EFFECTS OF SELECTED HERBICIDES ON TREATED AND ROTATIONAL CROPS

By

S. FAUSTO VENEGAS

Ingeniero Agronomo

Universidad de Guayaquil

Guayaquil, Ecuador

1972

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 1980

To my children

Maria Gabriela and Fausto Xavier

EFFECTS OF SELECTED HERBICIDES ON

TREATED AND ROTATIONAL CROPS

Thesis Approved:

Thomas F Peeper

Thesis Adviser

Howard A L Greer

Eddie Basler

Norman N Durham

Dean of the Graduate College

ACKNOWLEDGMENTS

The author whishes to express his appreciation to his major adviser, Dr. T. F. Peeper, for his constructive guidance, and valuable training during the course of this research. Appreciation is also extended to Dr. Eddie Basler and Dr. Howard Greer for their suggestions and assistance as members of the author's graduate committee.

A sincere thanks is expressed to the Department of Agronomy of Oklahoma State University for use of the facilities, equipment, and land for this research. Appreciation is also extended to the author's fellow graduate students and friends for their help and assistance.

Gratefully acknowledge is the encouragement of Dr. Robert Morrison throughout the statistical analyses.

I am especially thankful to my wife, Maria for her encouragement, patience, and help during the course of this studies. A sincere thanks is expressed to my parents and brothers for their interest and encouragement in furthering my education.

I am extremely grateful to National Institute of Agricultural Investigation (I.N.I.A.P., Ecuador) for the support of my studies.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

CHAPTER I

INTRODUCTION

Winter wheat (*Triticum* spp.) and sorghum sudan hybrids (*Sorghum bicolor* var. *sudanense*), mungbeans (*Phaseolus aureus* Roxb.), guar (*Cyamopsis tetragonoloba* L.), soybeans (*Glycine max* L.), millet (*Setaria italica* L.), and corn (*Zea mays* L.) can often be grown in rotation or double cropped in some areas of Oklahoma by taking advantage of frequently favorable weather conditions during early spring and early summer.

Unlike insects or fungi, weeds only seriously reduce yield or quality when they compete with the crop for available light, moisture, nutrients, heat energy (temperature), and carbon dioxide, and when factors such as the nature of the soil and farming technique do not in themselves seriously limit crop yield (1, 3, 4, 6, 7, 9, 11, 14, 16, 21, 33, 39, 41). With the use of selective herbicides, most weed problems in individual crops are easy to resolve. However, when rotational crops are planted soon after harvest of a treated crop, residual effects become much more important because of the possibilities of affecting crops planted in the area of previous applications. The increasing frequency of double cropping and the advent of use of residual herbicides on wheat have created some information deficiencies regarding the performance of selected herbicides to double cropping situations.

The objectives of this research were: (1) Evaluate the effects of herbicides used in the spring or as harvest aids to wheat on crops planted following wheat harvest. (2) Evaluate the effects of row crop herbicides on treated crops and fall sown wheat.

CHAPTER II

LITERATURE REVIEW

In a double cropping production program the time interval between successive planting is reduced considerable as compared to systems where only one crop is produced each year. The reduction of intervals between planting successive crops also means that less time is available for dissipation of residues of herbicides used for the various crops. In this situation, the persistence characteristics of various herbicides must be understood in order to avoid the possibility of injuring successive crops.

Persistence of Herbicides

Weber et al. (43) found that differences in soil constituents greatly influence the effectiveness, selectivity, and fate of herbicides.

Klingman and Ashton (21) stated that the length of time that a herbicide remains active or persists in the soil is extremely important because it determines the legnth of time that weed control can be expected and because it relates to phytotoxic after-effects that may prove injurious to succeding crops. They mentioned seven factors that affect the persistence of a herbicide in the soil: (1) microbial decomposition, (2) chemical decomposition, (3) adsorption on soil colloids, (4) leaching, (5) volatility, (6) photo-decomposition, and (7) removal by higher plants when harvested.

According to Radosevich and Winterlin (29), environmental conditions, especially temperature, rainfall, and soil moisture, play an important role in the persistence of 2,4-D (the chemical names of all herbicides mentioned are in Table I) and 2,4,5-T.

Crafts and Robin (6) found that decomposition of 2,4-D occurs most rapidly in moist, warm, acid soils. Where summer rains are prevalent, it may present no problems, but where summers are dry, as in the southwestern and western States, 2,4-D has killed seedlings as long as 6 to 9 months after application.

Corbin and Upchurch (8) argued that soil pH may directly or indirectly influence the activity and detoxication of herbicides by affecting the ionic or molecular character of the chemical, the ionic character of soil colloids, the cation exchange capacity, and the inherent capacity of microbial population to attack a given herbicide. Bailey and White (2) stated that surface acidity is probably the most important property of the soil or colloidal system in determining the extent and nature of adsorption and desorption of basic organic compounds. In the case of triazines, numerous studies (22, 23, 24) have shown that they are less phytotoxic under acid soil conditions than under basic conditions.

TABLE I

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Name	Chemical Name
alachlor	2-chloro-2',6'-diethyl-N-(methoxymethyl) acentanilide
atrazine	2-chloro-4-ethylamino-6-isopropylamino-S-triazine
benefin	N-butyl-N-ethyl- , , -trifluoro-2,6-dinitro-p-toluidine
chlorazine	2-chloro-4,6-bis(diethylamino)-s-triazine
cyanazine	2- 4-chloro-6-(ethylamino)-s-triazin-2-yl amino -2-methylpropionitrile
dinitramine	N^4,N^4-diethyl- , , -trifluoro-3,5-dinitro-toluene-2,4-diamine
diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
fenuron	1,1-dimethyl-3-phenylurea
fluchloralin	N-(2-chloroethyl)-2,6-dinitro-N-propyl-4-(trifluoro-methyl)aniline
fluometuron	1,1-dimethyl-3-(, , -trifluoro-m-tolyl)urea
ipazine	2-chloro-4-isopropylamino-6-diethylamino-s-triazine
linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
metolachlor	2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-Methoxy-1-methylethyl)
metribuzin	4-amino-6ter-butyl-3-(methylthio)-as-triazine-5(4H)one
monuron	3-(p-chlorophenyl)-1,1-dimethylurea
nitralin	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline
norea	3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea
oryzalin	3,5-dinitro-N^4,N^4-dipropylsulfanilamide
penoxalin	N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine
profluralin	N-(cyclopropylmethyl)- , , -trifluoro-2,6-dinitro-N-propyl-p-toluidine
prometryn	2,4-bis(isopropylamino)-6-(methylthio)-s-triazine
propazine	2-chloro-4,6-bis(isopropylamino)-s-triazine
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
terbacil	3-tert-butyl-5-chloro-6-methyluracil
trifluralin	, , -trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
2,4-D	(2,4-dichlorophenoxy)acetic acid
2,4,5-T	(2,4,5-trichlorophenoxy)acetic acid

Weber et al. (44, 45) have shown that triazines containing a methyl mercapto group are more highly adsorbed to organic matter, especially at low pH, than similar triazines possessing methoxy, hydroxy, or chlorine instead of the methyl mercapto substituent. Their studies indicate that the methyl mercapto group at the 5 position in triazinone ring of metribuzin could be important in affecting adsorption to soil organic matter.

Sharon and Stephenson (35) found that the half life of metribuzin in soil can vary from 2.5 to 4 months, thus failures in preemergence weed control could not be related to the rapid degradation, but could result under high rainfall conditions in soils with low organic matter due to leaching below the zone of weed seed germination. A significant percentage of the applied metribuzin could be present at the beginning of the subsequent season in most soils. The herbicide is biodegradable in muck and mineral soils but it is more likely to persist longer in muck soil since the herbicide loss through leaching is negligible and higher rates of application are generally required for effective weed control in muck soil. Ladlie et al. (24) determined that metribuzin leaching increased with increasing soil pH.

According to numerous studies (5, 18, 37, 38, 40) tria zine herbicides with a methoxy substituent in the two position of the ring are more persistent than those containing chloro or methylthio substituents. Switzer and Ranser (40) ranked six chloro-triazines in order of activity and persistence in soils as follows: simazine=atrazine=propazine ipazine trietazine chlorazine.

Several investigators (12, 13, 20) found that the hazard to rotational crops is greatest in fields which have been sprayed two or three years in succession with simazine or atrazine. Ilnichi, as cited by Sheets (36), determined the response of wheat and barley to residues of atrazine and simazine over a six-year period, and compared the effect of continous annual application (one each year) to that of two or more annual applications followed by a year without herbicide. The results showed that injury was less the year without herbicide, but when an omission of an annual application preceded an application by one year or more, injury to wheat and barley was about as severe as when the herbicides were applied each year.

In experiments involving the application of nitralin during a 2 year period, Miller et al. (27) found its residues in soil increased with rate and number of application, and accumulated to higher concentrations in a soil with 2.9 % organic matter than in soil with 0.7% organic matter.

Rahman (30) studyed the residual activity in different soils of terbacil and trifluralin at the end of the cropping season, approximately 6 months after application, and found that when 1 kg/ha of terbacil was applied phytotoxic residues occurred in a majority of the trials while at 2 kg /ha such a carry-over could be found in every case. With trifluralin rates of up to 1 kg/ha did not persist in phytotoxic amounts in most soils, while application at 2 kg/ha showed residual activity in 74% of the trials. Both organic matter and clay content of the trial sites affected the persistence of terbacil, while trifluralin residues were influenced only by the soil organic matter content. However, Horowitz et al. (19) found that in soils with low organic matter content the persistence of trifluralin increased with increasing clay content.

Savage and Barrentine (34) by using bioassay and chemical analysis of trifluralin residues from both greenhouse and field experiments found that the persistence of this herbicide is increased by increasing the depth of incorporation compared to shallow incorporation or surface application. The influence of incorporation depth on persistence becomes apparent by considering that the primary modes of trifluralin disipation are volatilization, photodecomposition, and microbial and chemical decomposition.

Helling (15) determined that volatilization from surface applications to moist soil is substantial for trifluralin, benefin, and profluralin, but is low for nitralin and oryzalin and concluded that for normal use rates, persistence in soils ranges from about 2-3 months for oryzalin and dinitramine, to 5-6 months for benefin and trifluralin. Persistence increased with decreasing soil temperature and moisture content.

Lawrence and Frans (25) found inhibition of cotton and soybean lateral roots by trifluralin directly related to depth and method of incorporation. A bioassay of the soil showed that disking trifluralin-treated plots before bedding caused the greatest retention of the material 3 weeks later, and that retention was less when the herbicide was applied and shallowly incorporated after planting.

Savage and Barrentine (34) found a direct relationship between trifluralin volatilization and depth of soil incorporation. This is important in considering successive applications accompanied by deep incorporation because it could be an important factor in accumulation of trifluralin residue to levels that could prove detrimental to current or succeeding crops.

Rahman et. al. (31) studyed the effect of three levels of soil compaction on the activity of two soil-applied herbicides, atrazine and trifluralin. Using oats as test species, he found that trifluralin was more persistent than atrazine and the residual activities of both herbicides was increased significantly as a result of both the moderate and heavy compaction treatments. Rovira and Greacen (32) found that excessive compaction of the soil does not only affect the emergence and growth of plants adversely, but also alters the phytotoxicity of soil-applied herbicides which could affect the choice of subsequent crops in a rotation system. These results could also have implications for minimun tillage systems, where the activity and persistence of some herbicides may differ from those measured in conventionally tilled systems due to differing levels of soil compaction.

McCormick and Hiltbold (26) showed that microbial activity accelerated decomposition of atrazine and diuron, which doubling with each 10-degree rise in temperature from 10 to 30^{o}C, and paralleled the response of soil organic matter decomposition. Diuron decomposition approximately tripled with each 10 degree rise in temperature. Also Horowitz et. al. (19) while studying the concentration of trifluralin required for a given growth reduction in sorghum found that the concentration was approximately eight time greater after incubation at 40^{o}C than at 10^{o}C.

Murray et al. (28) studied the phytotoxicity of the five substituted urea herbicides diuron, monuron, fenuron, norea, and fluometuron in factorial combinations at four nitrogen levels of 0, 45, 450, and 900 ppm with the three Aspergilli: A. niger, A. sydowi, and A. tamarii. They found that A. niger was most effective in degrading these herbicides and high nitrogen levels in soil organic matter amendments generally favored increased rates of urea herbicide degradation.

Klingman and Ashton (21) pointed out that factors such as temperature, soil pH, organic matter, oxygen and mineral nutrient supply affect the growth and rate of multiplication of microorganisms. Most soil microorganisms are nearly dormant at 40^{o}F while 75-90^{o}F is most favorable for growth. Without water most organisms become dormant or die. Aerobic organisms are very sensitive to an adequate oxygen supply, and deficiency of nutrients, such as nitrogen, phosphorous, or potasium. Thus, the herbicides residual may be increased if the soil is cold, dry, poorly aerated, or if other conditions are unfavorable for microorganism growth. If the organisms are destroyed by soil sterilization (steam or chemical methods), decomposition of the herbicide may temporarily stop.

Double cropping of wheat with sorghum or soybeans has been practiced successfully for several years in areas of the United States where rainfall is adequate or irrigation is available. Now scientists and farmers in the Southern United States, especially in Oklahoma, have a marked interest in double cropping other crops after wheat harvest such as millet, cotton, mungbeans, guar, sorghum sudan hybrids, in efforts to obtain greater productivity from the soil.

Brief Description of Crops Investigated

According to Delorit and Ahlgren (10) corn is the most valuable crop grown in the United States, with the greatest production in a number of midwestern states in an area referred to as the Corn Belt. Most of the corn is fed to livestock and poultry and a smaller percent is used as food for human consumption and for production of industrial products. These authors affirmed that wheat is the most important grain crop grown on a worldwide basis and is second only to corn in acreage and production in the United States. Unlike corn, wheat is used primarily for human consumption rather than as livestock feed.

Sorghum is typically grown in areas with limited rainfall and high summer temperatures and used as a source of feed for livestock and poultry. The grain has a higher protein content than corn and is lower in fat.

Wolfe and Kipps (46) described foxtail millet as a cereal of wide cultivation in the tropics and parts of the warm temperature regions especially Asia and Africa. It is usually characterized by a short maturation period and is used mainly for hay.

The same authors (46) referred to soybeans as an oil crop adapted mainly to temperate regions with fairly humid, warm growing seasons. They indicate that soybeans are less sensitive to frost and less affected by drought or wet weather than corn.

Titus (42) described mungbeans as an annual legume widely grown in Oklahoma for hay, seed, green manure, and as a summer cover crop. One characteristic which has led to its popularity in northcentral Oklahoma is its remarkable ability to grow well under severe drought conditions.

Hymowitz (17) described guar as an annual drought tolerant legume introduced to the United States from India and used principally as forage for cattle, as a green manure, and as a vegetable for human consumption. It has been used to some extent from Southwestern Oklahoma through Texas and Arizona.

CHAPTER III

METHODS AND MATERIALS

The present research comprised two field experiments conducted during 1979 and 1980 at the Oklahoma State University Agronomy Research Station at Stillwater, Oklahoma.

Effect of Wheat Herbicides on Treated and Rotational Crops

An experiment was initiated March 14, 1979, by applying selected herbicide treatments to tillered Osage-Centurk blend hard red winter wheat on a Port clay loam soil (Cumulic Hapus toll) with 1.4% O.M. A split plot design with 13 treatments and 4 replications was used. A hand weeded treatment was included as a control. The most important weed in the area was Henbit (Lamium amplexicaule L.). The herbicide treatments used are shown in Table II.

Ten treatments were applied March 14, 1979, when the wheat was in the full tiller stage and two treatments were applied as harvest aids June 7, 1979, when the wheat was in the dough stage. Treatments were applied to 6 x 12 meter (m) plots using a small plot sprayer calibrated to apply 189 liter/hectare (l/ha) to a constant pressure of 1.7 kilogram/centimeters^2 (kg/cm^2) at a speed of 4.8 kilometer/hour (km/

TABLE II

TREATMENTS STUDIED IN WHEAT'S HERBICIDES EFFECTS TO ROTATIONAL CROPS STILLWATER, 1979

Treatment		Formulation(1)	Rate (kg/ha)	Growth Stage
1.	Metribuzin	WP	0.55	Full Tiller
2.			0.83	"
3.	Diuron	WP	1.30	"
4.			1.80	"
5.	2,4-D	Amine	0.83	"
6.			1.70	"
7.	Oryzalin	WP	1.10	"
8.			2.20	"
9.	Cyanazine	G	1.70	"
10.			3.30	"
11.	2,4-D	Amine	0.83	Soft dough
12.			1.70	"
13.	Check	-	-	-

(1) WP=wetable power, G=granular.

hr). The granular herbicide treatments were applied with the cone seeder type spreader.

Weed control and crop injury were visually evaluated 15 and 30 days after application of the treatments applied in March, using a scale of 0 to 100, where 0 equals no weed control or crop injury and 100 equals total crop or weed kill.

On June 26, 1979, 19.4 m^2 of each plot was harvested with a small plot combine and the yields recorded.

On July 11, 1979, glyphosate was applied to the entire area at 2.2 kg/ha to eliminate weeds that were present in the area, and three 0.55 m rows of each rotational crop were seeded in each plot with a no-till planter. The crops planted were "Dare" soybeans, "Ok-12" mungbeans, "Esser" guar, "BR-Y-93" sorghum, "Foxtail" millet, and sorghum sudan hybrid.

Crop injury was evaluated visually 7, 15 and 21 days after planting using the scale previously described. Sorghum sudan hybrid, sorghum, and millet were harvested on September 18, 1979, with a small plot forage harvester taking samples of 5.5 m^2/crop. Fresh weight yields were converted to dry forage yield by drying sample portions in a forage dryer.

The other crops were harvested with a small plot grain combine. The mungbeans were combined on September 28, 1979, and the guar and soybeans on November 28, 1979.

Effect of Row Crop Herbicides on Treated Crops and Fall Sown Wheat

An experiment was initiated on June 7, 1979, on a Port clay loan soil (Cumulic Hapus toll) to investigate the effect of several herbicides applied to summer row crops on wheat sown in the fall. In each case the herbicide treatments were applied at a typical use rate and at twice the normal rate of application. A randomized block experimental design with 26 treatments and 3 replications was used.

The herbicide treatments (Table III) were applied to 3 x 12 m plots with the high clearence plot sprayer calibrated to apply 189 l/ha at a constant pressure of 2.5 kg/cm^2 and a speed of 4.8 km/hr. Two hand-weeded treatments were included as controls. The preplant incorporated (P.P.I.) treatments were incorporated inmediately after application with a 1.8 m tandem disc operated 10 to 12.5 cm deep twice over the plots in opposite directions.

Two rows of "OK-12" mungbeans, "Esser" quar, "Pay Master" sorghum, "Dare" soybeans, and "Northrump King PX-74" corn were seeded across each plot. The row spacing was 1 m.

Crop injury was visually evaluated 7, 15 and 21 days after planting as previously described.

Weed control was visually evaluated 30, 60 and 90 days after application using the scale explained previously.

On September 25, 1979, the sorghum was harvested with

TABLE III

TREATMENTS STUDIED IN SUMMER CROPS ROTATING TO WHEAT STILLWATER, 1979-80

Treatment		Formulation[1]	Rate (kg/ha)	Application[2]
1.	Fluchloralin	g/l	1.10	PPI
2.		"	2.20	"
3.	Penoxalin	"	0.83	"
4.		"	1.65	"
5.	Profluralin	"	0.83	"
6.		"	1.65	"
7.	Trifluralin	"	0.83	"
8.		"	1.65	"
9.	Check	-	-	-
10.	Oryzalin	WP	1.10	PRE
11.		"	2.20	"
12.	Metolachlor	g/l	1.65	"
13.		"	3.30	"
14.	Alachlor	"	1.65	"
15.		"	3.30	"
16.	Linuron	WP	1.45	"
17.		"	2.93	"
18.	Cyanazine	"	1.65	"
19.		"	3.30	"
20.	Atrazine	"	1.65	"
21.		"	3.30	"
22.	Prometryn	"	1.10	"
23.		"	2.20	"
24.	Metribuzin	"	0.55	"
25.		"	1.10	"
26.	Check	-	-	-

(1) g/l=gallon/liter, WP=wetable powder.
(2) PPI=preplant incorporated, PRE=preemergence.

the small plot forage harvester by chopping samples from 2.5 m^2/plot. Samples were dried in a forage drier to convert fresh weight to dry yield. Corn yield was determined the same day by cutting the stalks near ground level and weighing the entire plant. Seed yield of mungbeans, soybeans, and guar was determined by harvesting the crops with a small plot combine on September 25, October 23, and November 28, respectively. On October 28, TAM W 101 wheat was sown into the plots with a no-till type grain drill on 25 cm rows. The herbicide toxicity was registered during 164 and 180 days after planting.

The wheat was harvested on June 12, 1980, from 10.5 m^2 each plot with a small plot combine.

CHAPTER IV

RESULTS AND DISCUSSION

Effect of Wheat Herbicides on Treated and Rotational Crops

Evaluations of henbit control (*Lamium amplexicaule* L.) at 15 and 30 days after application of the full tiller growth stage treatments (Table IV) show that metribuzin and the higher rate of cyanazine gave excellent control of this weed. Diuron and the lower rate of cyanazine were less effective, and 2,4-D gave little control. Since the henbit was well established when treated, no control was anticipated with oryzalin.

At 15 days after application of the full tiller growth stage treatments (Table IV) cyanazine at 3.3 kg/ha was causing chlorosis and slight stunting of the wheat. The low rate of cyanazine (1.7 kg/ha) and metribuzin at 0.83 kg/ha were the only other treatments with over 10 percent injury. At 30 days after treatment injury from the high rate of cyanazine was unchanged, while the effects of metribuzin appeared to decrease. Cyanazine at 3.3 kg/ha and diuron at 1.3 kg/ha were the only treatments that reduced wheat yield.

Visual ratings on the rotational broadleaf crops 7, 15, and 21 days after planting (Table V) show that at 7 days af-

TABLE IV

HENBIT CONTROL, WHEAT INJURY AND YIELD
FROM HERBICIDE TREATMENTS
APPLIED TO WHEAT

Treatment		Growth Stage	Rate (kg/ha)	Henbit Control[1] 15 dat	Henbit Control[1] 30 dat	Wheat Injury 15 dat	Wheat Injury 30 dat	Wheat Yield[2] (kg/ha)
1.	Metribuzin	Full Tiller	0.55	10	95	5	3	3661 abc
2.		"	0.83	25	95	18	3	3708 abc
3.	Diuron	"	1.30	18	73	8	8	3333 c
4.		"	1.80	10	75	5	3	3802 abc
5.	2,4-D	"	0.83	0	10	10	10	3936 ab
6.		"	1.70	3	30	5	10	3989 ab
7.	Oryzalin	"	1.10	0	0	10	3	3661 abc
8.		"	2.20	0	0	8	5	3848 abc
9.	Cyanazine (G)	"	1.70	5	70	13	8	3591 bc
10.		"	3.30	18	98	40	40	1851 d
11.	2,4-D	Soft Dough	0.83	-	-	-	-	4182 a
12.		"	1.70	-	-	-	-	3884 ab
13.	Check	-	-	0	0	0	0	3889 ab

(1) Visual ratings are based on a scale of 0-100 with 0 being no control or plant injury and 100 being total control or plant kill. dat=days after treatment.
(2) DNMST 5%.

TABLE V

INJURY TO ROTATIONAL BROADLEAF CROPS FROM HERBICIDE TREATMENTS APPLIED TO WHEAT

	Treatment	Rate (kg/ha)	Soybeans[1]			Mungbeans			Guar		
			7	15	21[2]	7	15	21	7	15	21
1.	Metribuzin	0.55	0	0	5	0	5	0	0	10	3
2.		0.83	0	0	5	0	5	0	0	0	0
3.	Diuron	1.30	0	5	0	5	10	0	0	8	0
4.		1.80	5	5	0	8	5	8	0	5	5
5.	2,4-D	0.83	0	0	5	5	0	0	5	5	5
6.		1.70	0	8	0	8	8	0	0	8	8
7.	Oryzalin	1.10	0	0	0	0	0	0	0	5	0
8.		2.20	0	0	0	0	0	0	0	0	8
9.	Cyanazine (G)	1.70	0	0	0	0	0	0	0	5	13
10.		3.30	0	0	0	8	8	0	10	15	20
11.	2,4-D (Harvest	0.83	0	0	0	0	0	0	0	0	0
12.	aid)	1.70	0	5	3	0	0	0	0	0	15
13.	Check	-	0	0	0	0	0	0	0	0	0

(1) Visual ratings are based on a scale of 0-100 with 0 being no plant injury and 100 being plant kill.
(2) Days after planting.

ter planting soybeans were slightly injured in plots where diuron at 1.8 kg/ha had been applied. At 15 days after planting, slight injury was evidont from both diuron treatments and from the high rates of 2,4-D applied in March and June. At 21 days after planting slight soybean injury was present in plots treated with 2,4-D at 0.83 kg/ha applied in March and metribuzin at both rates.

Diuron, 2,4-D applied in March, and the higher rate of cyanazine were the only treatments that noticeably injured mungbeans. Although the injury was not severe, chlorosis was apparent from diuron at 15 and 21 days after planting.

In contrast to soybeans and mungbeans, guar demonstrated greater sensitivity to cyanazine that to diuron. Although guar injury from cyanazine was not severe, visual symptoms increased with time from 7 to 21 days after planting, whereas diuron did not significantly injure guar. At 21 days after planting some injury was noted from 2,4-D applied at 1.7 kg/ha as a harvest aid to the preceeding wheat crop.

At 7, 15, and 21 days after planting (Table VI) sorghum sudan hybrid were exhibiting obvious injury from cyanazine at 3.3 kg/ha, whereas millet appeared to be more tolerant to this herbicide. Oryzalin appeared to have a negative effect on all of the grass crops, but by 21 days after planting only the higher rate was causing significant injury on sorghum sudan hybrid, whereas both rates were affecting the millet. Diuron also appeared to have a greater effect on millet than the other grass crops. The injury from diuron on millet in-

TABLE VI

INJURY TO ROTATIONAL GRASS CROPS
FROM HERBICIDE TREATMENTS
APPLIED TO WHEAT

Treatment		Rate (kg/ha)	Sorghum (1) 7 (2)	15	21	S. sudan hybrid 7	15	21	Millet 7	15	21
1.	Metribuzin	0.55	13	13	3	8	0	15	0	5	20
2.		0.83	5	18	0	0	5	5	0	8	5
3.	Diuron	1.30	5	0	0	0	0	0	8	8	20
4.		1.80	5	8	0	0	0	0	0	15	18
5.	2,4-D	0.83	0	5	3	0	15	18	0	15	23
6.		1.70	5	8	0	0	8	13	0	0	8
7.	Oryzalin	1.10	23	13	5	5	0	8	5	20	25
8.		2.20	5	0	10	3	0	15	8	15	25
9.	Cyanazine (G)	1.70	10	0	0	5	0	0	0	0	10
10.		3.30	20	25	18	13	20	15	0	10	5
11.	2,4-D (Harvest	0.83	13	10	0	5	0	5	0	0	8
12.	aid)	1.70	13	15	5	5	0	10	0	0	0
13.	Check	-	0	0	0	0	5	0	0	5	5

(1) Visual ratings are based on a scale of 0-100 with 0 being no plant injury and 100 being plant kill.
(2) Days after planting.

creased considerably between 15 and 21 days after planting, where the other grass crops did not demonstrate diuron injury by 21 days after planting. The harvest aid application of 2,4-D had an early effect on sorghum that soon disappeared. The effect of metribuzin and the earlier 2,4-D application was not completely clear. There was some indication at 21 days after planting that millet and sorghum sudan hybrid were being stunted by the 2,4-D application in March.

Since very few weeds infested the plot area during the course of the experiment, the effects on yield should be considered effects from the herbicide applications. The statistical analysis revealed very few differences in yield of the broadleaf crops, however, there was considerable variability in the data (Table VII). None of the treatments reduced the yield of the broadleaf crops, but the guar yield was higher in the plots treated with the high rate of cyanazine. The guar was apparently not only able to overcome the early cyanazine injury, but also appeared to utilize the additional moisture and nutrients available as a result of severely reducing the yield of the preceeding wheat crop to produce a yield increase.

The yield of the grass crops was closely related to the visual ratings obtained early in the season, generally the sorghum sudan hybrid appeared more sensitive to 2,4-D applied in March or as a harvest aid. The higher rates of oryzalin and cyanazine reduced the sorghum sudan hybrid yield but not sorghum yield. In addition the lower rates of

TABLE VII

ROTATIONAL CROPS YIELD FROM HERBICIDE TREATMENTS APPLIED TO WHEAT

Treatment	Rate (kg/ha)	Yield (kg/ha) Soybeans	Mungbeans	Guar	Sorghum	S. sudan	Millet
1. Metribuzin	0.55	1054 a-c[(1)]	1715 a	930 a-d	11157 a-e	7252 d	4628 b-e
2.	0.83	888 bc	1219 bc	930 a-d	13616 ab	11095 a-c	5992 ab
3. Diuron	1.30	1260 ab	1074 c	971 a-c	13471 a-c	12645 a	5000 b-e
4.	1.80	1074 a-c	1157 bc	930 a-d	11488 a-d	10083 a-d	4298 c-e
5. 2,4-D	0.83	1136 a-c	1302 a-c	785 de	14029 a	9070 a-d	5000 b-e
6.	1.70	847 c	1467 ab	868 b-e	10558 c-e	7603 cd	5661 a-c
7. Oryzalin	1.10	1157 a-c	1281 bc	1054 ab	8388 e	8450 b-d	3719 e
8.	2.20	1178 a-c	1033 c	868 b-e	13781 ab	7872 cd	3740 d-e
9. Cyanazine (G)	1.70	1260 ab	1322 a-c	806 c-e	13843 ab	8967 a-d	5310 a-d
10.	3.30	1240 ab	1054 c	1116 a	11012 b-e	8202 cd	6653 a
11. 2,4-D (Harvest	0.83	1405 a	1157 bc	744 e	11033 b-e	9029 a-d	4835 b-e
12. aid)	1.70	1095 a-c	1302 a-c	682 e	10393 de	8244 cd	5393 a-c
13. Check	-	1116 a-c	1157 bc	868 b-e	12934 a-d	12169 ab	5434 a-c
CV%		32	28	19	22	37	27

(1) DNMST 5%.

these four herbicides resulted in sorghum sudan hybrid yields that appeared to be quite a bit lower than the untreated, but the differences were not statistically significant. In contrast to the sorghum sudan hybrid, only oryzalin at both rates reduced the yield of millet.

Effect of Row Crop Herbicides on Treated Crops and Fall Sown Wheat

On June 7, 1979, when the herbicide treatments were applied and the crops were planted, the soil surface was somewhat loose and dry even though moisture at 5 to 8 centimeters (cm) was adequate. Because moisture was available at 5 to 8 centimeters (cm), the crops were seeded at that depth. Two days after treatment heavy rains compacted the soil and the resulting hard crust made emergence difficult.

Despite the heavy rain after treatment, there was remarkably little injury to the soybeans from the triazine herbicides. The high rate of atrazine was the only triazine treatment that produced significant soybean injury by 21 days after planting (Table VIII). The higher rate of oryzalin was the only other preemergence treatment that produced noticeable injury.

The mungbeans demonstrated an early sensitivity to cyanazine, atrazine and metribuzin which was considerably worse at 15 days after planting than a week earlier. However, after additional rainfall on June 22 through 24, the mungbeans

TABLE VIII

SUMMER BROADLEAF CROPS INJURY FROM
HERBICIDE TREATMENTS APPLIED
PREPLANT INCORPORATED
OR PREEMERGENCE

Treatment	Growth Stage	Rate (kg/ha)	Soybeans[1]			Mungbeans			Guar		
			7	15	21[2]	7	15	21	7	15	21
1. Fluchloralin	PPI	1.10	0	0	7	0	0	10	0	0	10
2.	"	2.20	0	0	0	0	0	17	0	0	13
3. Penoxalin	"	0.83	0	0	7	0	0	17	0	0	17
4.	"	1.65	0	0	0	0	0	7	0	0	10
5. Profluralin	"	0.83	0	0	0	0	0	13	0	0	27
6.	"	1.65	0	0	0	0	0	13	0	0	30
7. Trifluralin	"	0.83	0	0	0	0	0	0	0	0	23
8.	"	1.65	0	0	0	0	0	13	0	0	30
9. Check	-	-	0	0	0	0	0	0	0	0	0
10. Oryzalin	PRE	1.10	0	0	0	0	0	3	0	0	10
11.	"	2.20	0	0	13	0	0	7	0	0	13
12. Metolachlor	"	1.65	0	0	0	0	0	0	0	0	7
13.	"	3.30	0	0	0	0	0	3	0	0	10
14. Alachlor	"	1.65	0	0	0	0	0	0	0	7	0
15.	"	3.30	0	0	0	0	0	7	0	7	7

TABLE VIII (Continued)

Treatment		Growth Stage	Rate (kg/ha)	Soybeans[1]			Mungbeans			Guar		
				7	15	21[2]	7	15	21	7	15	21
16.	Linuron	"	1.45	0	0	0	0	0	7	0	0	7
17.		"	2.93	0	0	0	0	0	7	0	0	10
18.	Cyanazine	"	1.65	0	0	0	10	13	0	10	10	0
19.		"	3.30	0	0	0	47	68	0	40	63	0
20.	Atrazine	"	1.65	0	0	0	33	43	40	30	40	27
21.		"	3.30	7	7	17	37	87	90	40	87	95
22.	Prometryn	"	1.10	0	0	0	0	0	10	0	0	17
23.		"	2.20	0	0	0	0	0	7	0	0	7
24.	Metribuzin	"	0.55	0	0	0	13	23	7	0	0	3
25.		"	1.10	0	0	0	33	63	0	0	0	7
26.	Check	-	-	0	0	0	0	0	0	0	0	0

(1) Visual ratings are based on a scale of 0-100 with 0 being no plant injury and 100 being plant kill.
(2) Days after planting.

quickly recovered from the chlorosis seen earlier in the cyanazine and metribuzin treated plots. The injury from atrazine persisted and at the higher rate, atrazine had completely killed most of the mungbeans by 21 days after planting. However, a few plants appeared to escape severe injury.

The response of guar to cyanazine and atrazine was very similar to the response of mungbeans. One notable difference was that metribuzin did not injure guar like it did mungbeans. Guar also appeared to be a little more stunted by the dinitroaniline herbicides than mungbeans at 21 days after planting.

None of the treatments caused severe visual injury on either corn or grain sorghum. However, all of the dinitroaniline treatments appeared to slightly stunt the corn (Table IX).

Weed control was evaluated 30, 60, and 90 days after treatment. The primary weed species present were prairie cupgrass (Eriochloa graciles L.), flower-of-an-hour (Hibiscus trionum L.), redroot pigweed (Amaranthus retroflexus L.), and prickly sida (Sida spinosa L.) at populations of 90 to $100/m^2$, 35 to $40/m^2$, 10 to $12/m^2$, and 1 to $3/m^2$ respectively (Table X). None of the herbicides was providing 100 percent control of prairie cupgrass 30 days after treatment at the lower rates of application. At the higher rates, which, with the exception of cyanazine were twice the typical rate of application, only metribuzin provided 100 percent control.

TABLE IX

SUMMER GRASS CROPS INJURY FROM HERBICIDE TREATMENTS APPLIED PREPLANT INCORPORATED OR PREEMERGENCE

Treatment	Growth Stage	Rate (kg/ha)	Corn[1] 7[2]	Corn[1] 15[2]	Corn[1] 21[2]	Sorghum 7	Sorghum 15	Sorghum 21
1. Fluchloralin	PPI	1.10	0	7	17	0	0	13
2.	"	2.20	0	23	13	0	0	0
3. Penoxalin	"	0.83	0	0	20	0	0	20
4.	"	1.65	0	0	7	0	0	0
5. Profluralin	"	0.83	0	0	10	0	0	7
6.	"	1.65	0	10	23	0	0	13
7. Trifluralin	"	0.83	0	7	7	0	0	0
8.	"	1.65	0	7	20	0	0	0
9. Check	-	-	0	0	0	0	0	0
10. Oryzalin	PRE	1.10	0	0	17	0	0	0
11.	"	2.20	0	0	3	0	0	0
12. Metolachlor	"	1.65	0	0	7	0	0	0
13.	"	3.30	0	0	0	0	0	0
14. Alachlor	"	1.65	0	0	0	0	0	0
15.	"	3.30	0	0	0	0	0	10

TABLE IX (Continued)

Treatment		Growth Stage	Rate (kg/ha)	Corn[1]			Sorghum		
				7	15	21[2]	7	15	21
16.	Linuron	"	1.45	0	0	0	0	0	0
17.		"	2.93	0	0	7	0	0	0
18.	Cyanazine	"	1.65	0	0	10	0	0	0
19.		"	3.30	0	0	0	0	0	0
20.	Atrazine	"	1.65	0	3	13	0	0	0
21.		"	3.30	0	0	7	0	0	0
22.	Prometryn	"	1.10	0	0	13	0	0	0
23.		"	2.20	0	0	0	0	0	0
24.	Metribuzin	"	0.55	0	7	0	0	0	0
25.		"	1.10	0	0	20	0	0	7
26.	Check	-	-	0	0	0	0	0	0

(1) Visual ratings are based on a scale of 0-100 with 0 being no plant injury and 100 being plant kill.
(2) Days after planting.

TABLE X

WEED CONTROL IN SUMMER CROPS 30, 60, 90
DAYS AFTER HERBICIDE APPLICATION

Treatment		Growth Stage	Rate (kg/ha)	Prairie[1]			Flower			Redroot			Prickly		
				30	60	90	30	60	90	30	60	90	30	60	90
1.	Fluchloralin	PPI	1.10	90	90	88	72	63	88	95	95	92	95	97	95
2.		"	2.20	93	93	90	87	91	92	93	99	95	95	92	95
3.	Penoxalin	"	0.83	88	94	93	70	90	79	90	95	93	93	96	95
4.		"	1.65	92	91	93	77	89	93	97	98	96	93	97	96
5.	Profluralin	"	0.83	92	94	93	73	81	91	92	96	89	88	95	92
6.		"	1.65	89	93	92	80	80	92	97	99	93	90	93	95
7.	Trifluralin	"	0.83	94	92	90	82	88	92	90	94	88	88	93	90
8.		"	1.65	94	95	94	82	81	88	95	96	93	92	89	88
9.	Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0
10.	Oryzalin	PRE	1.10	90	92	96	88	95	95	97	98	93	97	99	94
11.		"	2.20	98	98	98	94	97	97	98	100	98	95	100	97
12.	Metolachlor	"	1.65	95	94	96	82	90	92	95	98	95	95	97	95
13.		"	3.30	98	93	95	92	95	95	98	99	97	97	99	95
14.	Alachlor	"	1.65	88	93	94	86	91	90	98	100	94	95	100	93
15.		"	3.30	98	97	97	88	97	92	98	100	92	98	98	93

TABLE X (Continued)

Treatment		Growth Stage	Rate (kg/ha)	Prairie[1]			Flower			Redroot			Prickly		
				30	60	90	30	60	90	30	60	90	30	60	90
16.	Linuron	"	1.45	30	76	72	92	96	95	95	99	95	95	99	96
17.		"	2.93	77	83	86	93	92	96	98	97	96	98	97	96
18.	Cyanazine	"	1.65	47	75	67	96	97	95	95	94	93	98	100	95
19.		"	3.30	82	90	87	98	95	98	98	97	95	98	97	96
20.	Atrazine	"	1.65	80	78	75	98	100	99	98	100	98	98	100	99
21.		"	3.30	92	87	90	98	100	100	98	100	100	98	100	100
22.	Prometryn	"	1.10	22	65	69	77	97	95	97	99	95	97	99	97
23.		"	2.20	73	83	77	95	98	96	97	99	94	98	98	96
24.	Metribuzin	"	0.55	93	94	94	97	99	98	97	100	98	97	100	98
25.		"	1.10	100	100	98	100	100	100	100	100	99	100	100	98
26.	Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0

(1) Visual ratings are based on a scale of 0-100 with 0 being no control and 100 being total control.

Prairie=prairie cupgrass; Flower=flower-of-an-hour; Redroot=redroot pigweed; Prickly= prickly sida.

The s-triazine herbicides and linuron provided less control than the dinitroaniline or acetanilide herbicides. However, by 60 days after treatment, control from the low rates of linuron, cyanazine, and prometryn had improved considerably, while control from the other treatments remained essentially unchanged.

Among the broadleaf species, flower-of-an-hour control was only 70 to 82 percent 30 days after planting with the lower rates of the preplant incorporated treatments. Cyanazine, atrazine and metribuzin appeared to more effectively control flower-of-an-hour than the other treatments.

Redroot pigweed control was excellent with all treatments at 30 days after treated. Prickly sida control was excellent from all treatments except possibly the lower rates of profluralin and trifluralin. However, 60 days after treatment the control with these herbicides improved. The increased control noted for various dinitroaniline herbicide treatments between 30 and 60 days after treatment may have been due to the ability of these herbicides to reduce root growth to a point where the plants were unable to survive the water stresses in July that didn't occur in June.

The corn, harvested as fodder by cutting and weighting the entire plant, did not have pronounced differences in yield among the preplant incorporated treatments (Table XI), however, the coefficient of variance (CV) was 38.4% so discretion should be used when reviewing the data. Among the preemergence treatments there were yield differences (Table

TABLE XI

EFFECT OF PREPLANT INCORPORATED TREATMENTS ON SUMMER CROPS YIELD

Treatment		Rate (kg/ha)	Yield (kg/ha)				
			Corn	Sorghum	Soybeans	Mungbeans	Guar
1.	Fluchloralin	1.10	12424[1]	5515 b[2]	909 bc	1091 bc	727 a
2.		2.20	10485	2242 c	1455 ab	1333 a-c	667 ab
3.	Penoxalin	0.83	12727	5576 b	1152 a-c	1636 ab	727 a
4.		1.65	14606	3091 c	1091 a-c	970 c	848 a
5.	Profluralin	0.83	14000	5555 b	1333 ab	1818 a	545 ab
6.		1.65	15515	3333 c	1152 a-c	1758 a	424 ab
7.	Trifluralin	0.83	10303	2485 c	1576 ab	1879 a	545 ab
8.		1.65	13333	2970 c	1758 a	1818 a	545 ab
9.	Check	-	9818	7818 a	606 c	1515 a-c	242 b
	CV%		38.4	28.0	30.5	20.8	27.0

(1) Analysis of variance indicated no significant differences at the 5% level.
(2) DNMRT 5%.

XII). The yield of the weedy check for the preemergence treatments was only 38.8% of the yield for the higher rate of atrazine. Therefore any conclusions drawn from the yield data regarding herbicide injury to corn must be limited to those treatments where weed control, particularly prairie cupgrass control, was as good or better than that provided by the higher rate of atrazine. Thus, the only three treatments appeared to have injured the corn were oryzalin at both rates and alachlor at the higher rate. In contrast to alachlor, the higher rate of metolachlor did not injure the corn.

The sorghum was also harvested as fodder, however a small plot forage harvester was used to harvest the plots. The decision to harvest fodder rather than grain was made because of bird damage to the grain which was estimated to be as high as 30% in some plots. However, the mechanical harvesting process tended to harvest some weeds along with the sorghum. The combination of weed interference with harvesting and bird damage created considerable variability and consequently the coefficients of variance (CV's) were 28.0 and 38.6% respectively for the preplant incorporated and preemergence treatments. In spite of these difficulties, there were pronounced differences among treatments which provided excellent weed control. In general, all dinitroaniline treatments and the higher rates of the acetanilide herbicides metolachlor and alachlor reduced yield severely compared to the lower rate of atrazine or prometryn or high-

TABLE XII

EFFECT OF PREEMERGENCE TREATMENTS ON SUMMER CROPS YIELD

Treatment		Rate (kg/ha)	Yield (kg/ha)				
			Corn	Sorghum	Soybeans	Mungbeans	Guar
1.	Oryzalin	1.10	11333 b-d[1]	3091 cd	1515[2]	1394	788 ab
2.		2.20	7818 d	1091 d	1333	1515	788 ab
3.	Metolachlor	1.65	18182 a	7818 a-c	1576	1515	788 ab
4.		3.30	17758 ab	4848 b-d	1333	1939	848 ab
5.	Alachlor	1.65	12000 a-d	7394 a-c	1879	1939	788 ab
6.		3.30	11394 b-d	1636 d	1515	1576	970 a
7.	Linuron	1.45	9697 cd	9455 ab	1152	1576	606 ab
8.		2.93	14788 a-d	11212 a	1455	1697	667 ab
9.	Cyanazine	1.65	11818 a-d	10000 ab	1394	1697	667 ab
10.		3.30	16061 a-c	8182 a-c	1333	1455	788 ab
11.	Atrazine	1.65	12061 a-d	12182 a	1939	1272	606 ab
12.		3.30	19515 a	6970 a-c	788	677	61 c
13.	Prometryn	1.10	11576 b-d	11455 a	1515	1879	545 ab
14.		2.20	15758 a-c	8303 a-c	1212	1939	788 ab

. . . .

TABLE XII (Continued)

Treatment		Rate (kg/ha)	Yield (kg/ha) Corn	Sorghum	Soybeans	Mungbeans	Guar
15.	Metribuzin	0.55	16667 a-c[1]	9636 ab	1333[2]	1758	848 ab
16.		1.10	16182 a-c	8000 a-c	1697	970	1030 a
17.	Check	-	7576 d	10364 ab	1152	1394	424 bc
	CV%		28.8	38.6	41.3	32.0	36.1

(1) DNMRT 5%.
(2) Analysis of variance indicated no significant differences at the 5% level.

er rate of linuron. Among the preplant incorporated treatments, trifluralin at 0.83 kg/ha reduced sorghum yield more than penoxalin or profluralin at 0.83 kg/ha or fluchloralin at 1.1 kg/ha.

Among the broadleaf crops, data variability was also high, but some conclusions could be drawn. Among the preplant incorporated treatments soybean yields were not higher than the weedy check with the lower rates of fluchloralin or penoxalin, but were higher with the lower rates of profluralin and trifluralin. The former two herbicides also gave slightly less prairie cupgrass control at 30 days after planting. While the higher rate of fluchloralin did increase soybean yield to more than the weedy check, the high rate of profluralin decreased yield to where it was no longer greater than the weedy check.

None of the mungbean yields were different from the weedy checks. However, among the preplant incorporated treatments mungbean yield was higher in the trifluralin and profluralin treatments than it was with the higher rate of penoxalin, indicating that mungbeans are more sensitive to penoxalin than profluralin or trifluralin.

There was more variability in the guar yield data than for any other crop. However, in the first replication of the preplant incorporated treatments, the guar was growing under adverse soil conditions so the data from the first replication of these treatments was delected from the analysis. The data then demonstrated that guar yields were increased with application of fluchloralin at the low rate and peno alin at both rates.

The late seeding date of the wheat, together with a dry fall, prevented much wheat growth until spring (Table XIII). On March 30, the wheat was only in the 4 tiller growth stage. None of the row crop herbicide treatments persisted at levels severe enough to cause loss of the wheat stand. However, the wheat in the check plots appeared stunted to the point that use of the checks as a basis to evaluate herbicide injury would probably be invalid. The poor growth of the wheat in the check plots could be attributed to the heavy weed growth in the checks which left those plots drier and more depleted of nutrients than the herbicide treated plots. Also, the wheat was planted without prior tillage and the weed material, primarily frost killed prairie cupgrass, may have hindered the development of the wheat seedlings. However, among the preemergence treatments, the higher rates of oryzalin, metolachlor, alachlor, and metribuzin had injury ratings of less than 15%, which indicates that the wheat was more vigorous than in the untreated check.

Among the preplant incorporated treatments, the wheat yield in plots treated with the higher rate of penoxalin the previous June was higher than in plots treated with either rate of fluchloralin or either rate of trifluralin. There were no significant differences in wheat yield from the preemergence treatments.

TABLE XIII

WHEAT INJURY AND YIELD FROM HERBICIDE TREATMENTS APPLIED TO SUMMER CROPS

Treatment		Rate (kg/ha)	Visual Rating[1] 164 dap	Visual Rating[1] 180 dap	Wheat Yield[2] (kg/ha)
		Preplant Incorporated Treatments			
1.	Fluchloralin	1.10	20	27	2107 bc
2.		2.20	27	30	2338 bc
3.	Penoxalin	0.83	20	23	2612 ab
4.		1.65	0	17	3305 a
5.	Profluralin	0.83	20	27	1977 bc
6.		1.65	13	20	2540 a-c
7.	Trifluralin	0.83	27	40	1674 c
8.		1.65	20	33	2136 bc
9.	Check	-	20	27	1688 c
	CV%				20.5

TABLE XIII (Continued)

Treatment		Rate (kg/ha)	Visual Rating[1] 164 dap	Visual Rating[1] 180 dap	Wheat Yield[2] (kg/ha)
			Preemergence Treatments		
1.	Oryzalin	1.10	17	0	2973
2.		2.20	0	0	3651
3.	Metolachlor	1.65	0	0	3146
4.		3.30	0	13	2785
5.	Alachlor	1.65	13	17	2626
6.		3.30	7	10	3535
7.	Linuron	1.45	30	40	2136
8.		2.93	20	30	2684
9.	Cyanazine	1.65	20	33	3001
10.		3.30	20	17	3348
11.	Atrazine	1.65	33	37	2020
12.		3.30	17	17	3146
13.	Prometryn	1.10	30	30	2756
14.		2.20	20	27	2944
15.	Metribuzin	0.55	23	17	3506
16.		1.10	13	0	3608
17.	Check	-	33	40	2266
	CV%				26.7

(1) Visual ratings are based on a scale of 0-100 with 0 being no plant injury and 100 being plant kill. dap= days after planting.

(2) DNMRT 5%. The absence of letters indicates no significant difference.

CHAPTER V

SUMMARY

In studies of the effect of wheat herbicides on treated and rotational crops it was found that March application of metribuzin and cyanazine effectively controlled henbit. However, cyanazine applied in granular form at 3.3 kg/ha also reduced wheat yield. Among the broadleaf crops seeded after wheat harvest, soybeans were not severely injured by any of the treatments, nor were soybean yields affected. The only noticeable difference among broadleaf crops tolerance to the treatments applied to wheat was the greater injury to guar from cyanazine than the injury noted on mungbeans or soybeans. However, the guar yield was increased by the higher cyanazine rate and no other treatment, indicating ability to overcome early injury.

Sorhum and sorghum sudan hybrid were injured by cyanazine at 3.3 kg/ha and oryzalin at the higher rate was causing a significant injury 21 days after planting. Millet was generally less tolerant of the herbicide residues than the larger seeded grass crops with the noticeable exception that millet exhibited less injury from cyanazine.

The higher rate of 2,4-D applied in March or as harvest aid and the higher rates of oryzalin and cyanazine reduced the sorghum sudan yield, but not sorghum yield. The oryzalin treatments were the only treatments that reduced millet yield.

In the experiment designed to investigate the effect on wheat of row crop herbicides, injury to the treated row crops was less than anticipated. For instance, the higher rate of atrazine was the only treatment that injured soybeans by 21 days after planting. The mungbeans demonstrated an early sensitivity to cyanazine, atrazine and metribuzin, but early injury decreased considerably by 21 days after treatment in the cyanazine and metribuzin treated plots. Guar showed a similar response to cyanazine and atrazine. Metribuzin did not injure guar.

None of the treatments caused severe injury on sorghum. However, all dinitroaniline treatments and the higher rates of metolachlor and alachlor reduced yield. Corn was slightly injured by all of the dinitroaniline treatments and the yield reduced was by oryzalin at both rates and alachlor at the higher rate.

With respect to weed control metribuzin provided 100 percent control of prairie cupgrass whereas the three s-triazine herbicides did not. Linuron provided less control than the dinitroaniline or acetanilide herbicides. Cyanazine, atrazine and metribuzin appeared to more effectively control flower-of-an-hour than the other treatments. All of the treatments effectively control redroot pigweed and prickly sida.

None of the treatments applied to row crops severely affected the fall sown wheat. Wheat yields appeared to be lower where weed control in the preceeding row crops was lower.

LITERATURE CITED

1. Anderson, W. P. 1977. Weed Sciences principles. Edited by West Publishing Co. 578 pp.

2. Bailey, G. W., and J. L. White. 1970. Factors influencing the adsorption and movement of pesticides in soil. Residue Rev. 32:29-92.

3. Bell, A. R., and J. D. Nalewaja. 1968. Effect of duration of wild oat competition in flax. Weed Sci. 16:509-512.

4. Buchanan, G. A., and E. R. Burns. 1970. Influence of weed competition on cotton. Weed Sci. 18:149-154.

5. Buchanan, G. A., and E. G. Rogers. 1963. Role of temperature in the inactivation of some triazine herbicides. Proc. S. Weed Conf. 16:393.

6. Crafts, A. S., and W. W. Robbins. 1962. Weed control. Third Edition by McGraw-Hill Book Company, Inc. New York. 660 pp.

7. Cole, A. W. 1978. Southern pea response to tall morningglory competition. Proc. South Weed Sci. Soc. 31:169.

8. Corbin, F. T., and R. P. Upchurch. 1967. Influence of pH on detoxication of herbicides in soil. Weeds 15:370-377.

9. Dawson, J. H. 1970. Time and duration of weed infestation in relation to weed crop competition. Proc. South Weed Sci. Soc. 23:13-25.

10. Delorit, J. R., and Ahlgren, L.H. 1959. Crop production. Second Edition. Edited by Prentile-Hall, Inc. New Jersey. 666 pp.

11. Evetts, L. L., and O. C. Burnside. 1975. Effect of early competition on growth of common milk weed. Weed Sci. 23:1-3.

12. Fink, R. J., and O. H. Fletchall. 1969. Soybean in-

jury from triazine residues in soil. Weed Sci. 17:35.

13. Frank, R. 1966. Atrazine carryover in production of sugar beets in southwestern Ontario. Weeds 14:82.

14. Hassall, K. A. 1969. World Crop Protection, Vol. 2: 249 pp.

15. Helling, Ch. S. 1976. Dinitroaniline herbicides in soils. J. of Environmental Quality 5(1) 15 pp.

16. Hill, L. V., and P. W. Santelmann. 1969. Competitive effects of annual weeds on spanish peanuts. Weed Sci. 17:1-2.

17. Hymowitz. 1963. Studies on guar (Cyamopsis tetragonoloba L.). Thesis, Oklahoma State University. 113 pp.

18. Holly, K., and H. A. Roberts. 1963. Persistence of phytotoxic residues of triazine herbicides in soil. Weed Research 3:1.

19. Horowitz, M., N. Hulin, and T. Blumenfeld. 1974. Behavior and persistence of trifluralin in soil. Weed Research 14:213-220.

20. Jones, L. B., and H. Andrews. 1964. Effect of rate of application on the persistence in the soil of several preemergence herbicides. Proc. S. Weed Conf. 17:374.

21. Klingman, G. C., and Floyd M. Ashton. 1975. Weed science & principles and practices. Edited by John Wiley & Sons, New York. 431 pp.

22. Ladlie, J. S., W. F. Meggitt, and D. Penner. 1976. Effect of soil pH on microbial degradation, adsorption, and mobility of metribuzin. Weed Sci. 24:477-481.

23. Ladlie, J. S., W. F. Meggitt, and D. Penner. 1976. Effect of pH on metribuzin activity in the soil. Weed Sci. 24:505-507.

24. Ladlie, J. S., W. F. Meggitt, and D. Penner. 1976. Role of pH on metribuzin dissipation in field soils. Weed Sci. 24:508-511.

25. Lawrence, R. O., and R. E. Frans. 1968. Inhibition of cotton and soybean roots from incorporated trifluralin and persistence in soil. Weed Sci.

16:199-203.

26. McCormick, L. L., and A. E. Hiltbold. 1966. Microbial decomposition of atrazine and diuron in soil. Weeds 14:77-82.

27. Miller, C. H., T. J. Monaco, and T. J. Sheets. 1976. Studies on nitralin residues in soils. Weed Sci. 24:288-291.

28. Murray, D. S., W. L. Rieck, and J. Q. Lynd. 1969. Microbial degradation of five substituted urea herbicides. Weed Sci. 17:52-55.

29. Radosevich, S. R. and W. L. Winterlin. 1977. Persistence of 2,4-D and 2,4,5-T in chaparral vegetation and soil. Weed Sci. 25:423-425.

30. Rahman, A. 1977. Persistence of terbacil and trifluralin under different soil and climatic conditions. Weed Research. 17:145-152.

31. Rahman, A., B. Burney, and B. E. Manson. 1978. Effect of soil compaction on phytotoxicity and persistence of soil applied herbicides. Weed Research. 18:93-97.

32. Rovira and Greacen. 1957. The effect of agregate disruption on the activity of microorganisms in the soil. Aust. J. Agric. Res. 8:659-673.

33. Rydrych, D.J. 1974. Competition between winter wheat and downy brome. Weed Sci. 22:211-214.

34. Savage, K. E., and W. L. Barrentine. 1969. Trifluralin persistence as effected by depth of soil incorporation. Weed Sci. 17:349-352.

35. Sharon, M. S., and G. R. Stephenson. 1976. Behavior and fate of metribuzin in eight Ontario soils. Weed Sci. 24:153-160.

36. Sheets, T. J. 1970. Persistence of triazine herbicides in soils. Residue Review 32:303.

37. Sheets, T. J., A. S. Crafts, and H. R. Drever. 1962. Influence of soil properties on the phytotoxicities of the s-triazine herbicides. J. Agr. Food Chem. 10:458.

38. Sheets, T. J., and W. C. Shaw. 1963. Herbicidal properties and persistence in soils of s-triazines. Weeds 11:15.

39. Smith, R. J., Jr. 1974. Competition of barnyard grass with rice cultivars. Weed Sci. 22:423-426.

40. Switzer, C. M., and W. E. Ranser. 1960. Effectiveness and persistence of certain herbicides in soil. Proc. N. E. Weed control Conf. 14:329.

41. Thurlow, D. L., and G. A. Buchanan. 1972. Competition of sicklepod with soybeans. Weed Sci. 20:379-384.

42. Titus, E. L. 1948. Fungus flora of mungbeans. Thesis, Oklahoma State University. 33pp.

43. Weber, J. B., S. B. Weed, and T. W. Waldrep. 1974. Effect of soil constituents on herbicide activity in modified-soil field plot. Weed Sci. 22:454-459.

44. Weber, J. B., S. B. Weed, and T. M. Ward. 1969. Adsorption of s-triazines by soil organic matter. Weed Sci. 17:417-421.

45. Weber, J. B., S. B. Weed, and T. M. Ward. 1970. Mechanisms of adsorption of s-triazines by clay colloids and factors affecting plant availability. Residue Review. 32:93-130.

46. Wolfe, T. K. and Kipps, M. S. 1959. Production of field crops. Fifth edition by Mc Graw-Hill Book Company, Inc. New York. 653 pp.

APPENDIX

TABLE XIV

DAILY RAINFALL RECORD IN STILLWATER DURING THE LAST THREE MONTHS OF 1978

Date	Centimeters
Oct. 8	3.13
Oct. 22	0.63
Nov. 5	1.62
Nov. 12	0.22
Nov. 13	0.57
Nov. 14	0.05
Nov. 15	3.40
Nov. 16	1.50
Nov. 17	0.30
Nov. 19	0.05
Nov. 21	0.45
Nov. 25	1.05
Dec. 31	0.93

TABLE XV

DAILY RAINFALL RECORD IN STILLWATER
DURING 1979

Date	Centimeters	Date	Centimeters
Jan. 7	0.17	June 6	0.05
Jan. 11	0.10	June 7	0.75
Jan. 12	0.05	June 8	5.95
Jan. 14	0.45	June 9	2.40
Jan. 19	2.92	June 22	0.80
Jan. 27	0.30	June 23	0.12
Jan. 29	0.42	June 24	0.55
Feb. 6	1.50	June 29	0.17
Feb. 7	8.00	July 5	1.25
March 3	1.55	July 6	5.55
March 17	0.57	July 17	2.67
March 18	1.72	July 18	0.05
March 19	1.85	July 25	0.27
March 22	3.00	July 31	0.47
March 23	0.15	Aug. 1	0.05
April 1	0.37	Aug. 11	1.85
April 2	0.13	Aug. 20	0.02
April 3	0.70	Aug. 21	2.25
April 10	0.12	Aug. 22	3.27
April 11	3.90	Aug. 23	0.20
April 18	0.30	Aug. 25	0.30
April 19	0.42	Aug. 26	0.15
April 21	0.65	Sept. 1	1.05
April 27	0.10	Sept. 2	1.70
April 29	0.75	Sept. 7	0.52
May 2	0.25	Oct. 15	0.22
May 3	6.12	Oct. 22	1.47
May 4	3.62	Oct. 31	1.80
May 5	0.57	Nov. 8	0.45
May 11	0.22	Nov. 9	1.15
May 19	0.22	Nov. 20	1.40
May 21	1.15	Nov. 21	3.67
May 22	1.52	Dec. 28	3.45
May 26	0.20	Dec. 29	1.30

TABLE XVI

DAILY RAINFALL RECORD IN STILLWATER DURING THE FIRST SIX MONTHS OF 1980

Date	Centimeters	Date	Centimeters
Jan. 3	0.27	April 25	2.25
Jan. 19	0.07	April 26	5.77
Jan. 20	1.70	May 1	1.12
Jan. 21	2.17	May 2	0.17
Jan. 30	0.25	May 4	0.40
Feb. 8	1.52	May 5	0.05
March 12	1.37	May 12	1.55
March 21	0.40	May 16	4.37
March 23	0.97	May 18	2.47
March 24	3.37	May 21	0.50
March 27	0.30	May 27	4.85
March 28	0.40	May 29	0.87
March 29	0.32	June 17	4.00
March 30	0.05	June 18	3.47
April 3	1.20	June 19	7.50
April 8	0.07	June 20	5.07
April 18	0.40	June 22	0.50
April 24	3.70	June 23	0.05

VITA

S. Fausto Venegas

Candidate for the degree of

Master of Science

Thesis: EFFECT OF SELECTED HERBICIDES ON TREATED AND ROTATIONAL CROPS

Major Field: Agronomy

Biographical:

Personal Data: Born September 26, 1948, at Guayaquil, Ecuador, the son of Fausto Venegas and Fanny R. de Venegas; married Maria Pila, October 26, 1974; children Maria Gabriela and Fausto Xavier.

Education: Graduated from Vicente Rocafuerte High School (Ecuador) January, 1965; received the Ingeniero Agronomo degree in Agronomy from Universidad de Guayaquil (Ecuador) April, 1972; completed a Crop Production course and Weed Control course from International Center of Tropical Agriculture (CIAT, Colombia) during March, 1973, to June, 1974; completed requirements for Master of Science degree at Oklahoma State University in December, 1980.

Professional Experience: Employed by Banana National Program during 1968. Obtained a scholarship from the American Cocoa Research Institute (ACRI) in National Institute of Agricultural Investigation (INIAP, Ecuador) from September, 1970, through June, 1972, to obtain the Bachelor degree in Agronomy. Employed as assistant by the Deparment of Weed Control, Pichilingue Experimental Station, INIAP from July, 1972, through July, 1975, and as a major from August, 1975, until now.

Professional Organizations: Latin American Association of Weed Control (ALAM). Colombian Society of Weed Control and Physiology (COMALFI). Publications Department, International Center of Tropical Agriculture (CIAT). Southern Weed Science Society of America.