	0.56	22	30	23	25 ns
	1.12	21	21	33	25
Sethoxydim	0.56	26	30	22	26
	1.12	25	25	19	23
Fluazifop	0.14	20	25	21	22
	0.56	22	25	28	25
Diclofop	0.84	20	26	23	23
	1.40	19	22	22	21
Haloxyfop	0.28	25	19	22	22
	0.56	26	25	33	28
Bromoxynil +	0.56 + 0.84	24	19	20	21
diclofop	1.12 + 1.40	19	25	22	22
Bromoxynil +	0.56 + 0.14	21	33	27	27
fluazifop	1.12 + 0.56	18	22	20	20
Bromoxynil +	0.56 + 0.56	20	23	23	22
sethoxydim	1.12 + 1.12	20	28	18	22
Bromoxynil +	0.56 + 0.28	25	31	25	27
haloxyfop	1.12 + 0.56	24	24	18	22
Desmedipham	0.84	21	25	26	24
	1.40	20	20	20	20
Phenmedipham	1.12	19	20	30	23
	1.68	22	22	25	23
Desmedipham +	0.84 + 0.84	25	18	20	21
phenmedipham	1.40 + 1.40	26	21	19	22
Desmedipham +	0.84 + 0.84	25	26	21	24
diclofop	1.40 + 1.40	21	22	23	22
Desmedipham +	0.84 + 0.14	23	25	30	26
fluazifop	1.40 + 0.56	22	24	23	23
Desmedipham +	0.84 + 0.56	22	22	22	22
sethoxydim	1.40 + 1.12	20	21	19	20
Desmedipham +	0.84 + 0.28	22	23	30	25
haloxyfop	1.40 + 0.56	26	30	25	27
Check	----	19	30	20	23

Appendix Table 20. Cuphea inflorescence length 6 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	----------(cm)----------			
Bromoxynil	0.56	10	20	12	14 ns
	1.12	10	8	21	13
Sethoxydim	0.56	19	16	10	15
	1.12	15	16	5	12
Fluazifop	0.14	11	13	12	12
	0.56	8	17	17	14
Diclofop	0.84	10	12	17	13
	1.40	10	10	10	10
Haloxyfop	0.28	15	8	13	12
	0.56	17	17	20	18
Bromoxynil +	0.56 + 0.84	15	8	10	11
diclofop	1.12 + 1.40	10	16	13	13
Bromoxynil +	0.56 + 0.14	11	22	18	17
fluazifop	1.12 + 0.56	8	13	12	11
Bromoxynil +	0.56 + 0.56	8	12	13	11
sethoxydim	1.12 + 1.12	10	17	3	10
Bromoxynil +	0.56 + 0.28	16	20	18	18
haloxyfop	1.12 + 0.56	13	15	8	12
Desmedipham	0.84	11	16	21	16
	1.40	8	8	8	8
Phenmedipham	1.12	6	7	20	11
	1.68	8	15	16	13
Desmedipham +	0.84 + 0.84	15	8	7	10
phenmedipham	1.40 + 1.40	18	15	6	13
Desmedipham +	0.84 + 0.84	19	17	6	14
diclofop	1.40 + 1.40	15	11	16	14
Desmedipham +	0.84 + 0.14	19	18	20	19
fluazifop	1.40 + 0.56	12	10	17	13
Desmedipham +	0.84 + 0.56	14	11	11	12
sethoxydim	1.40 + 1.12	15	12	9	12
Desmedipham +	0.84 + 0.28	15	13	20	16
haloxyfop	1.40 + 0.56	16	20	15	17
Check	----	19	22	10	17

Appendix Table 21. Flower reduction of cuphea 6 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	-----------	(%)	-----------	
Bromoxynil	0.56	0	0	0	0
	1.12	9	0	0	3
Sethoxydim	0.56	0	0	0	0
	1.12	0	0	0	0
Fluazifop	0.14	0	0	0	0
	0.56	0	0	0	0
Diclofop	0.84	0	0	0	0
	1.40	0	0	0	0
Haloxyfop	0.28	0	0	0	0
	0.56	0	0	0	0
Bromoxynil +	0.56 + 0.84	0	0	0	0
diclofop	1.12 + 1.40	21	0	0	7
Bromoxynil +	0.56 + 0.14	0	0	0	0
fluazifop	1.12 + 0.56	20	10	0	10
Bromoxynil +	0.56 + 0.56	9	0	0	3
sethoxydim	1.12 + 1.12	0	0	21	7
Bromoxynil +	0.56 + 0.28	0	0	0	0
haloxyfop	1.12 + 0.56	0	10	11	7
Desmedipham	0.84	0	0	0	0
	1.40	0	9	0	3
Phenmedipham	1.12	0	0	0	0
	1.68	9	0	0	0
Desmedipham +	0.84 + 0.84	0	9	0	0
phenmedipham	1.40 + 1.40	0	0	21	7
Desmedipham +	0.84 + 0.84	0	0	0	0
diclofop	1.40 + 1.40	0	0	0	0
Desmedipham +	0.84 + 0.14	0	0	0	0
fluazifop	1.40 + 0.56	0	0	0	0
Desmedipham +	0.84 + 0.56	0	0	0	0
sethoxydim	1.40 + 1.12	0	0	9	3
Desmedipham +	0.84 + 0.28	0	0	0	0
haloxyfop	1.40 + 0.56	0	0	0	0

Appendix table 22. Dry weight of cuphea 6 weeks after treatment in the 1985 herbicide combination trial.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	-----------	(g)	-----------	
Bromoxynil	0.56	487	782	645	638 ns
	1.12	324	477	761	521
Sethoxydim	0.56	632	765	528	642
	1.12	570	668	444	561
Fluazifop	0.14	478	666	555	566
	0.56	525	668	716	636
Diclofop	0.84	413	682	289	447
	1.40	401	567	639	536
Haloxyfop	0.28	652	482	478	537
	0.56	624	650	811	695
Bromoxynil +	0.56 + 0.84	600	462	442	501
diclofop	1.12 + 1.40	344	623	553	507
Bromoxynil +	0.56 + 0.14	446	789	642	626
fluazifop	1.12 + 0.56	359	629	453	480
Bromoxynil +	0.56 + 0.56	370	533	535	479
sethoxydim	1.12 + 1.12	362	737	325	475
Bromoxynil +	0.56 + 0.28	503	689	488	560
haloxyfop	1.12 + 0.56	524	570	379	491
Desmedipham	0.84	334	563	765	554
	1.40	346	414	439	400
Phenmedipham	1.12	358	344	645	482
	1.68	363	654	582	533
Desmedipham +	0.84 + 0.84	548	373	439	453
phenmedipham	1.40 + 1.40	549	429	402	460
Desmedipham +	0.84 + 0.84	629	701	430	587
diclofop	1.40 + 1.40	455	517	463	478
Desmedipham +	0.84 + 0.14	481	717	707	635
fluazifop	1.40 + 0.56	375	489	646	503
Desmedipham +	0.84 + 0.56	455	516	538	503
sethoxydim	1.40 + 1.12	369	439	416	408
Desmedipham +	0.84 + 0.28	554	548	716	606
haloxyfop	1.40 + 0.56	504	775	633	637
Check	----	612	800	474	629

Appendix Table 23. Estimate of cuphea injury 6 weeks after planting in greenhouse experiment I, in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(Kg/ha)		(%)	
Pre-plant				
Trifluralin	0.28	100	100	100
	0.56	100	100	100
	1.12	100	100	100
	1.68	100	100	100
Ethalfluralin	0.28	100	100	100
	0.56	100	100	100
	1.12	100	100	100
	1.68	100	100	100
Preemergence				
Benefin	1.12	0	0	0
	1.40	0	0	0
	1.68	0	0	0
	2.24	5	5	5
Propham	1.12	0	0	0
	4.48	70	30	50
	6.72	50	50	55
	8.96	60	50	55
Postemergence				
Bromoxynil	0.56	0	10	5
	1.12	5	5	5
	1.68	5	5	5
	2.24	10	10	10
Sethoxydim	0.11	10	20	15
	0.56	10	10	10
	1.12	10	10	10
	2.24	15	5	10
Fluazifop	0.14	0	0	0
	0.56	0	10	5
	1.12	0	0	0
	2.24	0	0	0
Diclofop	0.84	0	10	5
	1.12	5	5	5
	1.40	5	15	10
	3.36	0	0	0

(continued on next page)

Appendix Table 23. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(Kg/ha)	-----------	(%)	-----------
Haloxyfop	0.28	5	5	5
	0.56	0	20	10
	1.12	0	0	0
	2.24	10	10	10
Bromoxynil + diclofop	0.56 + 0.84	5	5	5
	1.12 + 1.12	10	10	10
	1.68 + 1.40	10	10	10
	2.24 + 3.36	40	30	35
Bromoxynil + fluazifop	0.56 + 0.14	0	0	0
	1.12 + 0.56	0	0	0
	1.68 + 1.12	10	10	10
	2.24 + 2.24	75	85	80
Bromoxynil + sethoxydim	0.56 + 0.11	5	5	5
	1.12 + 0.56	10	40	25
	1.68 + 1.12	40	60	50
	2.24 + 2.24	40	60	50
Bromoxynil + haloxyfop	0.56 + 0.28	10	10	10
	1.12 + 0.56	50	40	45
	1.68 + 1.12	30	70	50
	2.24 + 2.24	20	80	50
Desmedipham	0.56	80	50	65
	0.84	70	90	80
	1.40	80	80	80
	2.24	95	95	95
Phenmedipham	1.12	80	90	85
	1.40	90	90	90
	1.68	80	100	90
	3.36	80	90	85
Asulam	1.12	10	10	10
	1.68	20	10	15
	3.92	30	20	25
	7.84	40	20	30
Desmedipham + phenmedipham	0.56 + 0.56	80	90	85
	1.12 + 1.12	90	90	90
	2.24 + 2.24	100	100	100
	3.36 + 3.36	100	100	100
Check	----	0	0	0

Appendix Table 24. Cuphea height 6 weeks after planting, in greenhouse experiment I in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg[a]
	(Kg/ha)	------------	(cm)	---------
Pre-plant				
Trifluralin	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
	1.68	0	0	0
Ethalfluralin	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
	1.68	0	0	0
Preemergence				
Benefin	1.12	9	9	9 ns
	1.40	8	8	8
	1.68	8	8	8
	2.24	9	7	8
Propham	1.12	8	8	8
	4.48	4	6	5
	6.72	5	5	5
	8.96	4	4	4
Postemergence				
Bromoxynil	0.56	9	9	9
	1.12	9	9	9
	1.68	9	9	9
	2.24	11	9	10
Sethoxydim	0.11	9	9	9
	0.56	11	9	10
	1.12	9	9	9
	2.24	9	9	9
Fluazifop	0.14	8	10	9
	0.56	8	10	9
	1.12	8	10	9
	2.24	9	9	9
Diclofop	0.84	9	7	8
	1.12	9	9	9
	1.40	8	8	8
	3.36	9	9	9

(continued on next page)

a Excluding the values of trifluralin and ethalfluralin treatments, values in this column are not significantly different at the 5% level as determined by Duncan's multiple range test.

Appendix Table 24. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(Kg/ha)	(cm)		
Haloxyfop	0.28	8	8	8 ns
	0.56	9	7	8
	1.12	10	10	10
	2.24	8	8	8
Bromoxynil + diclpfop	0.56 + 0.84	9	7	8
	1.12 + 1.12	8	8	8
	1.68 + 1.40	10	10	10
	2.24 + 3.36	7	9	8
Bromoxynil + fluazifop	0.56 + 0.14	9	9	9
	1.12 + 0.56	10	10	10
	1.68 + 1.12	10	8	9
	2.24 + 2.24	10	8	9
Bromoxynil + sethoxydim	0.56 + 0.11	9	9	9
	1.12 + 0.56	10	8	9
	1.68 + 1.12	9	7	8
	2.24 + 2.24	8	8	8
Bromoxynil + haloxyfop	0.56 + 0.28	8	8	8
	1.12 + 0.56	5	9	7
	1.68 + 1.12	8	8	8
	2.24 + 2.24	9	7	8
Desmedipham	0.56	9	7	8
	0.84	10	7	8
	1.40	9	9	9
	2.24	9	9	9
Phenmedipham	1.12	10	8	9
	1.40	10	8	9
	1.68	7	9	8
	3.36	11	9	10
Asulam	1.12	9	9	9
	1.68	10	10	10
	3.92	8	10	9
	7.84	9	9	9
Desmedipham + phenmedipham	0.56 + 0.56	9	9	9
	1.12 + 1.12	9	9	9
	2.24 + 2.24	7	9	8
	3.36 + 3.36	9	9	9
Check	----	9	9	9

Appendix Table 25. Cuphea dry weight 6 weeks after planting, in greenhouse experiment I, in 1984.

Treatments		Replications		
Herbicides	Rates	I	II	Avg[a]
	(Kg/ha)	--------(mg)----------		
Pre-plant				
Trifluralin	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
	1.68	0	0	0
Ethalfluralin	0.28	0	0	0
	0.56	0	0	0
	1.12	0	0	0
	1.68	0	0	0
Preemergence				
Benefin	1.12	23	27	25 a-f
	1.40	20	16	18 d-j
	1.68	18	26	22 c-i
	2.24	20	18	19 d-j
Propham	1.12	25	21	23 c-h
	4.48	12	22	17 e-j
	6.72	16	20	18 d-j
	8.96	15	15	15 g-j
Postemergence				
Bromoxynil	0.56	24	20	22 c-i
	1.12	18	24	21 c-j
	1.68	18	20	19 d-j
	2.24	30	18	24 b-g
Sethoxydim	0.11	30	18	24 b-g
	0.56	38	28	33 ab
	1.12	23	23	23 c-h
	2.24	18	18	18 d-j
Fluazifop	0.14	20	34	27 a-d
	0.56	22	20	21 c-j
	1.12	22	28	25 a-f
	2.24	27	25	26 a-e
Diclofop	0.84	27	13	20 c-j
	1.12	17	23	20 c-j
	1.40	20	18	19 d-j
	3.36	26	20	23 c-h

(continued on next page)

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

Appendix Table 25. (continued)

Treatments		Replications		
Herbicides	Rates	I	II	Avg
	(Kg/ha)	--------(mg)----------		
Haloxyfop	0.28	23	23	23 c-h
	0.56	27	13	20 c-j
	1.12	25	27	26 a-e
	2.24	20	20	20 c-j
Bromoxynil + diclofop	0.56 + 0.84	25	15	20 c-j
	1.12 + 1.12	15	15	15 g-j
	1.68 + 1.40	20	22	21 c-j
	2.24 + 3.36	13	17	15 g-j
Bromoxynil + fluazifop	0.56 + 0.14	17	17	17 e-j
	1.12 + 0.56	25	31	28 a-d
	1.68 + 1.12	25	17	21 c-j
	2.24 + 2.24	25	15	20 c-j
Bromoxynil + sethoxydim	0.56 + 0.11	22	18	20 c-j
	1.12 + 0.56	22	10	16 f-j
	1.68 + 1.12	21	13	17 e-j
	2.24 + 2.24	13	17	15 g-j
Bromoxynil + haloxyfop	0.56 + 0.28	20	16	18 d-j
	1.12 + 0.56	7	17	12 j
	1.68 + 1.12	20	14	17 e-j
	2.24 + 2.24	20	12	16 f-j
Desmedipham	0.56	17	13	15 g-j
	0.84	20	12	16 f-j
	1.40	16	22	19 d-j
	2.24	12	14	13 ij
Phenmedipham	1.12	15	15	15 g-j
	1.40	17	15	16 f-j
	1.68	18	18	18 d-j
	3.36	20	12	16 f-j
Asulam	1.12	23	23	23 c-h
	1.68	35	33	34 a
	3.92	22	36	29 abc
	7.84	27	25	26 a-e
Desmedipham + phenmedipham	0.56 + 0.56	17	17	17 e-j
	1.12 + 1.12	17	15	16 f-j
	2.24 + 2.24	10	16	13 ij
	3.36 + 3.36	14	14	14 hij
Check	----	20	22	21 c-j

Appendix Table 26. Visual estimate of cuphea injury 2 weeks after treatment, in greenhouse experiment II, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	------------(%)------------			
Pre-plant					
Benefin	1.12	0	0	0	0
	1.40	0	0	0	0
	1.68	0	0	0	0
	2.24	0	0	0	0
Preemergence					
Benefin	1.12	0	0	0	0
	1.40	0	0	0	0
	1.68	0	0	0	0
	2.24	0	0	0	0
Check	----	0	0	0	0

Appendix Table 27. Cuphea height 6 weeks after the herbicides application, in the greenhouse experiment II, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg[a]
	(Kg/ha)	----------- (cm)-----------			
Pre-plant					
Benefin	1.12	12	13	14	13 ab
	1.40	13	12	14	13 ab
	1.68	14	14	14	14 a
	2.24	12	10	11	11 b
Preemergence					
Benefin	1.12	15	14	16	15 a
	1.40	13	15	17	15 a
	1.68	14	14	11	13 ab
	2.24	12	14	13	13 ab
Check	----	13	12	14	13 ab

a Values in this column having a common letter are not significantly different as determined by the LSD test at the 5% level.

Appendix Table 28. Cuphea dry weight 6 weeks after treatment, in greenhouse experiment II, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	------------(mg)-----------			
Pre-plant					
Benefin	1.12	20	22	30	24 ns
	1.40	18	18	27	21
	1.68	20	24	22	22
	2.24	17	14	23	17
Preemergence					
Benefin	1.12	23	26	26	25
	1.40	24	24	30	26
	1.68	23	21	22	22
	2.24	20	22	12	18
Check	----	23	21	25	23

Appendix table 29. Visual estimate of cuphea injury 6 weeks after planting, in greenhouse experiment III, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg
	(Kg/ha)	(%)			
Pre-plant					
Ethalfluralin	0.28	0	0	0	0
	0.56	0	9	0	3
	1.68	70	50	75	65
Preemergence					
Benefin	1.12	0	0	0	0
	1.40	0	0	0	0
	2.24	0	0	0	0
Propham	1.12	20	5	50	25
	4.48	95	95	95	95
	8.96	95	95	95	95
Postemergence					
Bromoxynil	0.56	0	15	0	5
	1.12	20	20	20	20
	2.24	90	90	75	85
Sethoxydim	0.11	0	0	0	0
	0.56	0	0	9	3
	2.24	75	90	90	85
Fluazifop	0.14	0	0	0	0
	0.56	0	0	0	0
	2.24	0	0	9	3
Diclofop	0.84	9	0	0	3
	1.12	0	0	0	0
	3.36	20	20	20	20
Haloxyfop	0.28	0	0	0	0
	0.56	0	0	0	0
	2.24	25	15	20	20
Desmedipham	0.56	10	30	5	15
	0.84	20	40	0	20
	2.24	20	80	20	40
Check + oil	----	0	0	0	0
Check	----	0	0	0	0

Appendix Table 30. Cuphea height 6 weeks after planting, in greenhouse experiment III, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg[a]
	Kg/ha)	(cm)			
Pre-plant					
Ethalfluralin	0.28	9	9	9	9 b
	0.56	8	8	8	8 b
	1.68	5	5	5	5 c
Preemergence					
Benefin	1.12	10	10	10	10 b
	1.40	9	9	9	9 b
	2.24	9	9	9	9 b
Propham	1.12	5	6	4	5 c
	4.48	1	1	1	1 d
	8.96	1	1	1	1 d
Postemergence					
Bromoxynil	0.56	8	8	8	8 b
	1.12	9	7	8	8 b
	2.24	8	8	8	8 b
Sethoxydim	0.11	10	10	10	10 b
	0.56	10	9	8	9 b
	2.24	8	8	8	8 b
Fluazifop	0.14	11	10	9	10 b
	0.56	10	7	10	9 b
	2.24	9	9	9	9 b
Diclofop	0.84	9	9	9	9 b
	1.12	10	10	10	10 b
	3.36	9	8	21	12 a
Haloxyfop	0.28	10	10	10	10 b
	0.56	9	9	9	9 b
	2.24	7	7	7	7 bc
Desmedipham	0.56	9	9	9	9 b
	0.84	9	9	9	9 b
	2.24	7	9	8	8 b
Check + oil	----	9	9	9	9 b
Check	----	9	9	9	9 b

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

Appendix Table 31. Cuphea dry weight 6 weeks after planting, in greenhouse experiment III, in 1984.

Treatments		Replications			
Herbicides	Rates	I	II	III	Avg[a]
	Kg/ha)	(mg)			
Pre-plant					
Ethalfluralin	0.28	20	22	24	22 def
	0.56	18	15	20	18 hi
	1.68	5	10	6	7 m
Preemergence					
Benefin	1.12	21	30	30	27 ab
	1.40	30	20	22	24 cd
	2.24	26	23	23	24 cd
Propham	1.12	13	16	10	13 kl
	4.48	1	1	1	1 n
	8.96	1	1	1	1 n
Postemergence					
Bromoxynil	0.56	17	18	16	17 ij
	1.12	14	13	18	15 jk
	2.24	12	11	13	12 l
Sethoxydim	0.11	30	23	22	25 bc
	0.56	28	20	18	22def
	2.24	13	7	7	9 m
Fluazifop	0.14	40	24	23	29 a
	0.56	28	14	33	25 bc
	2.24	26	22	15	21 efg
Diclofop	0.84	20	20	20	20 fgh
	1.12	30	21	18	23 cde
	3.36	24	19	23	22 def
Haloxyfop	0.28	30	23	22	25 bc
	0.56	22	21	20	21 efg
	2.24	18	10	17	15 jk
Desmedipham	0.56	12	13	14	13 kl
	0.84	14	13	12	13 kl
	2.24	12	14	13	13 kl
Check + oil	----	27	23	22	24 cd
Check	----	23	26	26	25 bc

a Values in this column having a common letter are not significantly different as determined by Duncan's multiple range test at the 5% level.

Appendix Table 32. Analysis of variance of Appendix Table 11.

Source	S.S.	d.f.	M.S.	F
Treatments	46.66	8	5.83	2.35
Blocks	0.22	2	0.11	
Error	39.78	16	2.49	
Total	86.66	26		

C.V = 8.9%

Appendix Table 33. Analysis of variance of Appendix Table 12.

Source	S.S.	d.f.	M.S.	F
Treatments	122.66	8	15.33	2.09
Blocks	26.89	2	13.44	
Error	117.11	16	7.32	
Total	266.66	26		

C.V = 44.3%

Appendix Table 34. Analysis of variance of Appendix Table 13, and Table 5.

Source	S.S.	d.f.	M.S.	F[a]
Treatments	66750.00	8	8343.75	3.71 *
Blocks	4572.22	2	2286.11	
Error	36027.20	16	2251.74	
Total	107349.42	26		

C.V = 32.7%

Appendix Table 35. Analysis of variance of Appendix Table 19.

Source	S.S.	d.f.	M.S.	F
Treatments	574.53	33	17.41	1.34
Blocks	94.37	2	47.19	
Error	859.98	66	13.03	
Total	1528.88	101		

C.V = 15.4%

a * indicate significance at the 5% level.

Appendix Table 36. Analysis of variance of Appendix Table 20.

Source	S.S.	d.f.	M.S.	F
Treatments	8618.28	33	261.16	0.92
Blocks	484.38	2	242.19	
Error	18699.78	66	283.33	
Total	27802.44	101		

C.V = 1.1%

Appendix Table 37. Analysis of variance of Appendix Table 22 and Table 7.

Source	S.S.	d.f.	M.S.	F
Treatments	648994.5	33	19666.5	1.46
Blocks	276054.0	2	138027.0	
Error	891660.0	66	13510.0	
Total	1816708.5	101		

C.V = 21.4%

Appendix Table 38. Analysis of variance of Appendix Table 24.

Source	S.S.	d.f.	M.S.	F
Treatments	115.71	60	1.93	1.11
Blocks	1.84	1	1.84	
Error	104.66	60	1.74	
Total	222.21	121		

C.V = 15.4%

Appendix Table 39. Analysis of variance of Appendix Table 25 and Table 8.

Source	S.S.	d.f.	M.S.	F[a]
Treatments	3436.72	60	57.28	3.68 *
Blocks	216.65	1	216.65	
Error	939.35	60	15.56	
Total	4592.72	121		

C.V = 19.9%

a * indicate significance at the 5% level.

Appendix Table 40. Analysis of variance of Appendix Table 27.

Source	S.S.	d.f.	M.S.	F[a]
Treatments	36.0	8	4.50	3.08 *
Blocks	2.6	2	1.33	
Error	24.0	16	1.49	
Total	62.6	26		

C.V = 9.2%

Appendix Table 41. Analysis of variance of Appendix Table 28 and Table 9.

Source	S.S.	d.f.	M.S.	F
Treatments	188.8	8	23.58	1.89
Blocks	54.8	2	27.44	
Error	201.6	16	12.57	
Total	445.2	26		

C.V = 16%

Appendix Table 42. Analysis of variance of Appendix Table 30.

Source	S.S.	d.f.	M.S.	F
Treatments	504.85	28	18.03	8.62 *
Blocks	2.92	2	1.46	
Error	117.08	56	2.09	
Total	624.85	86		

C.V = 17.6%

Appendix Table 43. Analysis of variance of Appendix Table 31 and Table 10.

Source	S.S.	d.f.	M.S.	F
Treatments	4532.95	28	161.89	11.86 *
Blocks	130.30	2	65.15	
Error	764.37	56	13.65	
Total	5427.61	86		

C.V = 20.4%

a * indicate significance at the 5% level.

Appendix Table 44. List of chemicals discussed or used in this study.

Common name	Trade name	Chemical name
alachlor	Lasso	2-chloro-N-(ethoxymethyl)-(2-ethyl-6-methylphenyl) acetamide.
asulam	Asulox	methyl[(4-aminophenyl) sulfonyl]carbamate.
atrazine	Aatrex	6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine
benefin	Balan	N-butyl-N-ethyl-2,6-dinitrol-4-trifluoromethyl)benzenamine
bentazon	Basagran	3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide.
bromoxynil	Buctril	3,5-dibromo-4-hydroxybenzonitrile
chloramben	Amiben	3-amino-2,5-dichlorobenzoic acid.
chloroxuron	Tenoran	N'-[4-(4-chlorophenoxy) phenyl]-N,N-dimethylurea.
chlorpropham	Furloe	1-methylethyl 3-chlorophenylcarbamate.
2,4-D	(Several)	(2,4-dichlorophenoxy)acetic acid.
dalapon	Dowpon	2,2-dichloropropanoic acid.
dazomet	Basamid	tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione
DCPA	Dacthal	Dimethyl2,3,5,6-tetrachloro-1,4-benzenedicarboxylate
desmedipham	Betanex	ethyl[3-[[(phenylamino) carbonyl]oxy]phenyl] carbamate.
dichlobenil	Casoron	2,6-dichlorobenzonitrile.
diclofop	Hoelon	(+/-)-2[4-(2,4-dichloro phenoxy)phenoxy]propanoic acid
dinoseb	Premerge	2-(1-methylpropyl)-4,6-dinitrophenol.
diuron	Karmex	N'-(3,4-dichlorophenyl)-N,N-dimethylurea.
EPTC	Eptam	S-ethyl dipropyl carbamothioate.
ethalfluralin	Sonalan	N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl) benzenamine.
ethofumesate	Nortron	(+/-)-2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranyl methanesulfonate.

(continued on next page)

Appendix Table 44. (continued)

Common name	Trade name	Chemical name
fluazifop	Fusilade	(+/-)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy] propanoic acid.
glyphosate	Roundup	N-(phosphonomethyl)glycine.
haloxyfop	Verdict	Methyl ester of 2-[4-[[3-chloro-5-(trifluoromethtl) -2-pyridinyl]oxy]phenoxy]-propanoic acid
metribuzin	Sencor	4-amino-6-(1,1-dimethyl ethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one.
napropamide	Devrinol	N,N-diethyl-2-(1-naphtalenyloxy)propanamide.
nitrofen	Tok	2,4-dichloro-1-(4-nitrophenoxy)benzene
oryzalin	Surflan	4-(dipropylamino)-3,5-dinitrobenzenesulfonamide.
oxadiazon	Ronstar	3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5--(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3H)-one.
oxyfluorfen	Goal	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene.
paraquat	Gramoxone	1,1'-dimethyl-4,4'-bipyridinium ion.
pendimethalin	Prowl	N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine.
phenmedipham	Betanal	3-[(methoxycarbonyl) amino]phenyl(3-methylphenyl)carbamate.
propanil	Stam	N-(3,4-dichlorophenyl) propanamide.
propachlor	Ramrod	2-chloro-N-(1-methylethyl)-N-phenylacetamide.
propham	Chem Hoe	1-methylethyl phenylcarbamate.
sethoxydim	Poast	2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one.
simazine	Princep	6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine.
terbacil	Sinbar	5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione.
trifluralin	Treflan	2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl) benzenamine