RESPONSE OF *SOLANUM CAROLINENSE* TO VARIOUS HERBICIDAL TREATMENTS

By

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PREFACE

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CHAPTER I

INTRODUCTION

Weed control has become an invaluable tool for the modern peanut (Arachis hypogaea L.) producer. In Oklahoma 118,000 acres were planted to peanuts in 1971 and at least 90 percent were treated with a herbicide (9). Effective control of most annual weeds was obtained throughout the growing season using combinations of cultural procedures and herbicide applications. However, perennial weeds frequently escaped control.

Carolina horsenettle (Solanum carolinense L.), often referred to as bullnettle, has survived years of cultural control practices and herbicidal treatments. Isolated areas have infested large tracts of many fields.

Horsenettle has become a serious problem because of competition with the crop and peanut grade reduction. By the time peanuts are seeded, the horsenettle has already emerged. Normal plantbed preparation procedures may temporarily kill the top of the plant, but within ten to fifteen days the weed is vigorously growing. The grade of the marketable peanuts after harvest is reduced because of increased foreign material (horsenettle seedballs) and spoilage of stored peanuts. The fruits of the horsenettle are harvested with peanuts due to the size similarity to an unshelled peanut and provide excellent moisture source for mold growth in dry, stored peanuts.

Field and greenhouse experiments were conducted to correlate herbicidal activity to weed and crop development. Recommended and experimental herbicides were evaluated for seasonal top kill and residual control. The effect of herbicides when applied at various stages of horsenettle development was evaluated. Seed germination and herbicide translocation studies were conducted.

CHAPTER II

LITERATURE REVIEW

Peanuts

Peanuts are a member of the Papilionaceae family and are valued for their high protein and oil. Developing during a 120 to 140 day growing season, the plant produces best with high soil fertility and 42 to 54 inches of water on a light sandy loam soil (26).

To obtain maximum production in Oklahoma, weed control programs must be followed. Commonly applied herbicides include trifluralin (a, a, a-trifluoro - 2, 6-dinitro - N, N- dipropyl - p - toluidine), alachlor (2-chloro-2', 6' - diethyl - N - (methoxymethyl) acetanilide), chloramben (3-amino-2, 5-dichlorobenzoic acid), benefin (N-butyl-N-ethyl-a, a, a-trifluoro-2, 6-dinitro-p-toluidine), dinoseb (2-sec-butyl-4, 6-dinitrophenol), vernolate (S-propyl-dipropylthiocarbamate), and several of these compounds in combination (16). These herbicides control many annual grasses and broadleaves, but most perennial species are not affected.

Peanuts are sold according to a grade classification assigned from samples of the harvested nuts. This value is based on many things, but one of the most visible forms of grade reduction is caused by the presence of foreign material. This material may be composed of rock, sand, vine stalks, or other substances (25). A common contaminant in Oklahoma is the fruit of the horsenettle plant.

Horsenettle

Horsenettle is a perennial species found throughout much of Oklahoma and the southern and eastern United States. The plant grows to be eight to eighteen inches tall, has small spines protruding from the stems and veins of the alternating leaves, and is more commonly found growing in a sandy soil. The fruits are yellow in color and approximately one-half to one and one-half inches in diameter (3), being similar in size and weight to an unshelled peanut.

The horsenettle plant is classified belonging to the Solanaceae family. The name is derived from the latin word solamen meaning quieting from the sedative properties of some of the species (17). Two species are common in Oklahoma and vary slightly in growth characteristics. *Solanum carolinense* L. is the most widely known. It has the minute stellate or star-like shaped hairs, which cover the plant, sessile or appressed against the stem and leaves. *Solanum Torreyi* Gray varies primarily in the attachment of the stellate hairs. Small stipules raise the hairs slightly off the stem and leaves. Both species may have either violet-to-bluish or white flowers and are similar in size and other characteristics (22).

Several common vegetables and weeds also belong to the Solanaceae family. Tomato (*Lycopersicon esculentum* Mill.), tobacco (*Nicotiana tabacum* L.), and potato (*Solanum tuberosum*) are close relatives as are silverleaf nightshade (*S. elaeagnifolium*) and Jimsonweed (*Datura stramonium*).

One mechanism of plant propagation is the seed. The fruit of the horsenettle contains an average of 86 seeds (15). Of these seeds, 2-12 percent are capable of sprouting the following spring. Subsequent studies found seed viability as high as 67 percent which indicates seed dispersion may be a prime dissemination factor (2).

Another means of plant propagation has been the sectioning of the tap root from an established plant. Furrer (15) found that new plants had developed from sections of root three feet deep in the soil. Root sections less than one inch long by three-sixteenths inches in diameter were capable of plant propagation. Soil depth did not prevent emergence unless roots were planted twelve inches or deeper. A direct implication of this is that normal cultivation procedures do not control the horse-nettle, but instead spread it (2). The operations of plowing and disking, which dissect the tap root and spread these sections, may account for the gradual increase in size of infestations.

Several herbicides have been reported to kill the foliar portion of the plant. Albert (1) found 2, 4-D [2, 4-dichlorophenoxy) acetic acid] and 2, 4, 5-T [(2, 4, 5-trichlorophenoxy) acetic acid] very effective in top kill for a single season, but regrowth occurred the following year. Friesen (14) reported that 2, 4, 5-T at 3 pounds per acre (lb/A) caused good top kill. Bradbury (6) found summer applications of several phenoxy and benzoic compounds capable of top kill or fruiting suppression, but not residual control. He also reported that a 32 lb/A fall application of phenoxy compounds controlled 100 percent of the horse-nettle the following year. PEBC (S-propyl butylethylthiocarbamate) incorporated 1.25-2.4 inches deep produced satisfactory control when applied at 4 and 5 lb/A (14). Dicamba (3, 6-dichlor-o-anisic acid) applied at 18-27 lb/A resulted in excellent foliage kill and root kill to a sixteen inch depth (21). Bromacil (5-bromo-3-sec-butyl-6-methyluracil) and terbacil (3-tert-butyl-5-chloro-6-methyuracil) have partially controlled horsenettle in horticultural crops according to Reis (20). Also Pebulate and EPTC (S-ethyl dipropylthiocarbamate) at 1 lb/A (repeated three times) and DMPA (O-(2, 4-dichlorophenyl) O-methyl isopropylphosphoramidothioate) at 20 lb/A produced control (10).

The timing of application or tillage may affect the response obtained. Horsenettle roots reach their lowest starch content approximately 30 days after emerging (2). The greatest translocation to the root system may be obtained at this time. Fang (13) found 2, 4-D translocated into the roots and stems of the tomato. Augustein (4) found that dicamba translocates more readily into the roots than 2, 4-D. However, the amount translocated was a small fraction of the total applied. The differential translocation of dicamba and 2, 4-D was one reason more effective control was obtained and may explain the poor residual control of many phenoxy compounds.

Although research on horsenettle has been conducted in the United States, treatments for control in Oklahoma have not been investigated thoroughly.

CHAPTER III

MATERIALS AND METHODS

Greenhouse and controlled environment chamber experiments were conducted at the Oklahoma State University Agricultural Research Station, Stillwater. Field experiments in 1970 and 1971 were conducted at or near the Caddo County Peanut Research Station. Locations 10.5 miles north of Cromwell and 3 miles north of Shawnee were included in 1971.

All field treatments were applied to native horsenettle populations. Unless otherwise noted, an experimental-plot tractor-mounted boom sprayer was utilized to broadcast all the treatments. A 30 gallons per acre (gpa) carrier volume was used in all experiments except where noted. A completely randomized block experimental design was used. The visual injury data was based on a 0 - 100 scale with 0 representing no injury grading to 100 representing complete top kill. Herbicides used in this study are presented in Table II.

A. I. Vegetative Fallow and Retreatment

A preliminary screening experiment was conducted at the Ft. Cobb location in 1970 and 1971. The treatments were applied on horsenettle 4 to 12 inches tall with 10 - 20 percent of the plants blooming. Amitrole treatments were rotary cultivated 15 days after treatment. Two dicamba treatments based on an active ingredient per hundred gallons of water carrier (aihg) were hand applied. Environmental conditions at the time of application are given in Table I.

The experimental area was not cultivated until September, 1971. Overgrowth was removed by rotary mowing in November, 1970, and July, 1971. The data consisted of visual ratings in 1970 and visual ratings and plant counts in 1971.

A. II. Fallowed Fall Horsenettle Treatment

Treatments to evaluate residual effects to the horsenettle and a peanut crop planted nine months later were applied on vegetative horsenettle on September 30, 1970, at the Caddo County Station. Environmental conditions at application are shown in Table I. The horsenettle were 2-8 inches tall and approximately 30 percent were blooming. The area had remained fallow throughout the summer.

The area was plowed in May, 1971, and hand planted June 18 to Starr peanuts. The dryland peanuts and horsenettle were rated for visual injury.

A. III. Fallowed Fall Residue

A fallow area at the Caddo County location was treated to evaluate residual effects to the following summer's peanut crop using a fall application. Environmental conditions are shown in Table I. The treatments were applied on a horsenettle free area on September 29, 1970. The experimental area was plowed and prepared for planting in early spring. One-half lb/A of trifluralin was applied to control annual weeds. Irrigation was applied according to the station's schedule.

TABLE I

ENVIRONMENTAL AND FIELD CONDITIONS AT THE TIME OF HORSENETTLE TREATMENT

Experiment:	AI		AII	AIII	A-IV	
Date:	6/17/70	6/23/70	9/30/70	9/29/70	5/19/70	6/30/71
Temperature (°F)						
air:	98	84	78	82	82	82
soil:	103	87	76	84	92	80
Wind (mph):	8-10	0-4	3-5	none	0-2	2-6
Moisture:	good	dry	good	good	dry	wet
Sun:	bright	bright	bright	overcast	cloudy	cloudy
Soil Texture:	Sandy loam	Sandy loam	Sandy loam	Sandy loam	sand	sand
Plot size (ft.)	5 X 30	5 X 30	12 X 30	12 X 30	10 X 20	10 X 20
Replications:	3	3	4	4	3	3

Experiment:	AV		AVI	BI	BII
Date:	6/10/71	6/30/71	6/30/71	6/15/70	6/22/71
Temperature (°F)					
air:	87	82	95	109	88
soil:	84	80	90	116	92
Wind (mph):	4-8	2-6	0-2	12-15	0-4
Moisture:	moist	wet	dry	moist	good
Sun:	bright	broken cloudy	bright	bright	bright
Soil Texture:	sand	sand	Sandy loam	Fine Sandy loam	Fine Sandy loam
Plot size:	10 X 20	10 X 20	6 X 20	12 X 40	12 X 40
Replications:	3	3	3	4	3
Variety				Starr	Comet
Planted				6/11/70	6/15/71
Harvested				10/70	10/70

TABLE II

HERBICIDES USED IN THESE STUDIES ON HORSENETTLE

COMMON NAME	CHEMICAL NAME
Amitrole	3 - amino - S - triazole
Bromoxynil	3,5 - dibromo - 4 - hydroxybenzonitrile, octanoic acid ester
Dicamba	3,6 - dichloro - O - anisic acid, diethylamine salt
DPX 1840	3,3a - dihydro - 2 - (p - methoxyphenyl) - 8H - pyrazolo - [5,1-a] Isoindol- 8 - one
Fluometuron	1,1 - dimethyl - 3 - (a, a, a - trifluoro - m - tolyl) urea
MSMA	monosodium methanearsonate
MSMA + Cacodylic acid[1]	monosodium acid methanearsonate plus sodium cacodylate
Naptalam	N - 1 - naphthylphthalamic acid
Picloram	4 - amino - 3,5,6 - trichloropicolinic acid, sodium salt
Prometryne	2,4 - bis (isopropylamino) - 6 - (methythio) - S - triazine
Silvex	2 - (2,4,5 - trichlorphenoxy) propionic acid, propylene glycol (C_3H_60 to $C_9H_{18}0_3$) butyl ether esters
Surfactant	dodecyl ether of polyethylene glycol
2,4-D acid	2,4 - dichlorophenoxyacetic acid
2,4-D amine	2,4 - dichlorophenoxyacetic acid, diethylamine salt
2,4-D LVE	2,4 - dichlorophenoxyacetic acid, butoxyethanol ester
2,4-DB amine	4 - (2,4 - dichlorophenoxy) buteric acid, diethylamine salt
2,4-DB ester	4 - (2,4 - dichlorophenoxy) buteric acid, butoxyethanol ester
2,4-DB + Linuron[1]	4 - (2,4 - dichlorophenoxy) buteric acid plus 3 - (3,4 - dichlorophenyl) - 1 - methoxy - 1 - methylurea

[1]A formulated mixture.

Starr peanuts were mechanically planted in June and harvested in October of 1971.

A. IV. Vegetative Fallow and Same-Season Retreatment

A fallowed area of horsenettle near Cromwell was treated for plant control in 1971. The May 19 treatment was applied on plants 2-14 inches tall in a vegetative growth stage. The retreatment of selected treatments was applied on 4-18 inches regrowth on June 30. Alachlor at 2 lb/A was applied to the experimental area to control annual weeds. One half of each plot was disked on May 30, to evaluate the herbicidal and cultivational combination treatment. Data collected consisted of visual ratings and total plant counts. Environmental conditions at treatment are shown in Table I.

A. V. Growth Suppression

Several herbicides were applied on plants in an area mechanically prepared for peanut planting. A 2 lb/A treatment of alachlor was applied on the area to control annual weeds and grasses. The treatments were applied on 6 to 12 inch vegetative stage plants on June 10, and on 4 to 18 inch flowering stage plants June 30, 1971. Environmental conditions at the time of application are given in Table I.

The plants were evaluated for topical injury, control, and the percentage of plants blooming and setting fruits.

A. VI. 2, 4-DB Comparison

The amine and ester formulations of 2, 4-DB were applied on 8 to 15 inch plants in an early bloom stage near Shawnee. Visual injury ratings and fruiting control were taken. Environmental conditions are shown in Table I.

B. I. Vegetative Cropped Area

Several herbicides were applied to 4 to 6 inch horsenettle plants growing in an area planted to peanuts. The herbicides were applied when the seedling peanuts were cracking the soil during emergence (ground crack). The cultivation and irrigation procedures of the Caddo County Research Station for 1970 were included. Manual hoeings of the horsenettle plants were omitted. Data were taken of horsenettle and crop injury, plant counts, and peanut yield. Environmental conditions are shown in Table I.

B. II. Horsenettle Suppression on Cropped Area

Several treatments were applied on 0.5 to 6 inch horsenettle plants and on 0.5 to 2 inch peanut plants in an area on the Caddo County Research Station. Normal station cultivation procedures were followed and an 0.5 lb/A application of trifluralin was included to control annual weeds and grasses. Mechanical cultivation and hand hoeings were included. Visual data were taken on horsenettle and peanut plant injury. Horsenettle plant counts and yield data of unshelled peanuts were taken from the treated area.

C. I. Seed Germination Study

Mature fruit pods from the Caddo County location were collected in October, 1970, and air dried until March, 1971, when the seeds were extracted. Three replications of 20 seeds per replication were then treated for zero, one, two, five, or fifteen minutes in full strength sodium hypochlorite (Clorox) or concentrated sulfuric acid. The treated seeds were rinsed three times in distilled water and placed in germination boxes moistened with distilled water or 0.2 percent potassium nitrate. Germination conditions were 29-32°C for 15 hours and 20-25°C for nine hours. Counts of the seeds which germinated were taken seven, fourteen, or twenty-one days following treatment.

C. II. ^{14}C- 2, 4-D Translocation

An experiment to study the translocation of foliar applied 2, 4-D was conducted using three-month-old horsenettle plants. The plants were grown from seed in potted loam soil, and transplanted to full strength Hoagland's solution two weeks prior to treatment. The plants were then placed in a growth chamber having 14 hours of light at 85°F and 10 hours of darkness at 68°F.

Ten microliters of radioactive 2, 4-D were applied to a mid leaf in ten-one microliter drops and allowed to dry. The solution also contained 0.1 percent Triton X-100 surfactant.

The plants were removed from the growth chamber 24, 48, 72 and 96 hours following treatment and immediately frozen until analysis. Samples of the growth solution of the 96 hour treatment were taken 0, 24, 48, 72 and 96 hours after treatment.

For liquid scintillation analysis, the plants were sectioned as follows:

1. leaf treated
2. leaves above the leaf treated
3. leaves below the leaf treated

4. stems above the leaf treated

5. stems below the leaf treated

6. six inches of root nearest the stem

7. remainder of root

Each segment was weighed and then homogenized in 10 milliliters (ml.) of 95 percent ethanol in a Vertis homogenizer for three minutes. A 0.2 ml. aliquot of this solution was then transferred into counting cocktail (7) and analyzed in a Beckman Scintillation Counter. The data was analyzed for percent translocation.

CHAPTER IV

RESULTS AND DISCUSSION

A. I. Vegetative Fallow and Retreatment

The preliminary screening experiment showed that several herbicides caused top injury and plant control. The greatest initial injury was produced by the treatments of 2, 4-D, 2, 4-D and amitrole, and dicamba (Table III). 2, 4-D produced stem curl and stunting of the plant which evolved to plant top kill followed by resprouting from the roots. Chlorosis, stem curl, and plant stunting were produced by the dicamba and amitrole treatments. The combination of amitrole and 2, 4-D produced symptoms characteristic of the 2, 4-D treatment.

Plant counts one year following treatment but prior to retreatment showed amitrole to be the most effective treatment for stand reduction. The 4 lb/A treatment of 2, 4-D LVE and the combination of 2, 4-D and amitrole were nearly as effective as were directed and 1 lb/A broadcast treatments of dicamba.

The treatments of fluometruron, MSMA, prometryne, bromoxynil, and MSMA plus cacodylic acid were not effective. The 0.5 lb/A of bromoxynil and 8 lb/A of MSMA treatments did reduce plant populations slightly.

Following the retreatment, 2, 4-D, dicamba, and MSMA produced the greatest visual injury. Dry weather throughout the summer suppressed normal plan development and furthur data was unobtainable.

TABLE III

HORSENETTLE INJURY AND STAND REDUCTION FROM JUNE HERBICIDE TREATMENTS (EXPT A. I.)

HERBICIDE	RATE (lb./A.)	VISUAL INJURY RATING 57[2]	384	STAND COUNT[3] 35[2]
Amitrole	2 gpa	30	10	10 ab[4]
	4 gpa	30	10	7 a
	8 gpa	40	10	12 ab
Bromoxynil	0.5	0	10	46 b-g
	1.0	0	30	80 g-j
	2.0	30	40	92 i-j
2,4-D acid	2	70	70	68 d-j
	4	80	70	78 g-j
2,4-D LVE	2	60	50	77 f-j
	4	90	80	42 a-f
2,4-D + Amitrole	1 + 1.5 gpa	80	70	25 a-c
Dicamba	1 aihg[1]	40	30	32 a-d
	1.25 aihg[1]	70	50	27 a-c
	1	60	40	37 a-e
	2	80	80	55 c-h
Fluometuron + oil	1.5 + 1 gpa	0	20	100 j
	3.0 + 1 gpa	10	40	100 j
MSMA	2	20	40	70 e-j
	4	20	20	70 e-j
	8	20	70	58 c-i
MSMA + Cacodylic acid	1 gpa	10	50	80 g-j
Prometryne + oil	1 + 1 gpa	0	30	87 h-j
	2 + 1 gpa	0	60	97 j
Check		0	0	100 j

[1] Hand directed treatment.

[2] Days after initial treatment.

[3] Stand count as % of check.

[4] Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

A. II. Horsenettle Treatment

The fall application to evaluate residual injury to horsenettle and the following summer's peanut crop produced different control results from the spring and summer applications (Table IV). The greatest initial horsenettle injury developed from the dicamba and 2, 4-D treatments. The following summer, 2, 4-D caused stunted growth and twisted, slightly chlorotic, malformed horsenettle leaves. The plants neither bloomed nor set fruits. The combination of 2, 4-D and amitrole produced similar effects, but to a lesser degree. Silvex at 2 and 4 lb/A prevented blooming and fruit development. The remaining treatments were much less effective.

The peanuts were stunted by the 4 lb/A treatment of 2, 4-D and the combination of 2, 4-D and amitrole.

A. III. Fallow Fall Residue

The fall application of herbicides did not significantly affect the yield of the peanut crop produced the following summer (Table V). No visual injury symptoms developed in the peanut crop throughout the growing season.

A. IV. Vegetative Fallow and Same-Season Retreatment

Treatments applied in late spring and retreated in mid-summer to control horsenettle in a fallowed area initially injured or killed the emerged portions of the treated plants (Table VI). All formulations of 2, 4-D, dicamba, picloram, and silvex caused stem and leaf curl. The 2, 4-D treatments evolved to chlorosis and greater curling and death of the top. Dicamba stunted the plant as curling increased followed by

TABLE IV

EFFECT OF FALL APPLIED HERBICIDES ON HORSENETTLE AND PEANUTS (EXPT. A. II.)

HERBICIDE	RATE (lb/A)	VISUAL INJURY RATING HORSENETTLE 17[1]	HORSENETTLE 308	PEANUTS 263
Amitrole	2 gpa	8 cd[2]	5 g	0
	4 gpa	8 cd	5 g	0
	8 gpa	20 bc	5 g	0
2, 4-D	1	8 cd	45 c	0
	2	25 ab	63 a	0
	4	18 bc	53 b	8
2,4-D + Amitrole	0.5 + 0.75 gpa	13 b-d	30 d	18
	1 + 1.50 gpa	15 bc	35 d	0
Dicamba	0.5	15 bc	8 f	0
	1	23 ab	13 f	0
	2	35 a	13 f	0
Silvex	1	15 bc	13 f	0
	2	13 b-d	20 e	0
	4	20 bc	20 e	0
Check	-	0 d	0 g	0

[1]The number of days after treatment.

[2]Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

TABLE V

EFFECT OF FALL APPLIED HERBICIDES ON THE FOLLOWING SUMMER'S PEANUT CROP YIELD (EXPT. A. III.)

HERBICIDE	RATE (lb/A)	YIELD (lb/A)
Amitrole	2 gpa	1013
	4 gpa	1258
	8 gpa	923
2,4-D acid	1	1173
	2	1101
	4	947
2,4-D + Amitrol	0.5 + 0.75 gpa	1424
	1.0 + 1.5 gpa	977
	2.0 + 3.0 gpa	1436
Dicamba	0.5	1319
	1.0	1177
	2.0	1146
Silvex	2.0	1134
	4.0	1234
Check	---	992

TABLE VI

EFFECT OF SINGLE AND DUAL TREATMENTS ON HORSENETTLE IN A FALLOWED AREA (EXPT. A. IV.)

	RATE	PERCENTAGE VISUAL INJURY				REGROWTH INJURY AT 87	
HERBICIDE	lb./A.	20[1]	42	50	78	UNDISKED	DISKED
Amitrole	2gpa	47 de[2]	70 a–c	10 d	97 a	20 bc	10 de
	4gpa	60 cd	77 a–c	90 a	100 a	13 bc	20 c–e
Amitrole	1,1gpa	53 de	57 c	47 bc	100 a	17 bc	13 c–e
	2,2gpa	60 cd	70 a–c	50 bc	100 a	13 bc	57 a–e
2,4-D acid	2	83 a–c	83 a–c	43 c	100 a	7 c	13 c–e
	4	87 ab	87 ab	90 a	93 a	17 bc	37 a–e
2,4-D acid	0.5, 0.5	50 de	73 a–c	70 a–c	97 a	67 ab	33 b–e
	1,1	80 a–c	80 a–c	77 ab	80 ab	63 ab	47 a–e
2,4-D amine	2	83 a–c	83 ab	87 a	90 a	7 c	40 a–e
	4	87 ab	87 ab	80 a	97 a	7 c	77 a–c
2,4-D amine	0.5, 0.5	40 e	80 a–c	90 a	100 a	23 bc	10 de
	1,1	47 de	67 bc	87 a	90 a	17 bc	90 ab
2,4-D LVE	2	87 ab	83 ab	87 a	90 a	27 bc	10 de
	4	87 ab	90 a	90 a	97 a	20 bc	20 c–e
2,4-D LVE	0.5, 0.5	67 cd	77 a–c	87 a	97 a	20 bc	67 a–d
	1,1	83 a–c	83 ab	83 a	100 a	7 c	40 a–e
Dicamba	1	80 a–c	87 ab	73 a–c	100 a	67 ab	---[3]
	2	83 a–c	80 a–c	90 a	97 a	7 c	7 de
Dicamba	1,1	67 bc	87 ab	90 a	93 a	100 a	7 de
	2,2	90 ab	90 a	90 a	100 a	100 a	---
Picloram	0.5	90 ab	83 ab	93 a	100 a	---	---
	1	97 a	93 a	97 a	100 a	---	---
Silvex	1	47 de	63 bc	83 a	67 b	0 c	90 ab
	2	50 de	77 a–c	83 a	93 a	40 bc	67 a–d
Silvex	0.5, 0.5	33 e	70 a–c	87 a	90 a	67 ab	100 a
	1,1	47 de	77 a–c	77 ab	87 ab	100 a	67 a–d
Check		0 f	0 d	0 d	0 c	0 c	0 e

[1]Days after initial treatment.

[2]Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

[3]Indicates regrowth did not occur.

defoliation and top kill. Silvex caused chlorosis and greatly stunted the plant. The 2 lb/A rate and retreatments were required for maximum topical injury of curling and chlorosis which progressed to defoliation and topical kill.

Regrowth emerged from all treatments of amitrole, 2, 4-D, and silvex and from two dicamba treatments. Picloram and disked treatments of dicamba prevented resprouting throughout the summer. Undisked dicamba treatments resprouted, but retreatment killed the top growth. Retreatments of 2, 4-D acid and silvex also caused severe injury to resprouts in nondisked areas. 2, 4-D amine, 2, 4-D LVE and silvex caused severe injury to regrowth in the disked areas. The 0.5 lb/A retreatment of silvex caused plant top kill in disked areas.

High rates of herbicides produced less control in some cases. The 1 lb/A rate-single application-undisked treatment of dicamba produced greater injury to the resprouted horsenettle than the 2 lb/A-single application-undisked treatment. Similar results developed for amitrole and 2, 4-D LVE single applications. Silvex and 2, 4-D LVE disked treatments also caused better control with low rates.

A. V. Growth Suppression

The treatments applied on horsenettle to suppress development and not control the plant showed little difference after 56 days (Table VII). Treatments of 2, 4-DB produced stunting, stem curl, chlorosis, and leaf necrosis which evolved to defoliation within twenty days of application. However, the degree of injury decreased as time elapsed. Dicamba initially caused stem curl, chlorosis, and leaf necrosis, which increased to defoliation. Chlorosis and leaf curl evolved to partial defoliation, more severe chlorosis, and stem curl from the MSMA treatments. DPX 1840 caused stunting, chlorosis, and leaf necrosis initially and eventually defoliated most of the plants. The amount of surfactant applied did not affect topical injury after 57 days (Table VII).

Flowering applications of 2, 4-DB, 2, 4-DB plus linuron, and dicamba were equally injurious after 27 days causing defoliation, stem curl, and chlorosis.

The greatest differences appeared in the fruiting response of the treated plants. The 2, 4-DB treatments applied at the vegetative stage reduced fruiting 60 to 78 percent compared with the check. The 0.2 lb/A rate was more effective than the 0.4 rate. Applied at flowering, 2, 4-DB reduced fruiting 72 percent. The 2, 4-DB plus linuron and dicamba treatments were more effective when applied at flowering. MSMA and naptalam was ineffective as a fruiting repressant. The maximum fruit reduction with DPX 1840 was obtained with the 1.0 + 0.5 percent lb/A rate and 0.5 + 2 percent lb/A. Higher rates of the herbicides with both rates of surfactant decreased the repression effect.

Horsenettle populations decreased as compared to the check from the application of 2, 4-DB plus linuron, dicamba, DPX 1840 plus surfactant and naptalam when treated at the vegetative growth stage. Similarly, 2, 4-DB, the 2, 4-DB plus linuron combination, and dicamba when applied at flowering, reduced populations. The 0.25 lb/A dicamba treatment at flowering reduced the population. However, the vegetative treatment increased the population. The 2, 4-DB treatment at the vegetative stage also increased the population whereas the flowering stage application reduced the population.

TABLE VII

COMPARISON OF 2, 4-DB FORMULATIONS ON HORSENETTLE (EXPT. A. VI.)

FORMULATION	RATE (lb/A)	VISUAL INJURY 52[1]
Amine	0.4	80
	0.8	80
Ester	0.4	50
	0.8	90
Check	---	0

[1]Days after treatment.

TABLE VIII

EFFECT OF HERBICIDES APPLIED TO HORSENETTLE DURING THE EARLY VEGETATIVE OR FLOWERING STAGES OF DEVELOPMENT (EXPT. A. V.)

STAGE	HERBICIDE	RATE (lb./A.)	% VISUAL INJURY 15[1]	28	56	% ORIG. POP. 161	% NOT FRUITING 161
Vegetative	2,4-DB	0.2	10 c[2]	13 d-f	43	150	78
		0.4	40 b	57 ab	43	125	60
	2,4-DB + Linuron	1.0	73 a	57 ab	40	100	6
		1.5	77 a	73 a	43	79	74
	Dicamba	0.125	37 b	33 b-d	50	79	50
		0.25	63 a	70 a	36	140	50
	DPX 1840 + S	0.5 + 0.5%	10 c	27 c-e	50	74	26
		1.0 + 0.5%	17 bc	20 c-f	57	120	84
		2.0 + 0.5%	20 bc	37 b-d	43	113	40
		0.5 + 2.0%	17 bc	17 d-f	37	87	0
		1.0 + 2.0%	20 bc	17 d-f	53	77	84
		2.0 + 2.0%	17 bc	43 bc	80	89	50
	MSMA	2.0	7 c	17 d-f	36	106	0
	Naptalam	2.0	20 bc	7 ef	0	70	10
		4.0	13 c	27 c-e	33	100	0
	Check		0 c	0 f			
Flowering	2,4-DB	0.4	30 ab	57 a	—	74	72
	2,4-DB +Linuron	1.5	17 bc	70 a	—	84	78
	Dicamba	0.25	33 a	83 a	—	75	96
	Naptalam	4.0	7 cd	13 b	—	100	40
	Check		0 d	0 b	0	100	0

[1]Days after treatment.

[2]Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

A. VI. A 2, 4-DB Comparison

The application of the amine and ester formulations of 2, 4-DB resulted in some variation from the previous results. The 2, 4-DB treatments produced stunting, leaf curling, and chlorosis (Table VIII). The horsenettle leaves were malformed after 52 days. The base was slender and the leaf stunted in size. A white to silver tinge appeared along the veins and leaf base.

The 0.8 lb/A of the ester formulation produced the greatest amount of injury. No difference in degree of injury was evident between the 0.4 and 0.8 lb/A amine treatments.

Fruiting was suppressed only for the 0.4 rate of the amine formulation which varies from other experiments where the amine and ester formulations were applied. Partial fruiting control was obtained, but complete suppression of fruiting was not observed.

B. I. Vegetative Cropped Area

The application of herbicides at plant emergence (ground crack) produced injury to the peanut crop.

The treatments of dicamba, 2, 4-D, silvex, and bromoxynil produced visual injury to the treated peanut plants (Table IX). Silvex, 2, 4-D, and dicamba caused leaf and stem curl. The symptoms dissipated within fifteen days for the 2, 4-D treatment. Silvex caused stunting and chlorosis which evolved to plant death. Dicamba also produced severe stunting, leaf curl, and chlorosis. However, the results were not as severe as the silvex treatments.

No visual peanut crop injury appeared in any treated area during the following year.

TABLE IX

EFFECT OF HERBICIDES ON HORSENETTLE AND PEANUTS WHEN APPLIED AT THE PEANUT GROUND CRACK STAGE (EXPT. B. I.)

HERBICIDE	RATE (lb/A)	PERCENT VISUAL INJURY HORSENETTLE 13[1]	HORSENETTLE 57	PEANUT 13	PEANUT 57	PEANUT 407	PEANUT YIELD (lb/A)
Amitrole	2gpa	20	0	0	0	0	2571 ab[2]
	4gpa	30	0	0	0	0	2487 ab
	8gpa	20	0	0	0	0	3061 a
Bromoxynil	1.0	10	10	10	0	0	2438 a-c
	2.0	10	0	20	0	0	2499 ab
2,4-D acid	2.0	50	10	0	0	0	3001 a
	4.0	40	20	10	0	0	2559 ab
2,4-D + Amitrole-T	1.0 + 1.5gpa	30	0	10	0	0	2414 a-c
Dicamba	1.0	20	20	30	30	0	2153 b-d
	2.0	30	30	50	50	0	1694 d
MSMA	2.0	0	0	0	0	0	2662 ab
	4.0	0	0	0	0	0	1766 cd
	8.0	10	0	0	0	0	2807 ab
Silvex	1.0	20	10	50	10	0	2154 b-d
	2.0	20	0	60	30	0	1022 e
	4.0	30	20	80	100	0	66 f
Check	---	0	0	0	0	0	2389 a-c

[1]Days after treatment.

[2]Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

Only treatments of silvex at 2 and 4 lb/A and dicamba at 2 lb/A reduced peanut yields significantly.

Visual injury of the horsenettle was very slight.

B. II. Horsenettle Suppression on Cropped Area

Treatments to suppress normal horsenettle development in emerged peanuts caused injury to the peanut crop (Table X). Chlorosis and plant stunting were evident for all amitrole applications. Dicamba stunted and curled the plant until plant death occurred. The injury produced from the application at this growth stage was greater than the injury from the ground crack application.

The applications of 2, 4-D, 2, 4-DB, 2, 4-DB plus linuron, DPX 1840, and naptalam did not produce significant horsenettle injury 38 days following treatment. The phenoxy compounds initially produced light stunting and plant curling which dissipated by 38 days. DPX 1840 caused curling, chlorosis, and stunting which dissipated after 38 days. Naptalam initially caused slight stunting which dissipated within 27 days of treatment.

The treatments that reduced horsenettle plant populations the most were 2, 4-D, 2, 4-DB, DPX 1840, naptalam, and picloram (Table XI). Picloram was the most effective. The 2, 4-DB treatment reduced the stand by 60 percent with the exception of the 0.4 lb/A application which did not reduce the stand. The 2, 4-D treatment reduced the stand by 39 to 51 percent. Naptalam reduced plant stands by nearly 60 percent although visual injury to the horsenettle was very minor. Mechanical cultivation was included in this experiment and may explain partial horsenettle population reductions.

TABLE X

EFFECT OF HERBICIDES ON PEANUTS WHEN APPLIED AT THE FOUR TRUE LEAF GROWTH STAGE (EXPT. B. II.)

HERBICIDE	RATE (lb/A)	PERCENT VISUAL INJURY 14[1]	27	38	YIELD (lb/A)
Amitrole	1gpa	56 b[2]	33 f	13 gh	1337 a-e
	2gpa	70 ab	57 e	60 ef	1243 c-e
	4gpa	73 ab	67 c-e	67 de	1134 de
Amitrole + Surfactant	2 + ½%	77 ab	73 b-d	60 ef	1137 de
	4 + ½%	83 a	77 bc	77 cd	1028 e
	2 + 2%	77 ab	60 de	50 f	1331 a-e
	4 + 2%	83 a	73 b-d	60 ef	1204 c-e
2,4-D	1	20 cd	3 i	0 h	1516 a-c
	2	23 cd	17 gh	20 g	1334 de
2,4-DB amine	0.4	3 d	0 i	0 h	1440 a-d
	0.8	7 d	3 i	0 h	1449 a-d
	1.0	10 cd	7 hi	0 h	1642 a
2,4-DB ester	0.4	7 d	0 i	0 h	1500 a-c
	0.8	10 cd	0 i	7 gh	1507 a-c
	1.0	10 cd	0 i	0 h	1594 ab
2,4-DB + Linuron	1.0	30 c	17 gh	0 h	1418 a-d
	1.5	23 cd	30 fg	20 g	1316 a-e
Dicamba	1	87 a	87 ab	83 bc	408 f
	2	90 a	100 a	100 a	12 g
DPX 1840 + Surfactant	0.5 + ½%	20 cd	17 gh	7 gh	1425 a-d
	1.0 + ½%	13 cd	7 hi	3 h	1509 a-c
	2.0 + ½%	20 cd	0 i	0 h	1649 a
	0.5 + 2%	7 d	0 i	3 h	1443 a-d
	1.0 + 2%	17 cd	0 i	0 h	1295 a-e
	2.0 + 2%	13 cd	0 i	7 gh	1443 a-d
Naptalam	2	7 d	0 i	7 gh	1425 a-d
	4	3d	0 i	0 h	1582 ab
Picloram	0.25	80 a	80 bc	80 cd	106 g
	0.50	77 ab	87 ab	97 ab	61 g
Check	---	0 d	0 i	0 h	1455 a-c

[1]Days after treatment.

[2]Treatments having the same letter are not significantly different.

TABLE XI

VISUAL INJURY AND STAND REDUCTION FROM HERBICIDES APPLIED TO HORSENETTLE IN A VEGETATIVE STAGE (EXPT. B. II.)

HERBICIDE	RATE (lb/A)	PERCENT VISUAL INJURY 14[1]	27	38	PERCENT STAND REDUCTION 73
Amitrole	1gpa	23 c-e[2]	3 ef	10 f-h	2
	2gpa	33 a-d	20 b-f	37 c-e	8
	4gpa	40 ab	27 b-f	7 gh	-12
Amitrole + Surfactant	2 + ½%	37 a-c	47 b	10 f-h	2
	4 + ½%	23 c-e	20 b-f	0 h	-19
	2 + 2%	33 a-d	30 b-e	20 e-h	-14
	4 + 2%	33 a-d	30 b-e	37 c-e	25
2,4-D	1	27 a-e	10 d-f	30 d-g	39
	2	13 ef	27 b-f	37 c-e	51
2,4-DB amine	0.4	10 ef	30 b-e	30 d-g	60
	0.8	17 d-f	20 b-f	37 c-e	63
	1.0	17 d-f	27 b-f	37 c-e	77
2,4-DB ester	0.4	13 ef	30 b-e	13 e-h	-22
	0.8	13 ef	23 b-f	37 c-e	60
	1.0	20 c-f	23 b-f	33 d-f	63
2,4-DB + Linuron	1.0	23 c-e	27 b-f	20 e-h	16
	1.5	20 c-f	37 b-d	23 d-g	17
Dicamba	1	20 c-f	37 b-d	47 b-d	1
	2	27 a-e	43 bc	63 ab	13
DPX 1840 + Surfactant	0.5 + ½%	13 a-d	7 ef	23 d-h	35
	1 + ½%	9 ef	0 f	17 e-h	76
	2 + ½%	17 d-f	13 c-f	0 h	65
	0.5 + 2%	10 e-f	7 ef	3 h	82
	1 + 2%	17 d-f	3 ef	0 h	23
	2 + 2%	13 ef	7 ef	10 f-h	-22
Naptalam	2	10 ef	3 ef	0 h	57
	4	10 ef	7 ef	0 h	62
Picloram	0.25	20 c-f	47 b	60 bc	78
	0.50	43 a	73 a	87 a	83
Check	---	0 f	0 f	0 h	0

[1]Days after treatment.

[2]Treatments having the same letter are not significantly different at the 0.05 level. Hyphen indicates "through."

DPX 1840 reduced plant populations by 23 to 82 percent with the 2 lb/A plus 2 percent surfactant rate. The increase in surfactant resulted in a reduced population for the 0.5 lb/A acre treatment. The 0.5 percent surfactant rate was more effective for all rates of DPX 1840 than the 2.0 percent surfactant rate.

The greatest visual injury to the horsenettle was produced by the picloram treatments (Table XI). The horsenettle defoliated and a stunted chlorotic stem remained. The plant stems did not die nor did they resprout. The higher rate of 0.5 lb/A in a fallow area killed the plants and suppressed resprouting.

Dicamba produced the plant injury symptoms of stunting, chlorosis, and curling. The degree of injury was 47 to 63 percent after 38 days. Only the treatments of naptalam, DPX 1840 plus surfactant (1+2 percent and 2+0.5 percent), and amitrole plus surfactant (4+0.5 percent) did not cause horsenettle visual injury after 38 days (Table XII). The treatments of dicamba, picloram, and one rate of amitrole-surfactant reduced crop yield (Table X). No other treatment significantly reduced peanut yield.

The 2, 4-DB compounds caused curling, stunting, and flowering suppression to horsenettle. Visual injury varied from 13 to 37 percent after 38 days (Table XII).

The most effective treatments to reduce plant populations and not injure the peanut crop appear to be the 2, 4-DB compounds, DPX 1840, and naptalam.

TABLE XII

EFFECT OF TREATMENT AND EXPOSURE TIME ON HORSENETTLE SEED GERMINATION (EXPT. C. I.)

TREATMENT	TIME (min.)	MOISTENING AGENT	PERCENTAGE GERMINATED
NaClO	2	water	60 a-c
	5	water	63 ab
	10	water	67 ab
	2	KNO_3	67 ab
	5	KNO_3	51 a-d
	10	KNO_3	61 a-c
H_2SO_4	2	water	32 e
	5	water	44 c-e
	10	water	37 d-e
	2	KNO_3	67 ab
	5	KNO_3	64 ab
	10	KNO_3	49 b-d
CHECK	--	water	62 ab
CHECK	--	KNO_3	68 a

C. I. Seed Germination

The greenhouse experiment to study horsenettle seed viability produced results similar to data reported by Furrer (5). Germination ranged from 32 to 68 percent. The NaC10 treatments had germination above 51 percent (Table XII). The sulfuric acid-water treatments reduced germination to 32 to 44 percent.

The percentage of seeds germinating corresponds to Furrer's report (5) of up to 65 percent. This indicates that seed dispersion could be a prime method of propagation in Oklahoma when the fruits are left in the field.

C. II. ^{14}C-2, 4-D Translocation

Radioactive 2, 4-D was applied to a single plant leaf to study translocation in the horsenettle plant in a greenhouse experiment. The results were similar to those found by Augustein and Thompson (6). The bulk of the applied radioactivity remained on or in the treated leaf. The next largest concentration was located in the stems below the treated leaf. Only in the 72 and 96 hour samplings did an appreciable amount of radioactivity appear in the analyzed roots (Table XIII). Approximately 8.5 percent of the accountable radioactivity was found in the root sample at the 72 hour sampling. However, this value dissipated to nearly 2.8 percent at the 96 hour sampling.

The location of the radioactivity from the applied 2, 4-D appears to indicate that very little of the herbicide remains in the root zone. The lack of retention in this area may account for the resprouting from topically killed plants (Part A. IV.).

TABLE XIII

DISTRIBUTION OF FOLIAR APPLIED ^{14}C 2, 4-D IN VARIOUS HORSENETTLE PLANT PARTS (EXPT. C. II.)

Plant Part Analyzed	% Radioactivity			
	24[1]	48	72	96
Treated leaf	76.0	65.0	44.5	65.3
Leaves above treated leaf	2.4	2.2	4.4	2.8
Leaves below treated leaf	3.5	3.5	3.2	3.8
Stem above treated leaf	5.0	9.0	6.6	7.0
Stem below treated leaf	12.0	17.1	35.6	17.6
6 inches or root nearest stem	0.3	0.1	4.5	2.2
Remaining root	0.7	0.6	4.0	0.6
Nutrient solution	0	0	0	0

[1]Hours after application.

It appears that horsenettle control in fallowed areas will have to consist of more than one treatment of a herbicide. Except for picloram, no single application treatment evaluated for more than one season produced consistant plant control. Amitrole greatly reduced the number of plants in one experiment. However, tillage and dry weather were included in the treatment. Noncultivated amitrole treatments applied in 1971 produced effective top kill, but root resprouting followed. Rainfall was more abundant at the site where root resprouting occurred.

Silvex and 2, 4-D treatments caused top kill, but resprouting was too abundant to produce effective long term control. These treatments may be effective to control plants originating from sectioned root segments, but established plants having deep root systems would probably not be controlled. If these treatments must be used, additives to increase translocation into and retention in the root zone need to be evaluated. Retreatments with silvex the same season appeared to enhance control, but 2, 4-D does not appear effective when applied throughout the summer.

Picloram produced horsenettle control for one season with a single application. Top kill was not followed by root resprouting which implies that effective long term control may be obtained with picloram. However, further evaluation must be completed before conclusions can be drawn.

The stage of horsenettle development at the time of application appears to have a definite effect on the herbicidal action. The 2, 4-D treatments applied in June caused top kill followed by root resprouting and continued growth. The September application produced a reduction in growth vigor throughout the following summer. Variation in herbicidal action was observed in treatments applied in May at the early seasonal stage of growth as contrasted to the late June flowering stage of horsenettle development. Dicamba was more effective as a fruiting suppressant when applied at the flowering stage, but was less effective for total control.

Treatments combining herbicides with mechanical cultivation need further evaluation. In fallowed areas, a disking operation reduced the time required for the plant to resprout. Retreatments caused top kill, but residual control the following year needs further evaluation. In cropped areas, the combination of cultivation and naptalam caused more horsenettle plant injury than naptalam applied alone.

The type of implement used may affect results in the fallowed areas. Since the plant is capable of propagation from root sections, a disk may be more effective than a plow or deep working sweep blade. The opposite may also be true and rototillering may prove to be more effective to control sectional propagation.

Evaluations of the effect of currently used herbicides upon seedling control should be conducted. Germination experiments showed horsenettle seed viability to be nearly 68 percent the following spring. The presence of new fruits annually provide an excellent source for the spread of the plant in the cultivated field.

On cropland, 2, 4-DB, naptalam, and DPX 1840 appear to be the only effective herbicides that do not injure the peanut plant. Single treatments of these herbicides either reduced horsenettle fruiting, population, or competition, or combinations of these. Variation in the degree of injury, population change, or fruiting characteristics was observed when treatments were applied at the horsenettle flowering stage of growth as contrasted to a vegetative, early season growth stage.

Retreatments of horsenettle control herbicides may be more effective than single treatments as the herbical action was affected by the stage of development of the weed. An application at the peanut ground crack stage repeated 20 to 30 days later when the majority of the horsenettle would be blooming may be much more effective for fruiting, population, and/or competition reduction.

Considering the current availability of herbicides for use in fallowed areas, the horsenettle control procedure that gives the greatest promise for providing some control would be a mid-June application of 2 gpa of amitrole of 2 lb/A of silvex, followed by disking within two weeks. Dicamba applied at 1 lb/A appears to be a better control when disking is not included in the treatment.

A more economical method might be the prevention of horsenettle fruiting in a peanut crop. The herbicide 2, 4-DB applied within one week of peanut emergence at rates of 0.2 or 0.4 lb/A appears to reduce horsenettle competition and fruiting with no prolonged injury to the peanut crop. A retreatment to suppress late emerging plants and regrowth should be applied when the horsenettle are 8 to 14 inches tall and before the horsenettle's blooming period. Naptalam applied at 4 lb/A at ground crack and mechanically cultivated appear to reduce the number of horsenettle plants during the season.

CHAPTER V

SUMMARY AND CONCLUSIONS

The influence of several herbicides on horsenettle growing in fallowed areas and in cropped areas was studied. The most effective treatment for killing the top of the horsenettle and suppressing regrowth was picloram. Silvex, 2, 4-D, dicamba, and amitrole were effective for top kill, but regrowth followed at a significant degree. In one experiment, amitrole, cultivation and dry weather controlled 90 percent of the treated plants. Other amitrole treatments appeared less effective. No single treatment appears to give effective long term control with the exception of picloram.

Two fall applied treatments on horsenettle in fallow areas appeared to suppress fruiting the following summer. No significant effects were found in the following year's crop of peanuts in the treated areas.

In cropped areas, the treatments of 2, 4-DB, 2, 4-D, naptalam, and DPX 1840 suppressed horsenettle fruiting and/or reduced plant populations without injuring the peanut crop. Picloram, dicamba, and silvex reduced plant populations but severely injured the peanut crop.

No treatment may be singled out as most effective as the bulk of the data is for one year and does not reflect results expected for longer than one growing season. The perennial species possess a large root food reserve and top kill does not reflect long term control.

The translocation of ^{14}C-2, 4-D appears to be restricted primarily to the above ground sections of the horsenettle plant. The inability of the herbicide to move into and remain in the root zone may be one explanation for the effective top kill and subsequent resprouting when the 2, 4-D and phenoxy related compounds are used.

The germination studies showed that 34 to 68 percent of the seeds extracted from horsenettle fruits are viable the following spring and that seed dispersion is one method of plant propagation.

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APPENDIX

1970 RAINFALL AT FORT COBB

(inches)

JANUARY		FEBRUARY		MARCH		APRIL	
	0.00	23	0.28	6	0.76	1	0.44
		24	0.05	7	0.52	4	0.06
				16	0.36	5	0.12
				19	0.17	10	0.15
				28	0.58	17	0.68
				31	0.05	30	1.34
MAY		**JUNE**		**JULY**		**AUGUST**	
15	0.78	1	0.66	11	0.23	21	1.29
28	0.02	3	0.17	21	0.50	22	0.25
29	1.96	4	0.27	29	0.41		
		12	0.65	31	0.56		
		13	0.71				
		25	0.20				
SEPTEMBER		**OCTOBER**		**NOVEMBER**		**DECEMBER**	
8	0.05	5	0.30	13	0.05	15	0.10
14	0.52	7	0.35	14	0.42	16	0.16
16	0.05	8	0.03			21	0.03
17	0.09	17	0.40				
22	0.60						
23	1.20						

1971 RAINFALL AT FORT COBB

(inches)

JANUARY		FEBRUARY		MARCH		APRIL	
3	0.72	19	0.30				
		25	0.82		0.00	18	0.03
						20	0.54
						29	0.02
						30	0.04

MAY		JUNE		JULY		AUGUST	
9	0.97	1	2.11	1	1.27	8	0.21
18	0.03	3	0.32	22	0.15	9	1.21
24	0.37	8	0.04	23	0.53	12	0.68
27	1.07	9	0.36	28	0.93	14	0.35
31	1.03	11	1.02	30	0.07	15	0.40
		20	0.25			16	0.20
		22	0.27			24	0.56
						29	0.75

SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
5	0.48	2	0.48	22	0.12	2	0.20
17	1.07	18	0.61	23	0.61	6	0.60
18	1.16	19	0.03			9	0.05
24	0.52	20	0.40			14	0.04
25	1.43	26	0.05			15	0.90
		27	0.77			30	0.37
		29	0.63				
		30	0.54				

1971 RAINFALL AT PRAGUE

(inches)

JANUARY		FEBRUARY		MARCH		APRIL	
3	0.87	4	1.24	13	0.15	5	0.07
13	0.08			29	0.02	17	0.17
19	0.62					18	0.69
21	0.43					20	0.75
22	0.86					23	0.18
25	0.26					29	0.12
						30	0.15

MAY		JUNE		JULY		AUGUST	
3	0.08	1	1.08	1	3.52	4	0.07
7	0.02	3	2.22	2	0.20	7	0.19
10	0.54	8	0.48	18	0.06	12	0.43
19	0.06	9	1.36	24	1.30	15	0.66
23	0.20	11	0.03	28	0.06	16	0.18
24	0.37	13	0.24	30	0.03	22	0.05
27	1.58	14	0.06			23	0.47
30	0.14	21	0.02				

SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
5	0.27	2	2.04	2	0.07	1	0.02
6	0.12	9	0.30	8	0.07	3	0.55
7	0.05	18	0.48	18	0.46	6	0.12
18	0.35	19	0.08	23	0.15	9	0.56
19	1.64	20	1.35	29	0.02	10	1.55
25	1.40	27	0.63			14	0.13
		31	0.02			15	1.66
						29	0.06
						30	0.38

1971 RAINFALL AT SHAWNEE

(inches)

JANUARY		FEBRUARY		MARCH		APRIL	
3	0.97	4	0.30	3	0.11	5	0.07
14	0.12	19	0.32	29	0.05	17	0.17
15	0.02	21	0.45			18	0.93
		22	0.74			20	1.85
		25	0.13			21	0.12
						23	0.03
						29	0.28
						30	0.07

MAY		JUNE		JULY		AUGUST	
2	0.04	1	0.82	1	2.02	7	0.23
3	0.13	3	1.59	2	0.50	8	0.28
4	0.01	8	0.15	23	0.42	12	0.13
7	0.06	9	0.48	24	0.08	13	0.01
10	0.57	11	0.01	28	0.96	14	0.09
11	0.02	12	0.06			15	0.98
23	0.01	13	0.42			16	0.02
24	0.55	21	0.11			22	0.10
27	0.81	29	0.41				

SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
5	0.10	3	1.84	2	0.06	1	0.04
6	0.05	18	0.07	8	0.04	3	0.56
17	1.23	19	0.25	18	0.34	5	0.03
18	1.58	20	1.82	23	0.07	6	0.09
19	0.55	21	0.08			9	0.55
20	0.15	27	0.36			10	1.38
24	0.28	31	0.01			14	0.03
25	0.96					15	1.14
26	0.02					29	0.03
						30	0.45

VITA

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Master of Science

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