RED HORNED POPPY: A NEW WEED PROBLEM IN WEST CENTRAL OKLAHOMA WINTER WHEAT FIELDS

By

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RED HORNED POPPY: A NEW WEED PROBLEM

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WINTER WHEAT FIELDS

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INTRODUCTION

Each chapter of this thesis is a manuscript to be submitted for publication in Weed Technology, a Weed Science Society of America publication.

CHAPTER I

RED HORNED POPPY (*Glaucium corniculatum*) CONTROL IN WINTER WHEAT (*Triticum aestivum*)

Red Horned Poppy (*Glaucium corniculatum*) Control in Winter Wheat (*Triticum aestivum*)

Abstract. Fourteen field experiments were conducted in Oklahoma to evaluate herbicides for red horned poppy control in winter wheat. Chlorsulfuron alone at 9 to 26 g ai ha^{-1} or with metsulfuron applied PRE controlled red horned poppy 90 to 100% in four of five locations. MCPA at 280 g ae ha^{-1} applied POST in mid-November controlled red horned poppy 90 to 100%. Herbicides applied POST in mid-March failed to consistently control the weed.

Nomenclature: Bromoxynil, 3,5-dibromo-4-hydroxybenzonitrile; CGA-131036, *N*-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-aminocarbonyl)-2-(2-chloroethoxy)-benzenesulfonamide; chlorsulfuron, 2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide; dicamba, 3,6-dichloro-2-methoxybenzoic acid; MCPA, (4-chloro-2-methylphenoxy)acetic acid;. metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoic acid; picloram, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid; trifluralin, 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl) benzenamine; 2,4-D, (2,4-dichlorophenoxy)acetic acid; red horned poppy, *Glaucium corniculatum* (L.) Rudolph; winter wheat, Triticum aestivum L.

Additional Index Words: Time of application, herbicide efficacy, crop injury, new weed problem.

INTRODUCTION

Red horned poppy, an annual or biennial native to the Mediterranean area, was first reported in North America in Clark County, Kansas in 1979 (2,3). In June 1987, Oklahoma State University received its first samples of red horned poppy from west central Oklahoma wheat growers seeking information on its control.

A survey conducted in 1988 identified 84 farmers in 13 Oklahoma and 3 Texas counties with infested fields (1). Infestations were found in alfalfa (Medicago sativa L.) and wheat fields, along roadsides, and near grain handling operations, and densities often exceeded 40 plants m^{-2} (1). Oklahoma wheat growers sought help because their routine springtime broadleaf weed control operations were not controlling this weed. They particularly complained that the lush vegetative growth made wheat harvesting very difficult.

Although recognized as an economically important weed throughout much of the Mediterranean and Europe, and a potential weed problem in the United States (5), little information could be found on Glaucium spp. control. In Israel, simazine (6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine) at 1.5 kg ai ha^{-1}, methazole (2-(3,4-

dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione) at 3.75 and 5.62 kg ai ha^{-1}, and diuron (N'-(3,4-dichlorophenyl)-N,N-dimethylurea) at 0.75 kg ai ha^{-1} controlled a Glaucium sp. in jojoba (Simmondsia californica Nutt.) (4). In Texas, bromoxynil at 0.56 kg ae ha^{-1} applied in April controlled red horned poppy 100%. Phenoxy and sulfonylurea herbicides were less effective (6).

The objective of this research was to identify herbicides to selectively control red horned poppy in winter wheat.

MATERIALS AND METHODS

General. Field experiments were conducted within a 70 km radius of Hammon in west central Oklahoma during the 1988-89, 1989-90, and 1990-91 winter wheat growing seasons to evaluate herbicides for red horned poppy control. A survey had indicated that this region had the highest density of infested fields (1). The cropping history at all sites included winter wheat annually and the use of conventional tillage practices.

All sites were naturally infested. Each site was also heavily grazed from late fall until mid-March by cattle (Bos spp.), which is a traditional practice. All herbicides were broadcast with a backpack sprayer with a four nozzle boom in 187 L ha^{-1} total volume. Plot size was 2.1 by 7.6 or 2.1 by 6.1 m. Weed control and crop injury were visually evaluated, plots were harvested with a small plot combine, and samples cleaned to determine yield.

The experimental design for each experiment was a randomized complete block with three or four replicates. All data were statistically analyzed and means were separated using protected LSDs. Arcsine transformation was performed on visual evaluation data; however, results of actual means are reported. Experiment numbers, treatment dates, days from treatment to rainfall, growth stage of wheat and weeds at time of application, weed density, and soil descriptions are in Table 1.

<u>PPI and PRE treatments.</u> Field experiments were conducted near Cheyenne and Hammon (2 sites) during the 1989-90 cropping season, and near Cheyenne and Elk City the next season to evaluate wheat injury and efficacy of herbicides applied PPI and PRE. In 1989-90, the seedbed was prepared with a flex-tine harrow before application of the PPI treatments. In 1990-91, the seedbed was prepared using a light s-tine field cultivator with rolling baskets before PPI treatment application.

Both years trifluralin at 560 and 1120 g ai ha^{-1} was applied immediately before seeding and incorporated about 2.5 cm deep with one pass of a flex-tine harrow. Chlorsulfuron and chlorsulfuron plus metsulfuron (premix) were each applied PRE at three rates. Wheat was seeded approximately 2.5 cm deep with a double disk drill in 1989 and a chisel-opener drill in 1990 and PRE treatments were immediately applied. Wheat injury and red horned poppy control were visually estimated 71 to 91 DAT.

Fall applied POST treatments. Field experiments were conducted near Cheyenne and Hammon during the 1989-90 cropping season, and near Hammon, Elk City, and Merritt the next season to evaluate 13 herbicide treatments applied to tillered wheat in mid-November for wheat injury and red horned poppy control. CGA-131036, chlorsulfuron, and chlorsulfuron + metsulfuron were applied with 0.25% (v/v) nonionic surfactant. Wheat injury and red horned poppy control were visually evaluated 41 DAT in 1989-90, and 207 to 211 DAT, at harvest, in 1990-91.

Spring applied POST treatments. Field experiments were conducted near Cheyenne and Hammon in 1989, and near Hammon and Strong City in 1991 to evaluate herbicides applied at the termination of grazing in mid-March. CGA-131036 and chlorsulfuron were applied with 0.25% (v/v) nonionic surfactant. Soil moisture at time of application was limiting at all locations in both 1989 and 1991. Wheat injury and red horned poppy control were visually estimated 55 DAT in 1989, and 93 to 94 DAT, at harvest, in 1991.

RESULTS AND DISCUSSION

General. Data was pooled across locations within the same cropping season where location by treatment interactions

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[1]Abbreviation: DAT, days after treatment; LVE, low volatile ester.

were not significant. Since location differed each year, data was not pooled across cropping seasons.

PPI and PRE treatments. Combined analyses indicated that red horned poppy control in 1989-90 could only be pooled across two of the three experiments (Table 2). At experiments 2 and 3, chlorsulfuron alone and prepackaged with metsulfuron at all rates controlled red horned poppy at least 90%. Trifluralin controlled 69 to 79% of the weeds, but reduced the wheat stand.

At experiment 1, chlorsulfuron controlled red horned poppy 5 to 60%, chlorsulfuron + metsulfuron controlled 75 to 89%, and trifluralin controlled only 5 to 20%. Variation in control at the different sites was not attributable to seed bed condition, because a fine seed bed was prepared at each site. The lower control at experiment 1 with some treatments may be attributed to the lack of rainfall for 40 DAT.

Red horned poppy control was also pooled across the two 1990-91 experiments (Table 2). At experiments 4 and 5, chlorsulfuron alone and with metsulfuron controlled red horned poppy 98 to 100%. Trifluralin at both rates was less effective, and reduced the wheat stand at one location. Grain yields from experiments 1,2, and 3, and 4 and 5 were pooled. Treatment did not effect yield either year (data not shown). Mean grain yields were 1180 to 1288 kg ha^{-1} in 1989-90 (C.V. = 18%) and 590 to 814 kg ha^{-1} in 1990-91 (C.V. = 37%). Inadequate winter and spring moisture and heavy grazing contributed to low, variable yields.

Fall applied POST treatments. Red horned poppy control was pooled across experiments within years except that experiment 9 in 1990-91 would not pool (Table 3.). MCPA LVE[1] alone and with bromoxynil controlled red horned poppy 94 to 100% at all locations. Rainfall did not occur at any site for 28 to 70 DAT, which could have caused the variable control (24 to 100%) obtained with sulfonylurea herbicides. Also, at experiment 9 metsulfuron controlled only 24% of the weeds. That location had the highest weed density (160 plants m^{-2}).

No treatments injured wheat at any location. Combined analyses (for 1989-90 and 1990-91) indicated that grain yields were not affected by treatment at any location (data not shown). Grain yields varied from 932 to 1140 kg ha^{-1} in 1989-90 (C.V. = 17%), and 355 to 435 kg ha^{-1} in 1990-91 (C.V. = 23%). Low grain yields were attributed to heavy grazing and inadequate winter and spring rainfall.

Spring applied POST treatments. Red horned poppy control could not be pooled across experiments. Control was very variable and no treatment consistently controlled red horned poppy. CGA-131036 and chlorsulfuron controlled red horned poppy <60% (Table 4). In two of four experiments 2,4-D LVE at 560 g ha^{-1} controlled red horned poppy better than 2,4-D amine at the same rate. Adding picloram or chlorsulfuron to 2,4-D LVE did not improve control.

Dicamba at 140 g ai ha^{-1} controlled ≤ 20%. Bromoxynil and MCPA LVE were much less effective when applied in the spring than in the fall.

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Table 1. Treatment dates, rainfall data, crop and weed growth stage at time of herbicide application, weed density, and soil description for the 14 red horned poppy control experiments.

	Treatment	Treatment to	Wheat	Red horned poppy		Soil		
Experiment	date	rainfall	tillers	Density	Diameter	Texture	pH	OM
		— d —		plants m^{-2}	— cm —			— % —
1	Sep 20, 89	40	0[a]	0[a]	0[a]	L	7.9	1.3
2	Sep 20, 89	16	0[a]	0[a]	0[a]	CL	7.7	2.3
3	Sep 21, 89	15	0[a]	0[a]	0[a]	L	7.9	1.3
4	Sep 24, 90	6	0[a]	0[a]	0[a]	L	7.6	1.2
5	Sep 25, 90	5	0[a]	0[a]	0[a]	L	7.9	1.3
6	Nov 09, 89	28	3 to 4	40	2 to 5	L	7.9	1.3
7	Nov 09, 89	69	3 to 4	1	2 to 8	L	8.0	1.2
8	Nov 14, 90	32	2 to 4	50	4 to 15	SiL	7.0	1.3
9	Nov 15, 90	47	2 to 4	160	2 to 10	L	8.0	1.3
10	Nov 14, 90	30	2 to 5	40	2 to 10	L	8.0	1.4
11	Mar 17, 89	10	7 to 8	10	4 to 5	SL	7.8	1.5
12	Mar 17, 89	10	7 to 8	50	1 to 2	SCL	7.7	1.1
13	Mar 09, 91	8	5 to 12	160	3 to 12	L	7.8	2.0
14	Mar 09, 91	8	2 to 7	50	1 to 3	CL	7.9	1.5

[a]Treatments applied PPI and PRE.

Table 2. Red horned poppy control and wheat injury with herbicides applied PPI and PRE at five sites.

Treatment	Application timing	Rate	Red horned poppy control			Wheat injury		
			Experiments[a]					
			1	2,3	4,5	1,2,3	4	5
		$g\ ha^{-1}$	%					
Trifluralin	PPI	560	20	79	87	11	0	13
Trifluralin	PPI	1120	5	69	83	22	5	23
Chlorsulfuron	PRE	8	5	96	98	4	0	3
Chlorsulfuron	PRE	18	56	97	100	4	5	0
Chlorsulfuron	PRE	26	60	93	100	8	0	0
Chlorsulfuron + metsulfuron	PRE	7.4 + 1.5	75	98	99	0	0	0
Chlorsulfuron + metsulfuron	PRE	14.8 + 3.0	74	100	100	4	3	0
Chlorsulfuron + metsulfuron	PRE	22.2 + 4.4	89	90	100	4	3	0
Check			0	0	0	0	0	0
LSD (0.05)			28	19	7	7	NSD	5

[a]Columns designated with more than one experiment number are pooled across the indicated locations.

Table 3. Red horned poppy control with herbicides applied in mid-November at five sites.

Treatment	Rate	Experiment[a] 6,7	8,10	9
	g ha^{-1}	%		
CGA-131036	20	90	99	95
CGA-131036	29	84	96	98
Chlorsulfuron	9	78	100	78
Chlorsulfuron	26	76	100	91
Metsulfuron	4	84	98	24
Chlorsulfuron + metsulfuron	14.8 + 3.0	98	100	85
Chlorsulfuron + metsulfuron	22.2 + 4.4	91	100	87
MCPA LVE	280	94	100	100
MCPA LVE	420	100	100	100
MCPA LVE	560	100	99	100
Bromoxynil + MCPA LVE	140 + 140	100	100	100
Bromoxynil + MCPA LVE	210 + 210	100	100	100
Bromoxynil + MCPA LVE	280 + 280	100	100	100
Check		0	0	0
LSD (0.05)		17	3	10

[a]Columns with more than one experiment number contain data pooled across the indicated locations.

Table 4. Red horned poppy control with herbicides applied in mid-March at four sites.

Treatment	Rate	Experiment 11	12	13	14
	g ha^{-1}	%			
CGA-131036	20	33	27	18	36
CGA-131036	29	57	32	19	24
Chlorsulfuron	9	37	13	14	13
Chlorsulfuron	18	40	7	13	38
2,4-D amine	280	0	0	10	3
2,4-D amine	560	0	23	16	3
2,4-D LVE	280	13	17	29	8
2,4-D LVE	560	87	37	75	18
2,4-D butyl ester	280	0	23	16	18
2,4-D butyl ester	560	77	0	51	25
MCPA LVE	280	63	13	35	10
MCPA LVE	560	97	60	39	10
Bromoxynil + MCPA LVE	210 + 210	100	60	13	13
Bromoxynil + MCPA LVE	280 + 280	90	86	21	18
Dicamba	140	7	12	20	18
Bromoxynil	420	-[a]	-[a]	21	28
2,4-D LVE + picloram	420 + 70	93	27	68	55
2,4-D LVE + chlorsulfuron	280 + 9	53	38	21	34
Check		0	0	0	0
LSD (0.05)		44	32	14	32

[a]Treatment not applied in 1989.

CHAPTER II

PHENOLOGY AND DISTRIBUTION OF RED HORNED POPPY (*Glaucium corniculatum*) IN OKLAHOMA

Phenology and Distribution of Red Horned Poppy (Glaucium corniculatum) in Oklahoma

Abstract. A survey conducted to determine the distribution of red horned poppy in western Oklahoma identified infestations in 14 Oklahoma and 3 Texas counties. Soil from 36 infested fields was analyzed and pH of all was 7.5 to 8.5. In phenology studies red horned poppy grew as an annual, with flower production on overwintering plants in April and mature seed in June. Plants that emerged in the fall survived -25 C. Germination period was extended, thus a variety of growth stages can be found simultaneously in infested fields. Plants that emerged in April flowered in June. Corolla color varied with time of anthesis.

Nomenclature: Red horned poppy, Glaucium corniculatum (L.) Rudolph.

Additional Index Words: Phenology, distribution, germination, emergence, flowering.

INTRODUCTION

Red horned poppy was classified as an economically important foreign weed and a potential weed problem in the United States in 1977 (10). At that time its presence in the United States was not documented. Red horned poppy occurs in the Mediterranean region, Middle East, northern Africa, Iberian Peninsula, British Isles, Russia, and Europe (2, 4, 10). The first record of red horned poppy in the United States was from Clark County, Kansas in 1979 (3).

Red horned poppy infests waste areas, rotational and perennial crops, and ports (3, 4, 10). Other common names include horned poppy, black-spot hornpoppy, and seapoppy (4). It is of concern to agriculture because it interferes with crop production and contains at least 13 alkaloids (Table 1) (5, 6, 12, 13).

The plant is described as an annual or rarely a biennial. Its leaves are villous, pinnatifid, dentate, rosulate at first, and often withered by flowering. Stems ascend erect up to 40 cm. Flowers are solitary, and reportedly yellow, orange, or red. The fruit is an elongated two-celled capsule, up to 20 cm long. The seeds are 1.2 to 1.5 mm long, semi-orbicular to globose (2, 3, 4, 10).

The plant was first brought to the attention of Oklahoma State University weed scientists in June, 1987. Dr. James K. McPherson, Oklahoma State University Botany Department, identified the samples received from west-central Oklahoma as red horned poppy. Farmers were complaining that this weed was seriously hindering direct combine harvesting of their wheat (Triticum aestivum L.) because the weed was so "tough" that it choked up their grain combines.

There was no prior record of red horned poppy in Oklahoma. A closely related species, yellow horned poppy (Glaucium flavum Crantz.) has been reported in the United States, and from two locations in southwestern Oklahoma (1, 9).

The objectives of this research were to survey the distribution of red horned poppy in western Oklahoma and to define its growth habit and reproductive characteristics.

MATERIAL AND METHODS

Survey. A survey was conducted from March to August 1989, in western Oklahoma by placing 56 by 72 cm posters in 55 grain buying facilities and 13 county Cooperative Extension Service offices. The colorful 56 by 72 cm posters contained four 10 by 15 cm color photos of the plant illustrating juvenile plants, fruit, and the variations in flower color (red versus yellow).

Simple forms were provided in an envelope attached to the posters so farmers could voluntarily indicate that they had infested fields, the location of these fields, and whether they would like to have assistance in controlling the weed. Soil samples were collected from 36 fields with confirmed infestations in Beckham, Custer, Harmon, and Roger Mills counties to determine whether soil pH, N, P, or K levels, texture, or organic matter content, were factors in the presence of the weed as a problem.

Phenology. Two fields near Hammon, Oklahoma, were tilled on September 20, 1989 and received rainfall on October 6, after which red horned poppy seedlings emerged. Eight plants 2 to 5 cm in radius were transplanted from the sites to a field near Stillwater on November 10. The next year two fields in the same vicinity were tilled on September 11, and rain fell the same day. Eight plants, 4 to 6 cm in radius were transplanted from these fields to Stillwater on December 5. Plants were dug with a shovel using care to minimize damage to the upper 28 cm of roots. Each plant and attached soil was placed in a plastic container and the soil was watered prior to transport. The bottoms were removed from the 9 cm diameter containers and they were buried flush with the ground in a tilled field, with one m between containers. Other weeds were removed from the area occasionally as they appeared.

The transplants received 2.5 cm of water by sprinkler irrigation weekly during the first month after transplanting. Soils at the site of origin were silt loam and loam soils with pH of 7.0 to 8.0. Soil at Stillwater was a loam with ph 6.2. Plant radius, bolting, stem production, height, flowering, and pod and seed production were monitored weekly until the first week in August of both years. Regression analysis was utilized to examine the influence of cumulative growing degree days on growth in the spring.

Fruit was clipped from all plants weekly as the fruit began to mature, as indicated by browning of the tip of each capsule. Seeds in that fruit were threshed by hand and with a belt thresher. Total weekly seed production was calculated by weight, based on the weight of 1000 seeds per plant, of the seed collected each week.

Plant radius and growth stage in winter wheat were determined by measuring plants at four sites on April 12 and 13, 1991, in Custer or Roger Mills counties. The sites had been cleaned tilled and seeded with wheat on September 11, 12, 15, and 30, 1990, for use in herbicide evaluation experiments.

A tape was placed lengthwise down the middle of each check plot in these replicated experiments (4 replicates at 3 sites and 3 at the site seeded on September 11). Plant radius and growth stage of the first 25 plants within 0.5 m of the tape in each plot were recorded. Plant radius was determined from the center to the end of the longest leaf. Plant growth stage was classified as rosette, plants with flower buds and no flowers, plants in anthesis, or plants producing fruit. Percent of plants in each classification was determined.

To examine the emergence of red horned poppy over time, seed separated from wheat harvested at experimental sites in western Oklahoma in June, 1990, was seeded in pots near Stillwater on November 21, 1990. The seed had been stored in a dark cabinet at room temperature between June and November. The four 25 cm diam, 19 cm tall pots were buried in an open field with 5 cm of the rim protruding. Red horned poppy seed (15,000 per pot) was blended into the top 5 cm of soil in each pot. The soil in the pots was a loam, with a pH of 7.6, and an organic matter content of 1.2%, collected from a red horned poppy infested wheat field near Cheyenne, Oklahoma. The soil contained 21, 29 and 368 ppm of nitrate nitrogen, and Melich III extractable P, and K, respectively.

Seedling emergence was recorded and emerged seedlings removed weekly through July 31, 1991. The soil was not disturbed through this period, except that eight of these seedlings were transplanted on April 24, 1991, 2 weeks after they emerged, into 8 cm diam by 10 cm tall plastic cups filled with the soil from near Cheyenne. After watering, the cups bottoms were removed and the cups buried flush with ground at the site in Stillwater. The plants were monitored weekly until senescence to determine time of bolting, anthesis, and fruit production of plants that emerged in the spring rather than in the fall.

RESULTS AND DISCUSSION

Survey. The survey identified infestations in 14 Oklahoma and 3 Texas counties (data not shown). The highest number of reports were from Beckham, Custer, Roger Mills, and Washita Counties, in west central Oklahoma, where 84 farmers reported infested fields. One to five infested fields per county were reported from Alfalfa, Blaine, Cotton, Dewey, Garfield, Harmon, Jackson, Major, Tillman, and Woodward Counties, Oklahoma. Childress, Hardeman, and Hemphill Counties, Texas along the western Oklahoma border, also had infestations.

Red horned poppy plants were found in alfalfa (Medicago sativa L.), in wheat, in fields recently seeded with perennial forage species as part of the Conservation Reserve Program, along roadsides, and near grain handling operations. Infestations often exceeded 40 plants m^{-2}. Variation in plant size and maturity was often seen, indicating an extended period of emergence.

Soil pH from the 36 sampled red horned poppy infested fields varied only from pH 7.5 to 8.5 (Table 2). While soils with pH > 7.3 are common in wheat fields in the four counties sampled, the soil pH in most of the wheat fields in these counties is < 7.3 (8).

Phenology. Three of the plants transplanted from western Oklahoma were lost to very high wind in the spring of 1990; therefore data reported for 1989-90 are from the remaining five. Red horned poppy plants grew very little from January 1 to March 1 either year (Figure 1). Plant radius increased rapidly after March 9, 1990 and March 20, 1991. The plant radius increase was highly correlated with cumulative growing degree days from March 2 to May 25, 1990, ($r = 0.99$), and March 6 to June 12, 1991 ($r = 0.97$). Plant radius and height stopped increasing after May 25, 1990, and June 12, 1991. The plant radius exhibited the typical s-shaped growth pattern of an annual (11).

All plants began bolting between April 6 and 13, 1990. Each stem had a single axillary flower bud that developed as the stem elongated and opened within a week after bolting began. One of eight plants bolted by April 10, 1991, and all plants had stems by April 24 (Figure 2). Anthesis began one to two weeks after bolting in 1991. The plant produced multiple main stems for 6 weeks in 1990 and 4 weeks in 1991. Branching of the main stems continued for several weeks, with a single axillary flower on each branch.

Maximum plant radius each year was 68 to 75 cm and height was 60 to 65 cm (Figure 1 and 2). Each year 8 or 9 stems bolted from each rosette and produced flowers (Figure 2). The plants senesed in early August each year.

The first flowers produced both years had red petals, (1.6 cm long and 1.6 cm wide), with a black spot, (0.7 cm long and 0.3 cm wide), at the base of the petal surrounded by a white ring (0.1 cm wide). All petals were red until May 18, 1990, and May 15, 1991, after which all new flowers on all plants had yellow petals with a black spot surrounded by a red ring or a red spot at the base. No plant had both colors of flowers simultaneously. Petals often dropped within one day.

Each year the change in flower color was noted a few days after the daily high temperature exceeded 30 C for 2 days (Figure 3). However, brief warm days in April each year, with maximum temperatures of 30 C in 1990 and 29 C in

1991 did not cause the color to change.

Capsules began dehiscing seed by June 15, 1990, and June 5, 1991. Capsules dehisced from the tip to base in all cases, in contrast to the description in Flora of the Great Plains (3).

Variation in plant radius and growth stage was present at all four experimental sites in April, 1991 (Figure 4 and Table 4). The extensive size variation was indicative of an extended period of germination. Red horned poppy growth was more vigorous in the site planted Sep 30, 1989. The soil at this site was a flood plain soil with a higher USDA-SCS predicted average wheat yield (2000 kg ha^{-1}) than the soils at the other sites (7). Predicted average wheat yields at the sites seeded on Sep 11 and Sep 15 were 1340 and 1010 kg ha^{-1}. The fourth field was classified as unsuitable for cultivation. This indicates that red horned poppy responds to favorable conditions by producing much more vigorous plants.

In mid-April, 20 to 58%, depending on location, of the red horned poppies were still in the rosette stage (Table 4). Floral buds were present on some plants at all sites and anthesis had begun on some plants at three sites. Thus, the development of the more mature plants present in the field was similar to the transplanted plants grown in Stillwater.

Emergence monitoring revealed that some red horned poppy seedlings emerged every month from November to July, except

December, January, and July. In all cases, when flushes of 20 or more seedlings per pot emerged, 2.5 cm or more of rain had fallen during the previous week (Figure 5). However, there was not a correlation between rainfall amounts either the week of or the week prior to emergence and the number of emerged seedlings ($r \leq 0.41$).

Peak spring emergence occurred in April and May. Of the 15,000 seeds planted in each pot, total emergence from Nov. 21 to July 31 was 215 ± 18 (mean ± standard error) seedlings per pot.

The red horned poppies transplanted from the spring emergence monitoring pots grew as rosettes from emergence (April 10) until June 5. Six of the plants bolted between June 5 and 12 and anthesis began one week later. Two of the eight plants were different. One remained in the rosette stage until senescence in August. The other did not bolt until July 17, began anthesis one week later, and senesed in August.

The flower petals on all seven plants that bloomed were yellow with a red spot at the base. At no time did these plants have red flower petals. The first mature capsules, (determined by browning of the tips of the capsules), were present by July 17. Fruit development continued until senescence by August 7.

Red horned poppy is well established and widespread across western Oklahoma and parts of the Texas Panhandle. It grows as an annual, with an extended period of emergence. Plants that emerged in the fall were winter hardy, but overwintering in a rosette stage was not required for anthesis. They are prolific seed producers producing mature seeds by mid-June which occurs during Oklahoma wheat harvest.

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Table 1. Alkaloids reported from red horned poppy.

Alkaloid	Reference
Allocryptopine	12, 13
Berberine	12
(-)ß-canadine methohydroxide	13
(-)ß-strylopine methohydroxide	13
Chelerythrine	5, 12
Chelidonine	5, 12
Chelirubine	12
Coptisine	5, 12
Corydine	12, 13
Heliotrine	13
Isocorydine	12
Protopine	6, 12, 13
Sanguinarine	5, 12, 13

Table 2. Soil pH in red horned poppy infested fields, and soil pH values for wheat fields in four Oklahoma counties.

County	Infested sites sampled	pH of infested soils			Routine nutrient analyses[a]	pH distribution of wheat soil samples analyzed[a]			
		Low	High	Mean		5 to 5.9	6 to 6.4	6.5 to 7.3	>7.3
					no.	(%)			
Custer	12	7.5	8.3	8.0	906	21	13	25	41
Harmon	4	7.8	8.2	8.0	73	22	5	32	41
Roger Mills	15	7.4	8.5	8.0	294	27	13	16	45
Washita	5	7.7	8.3	8.1	1073	20	14	31	36

[a]All samples submitted by wheat producers in 1985 for routine soil analysis by the Oklahoma State University Soil, Water, and Forage Analytical Laboratory (8).

Table 3. Mean weekly red horned poppy fruit and seed production for 1990 and 1991.

Year	Week ending	Maturing fruits harvested[a]	Seeds harvested[a]
		no. per plant	no. per plant
1990	June 8	0	0
	June 15	110 ± 29	25,200 ± 3,300
	June 22	143 ± 63	33,100 ± 14,500
	June 29	74 ± 31	10,600 ± 4,400
	July 9	36 ± 24	2,600 ± 1,900
	July 20	32 ± 19	550 ± 330
	July 27	1 ± 1	26 ± 26
	Aug 3	0	0
1991	May 29	0	0
	June 5	13 ± 5	5,600 ± 2,300
	June 12	54 ± 15	13,500 ± 3,600
	June 19	55 ± 11	14,200 ± 2,100
	June 26	204 ± 11	37,300 ± 3,100
	July 3	228 ± 10	26,400 ± 2,100
	July 10	262 ± 17	16,200 ± 1,900
	July 17	92 ± 18	3,500 ± 1,000
	July 24	78 ± 20	1,300 ± 500
	July 31	32 ± 13	300 ± 100
	Aug 7	0	0

[a]Means for five plants in 1990 and eight plants in 1991 ± the standard error.

Table 4. Growth stages of red horned poppy on April 12 and 13, 1991, in check plots of replicated studies at four sites in western Oklahoma[a].

Wheat seeding date	Rosette	Floral buds	Anthesis	Seed capsules present
	%			
Sep 11	28 ± 4	71 ± 3	1 ± 1	0
Sep 12	58 ± 7	42 ± 7	0	0
Sep 15	20 ± 9	48 ± 8	15 ± 8	17 ± 7
Sep 30	41 ± 11	57 ± 10	2 ± 1	0

[a]Means of three or four replications ± their standard errors.

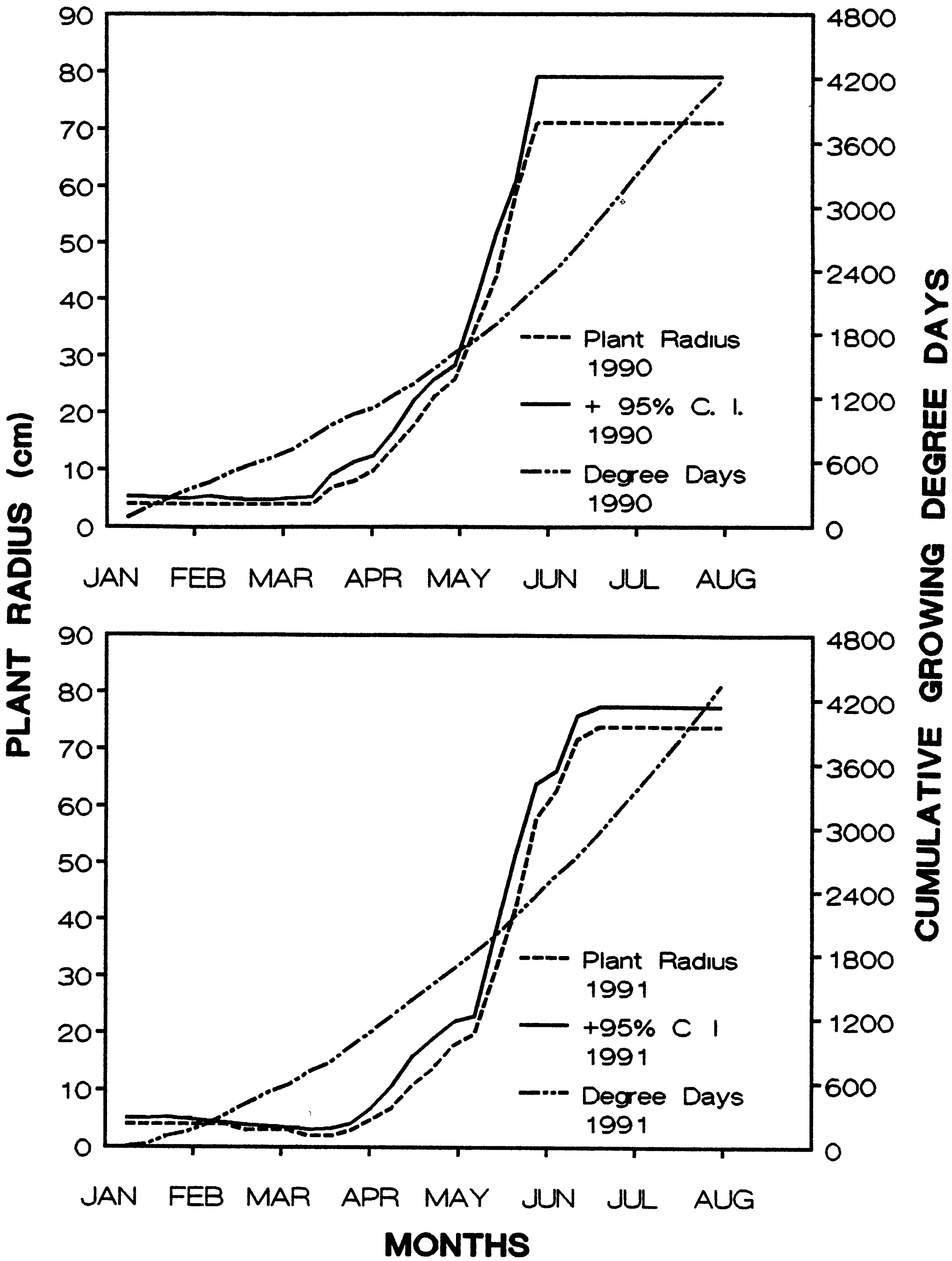

Figure 1. Red horned poppy plant radius measured weekly after Jan 1, 1990, and 1991, + 95% confidence intervals of the plant radius, and cumulative growing degree days after Jan 1, each year (3 C base).

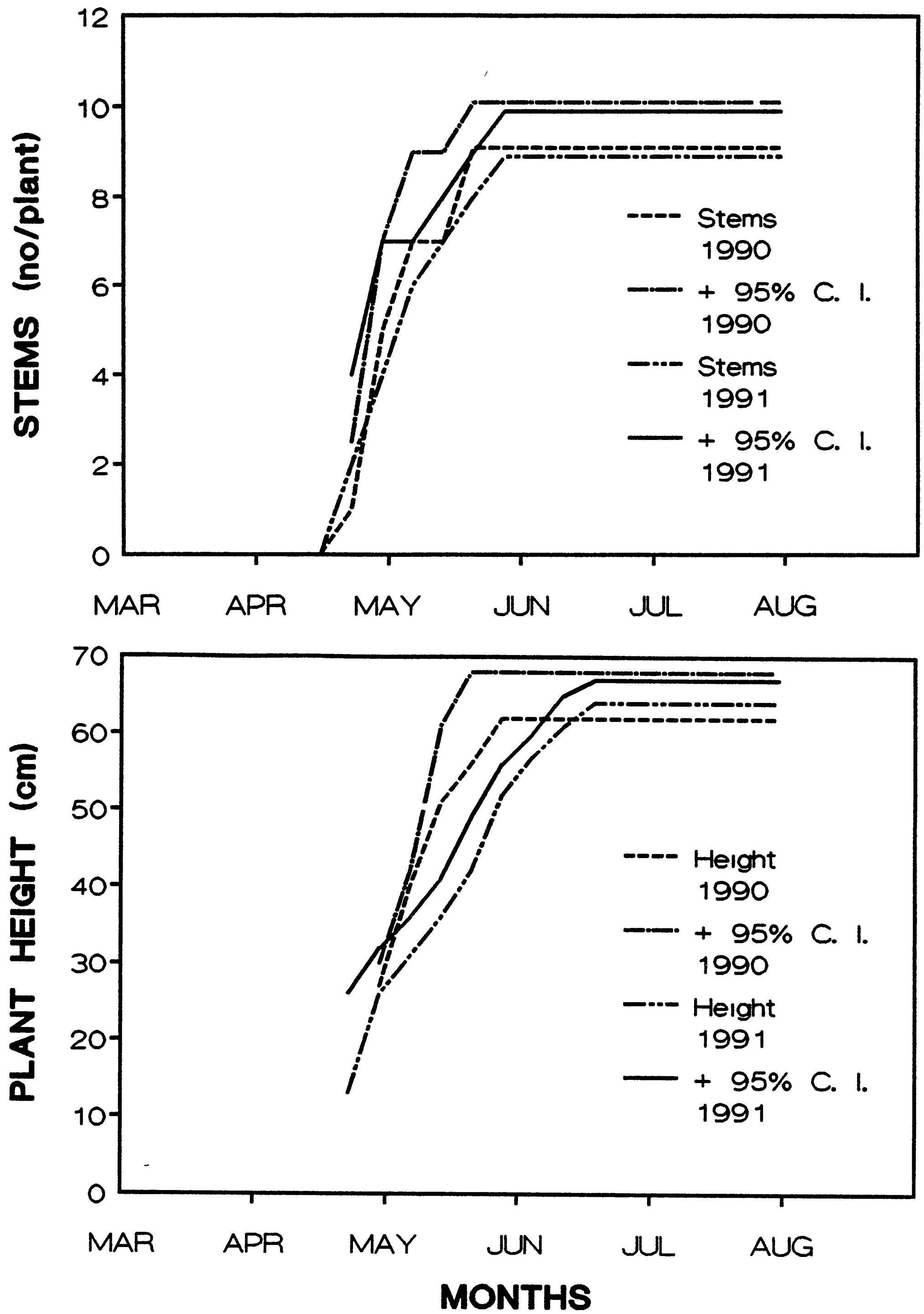

Figure 2. Red horned poppy stem production and plant height measured weekly after Mar 1, 1990, and 1991, and + 95% confidence intervals for each.

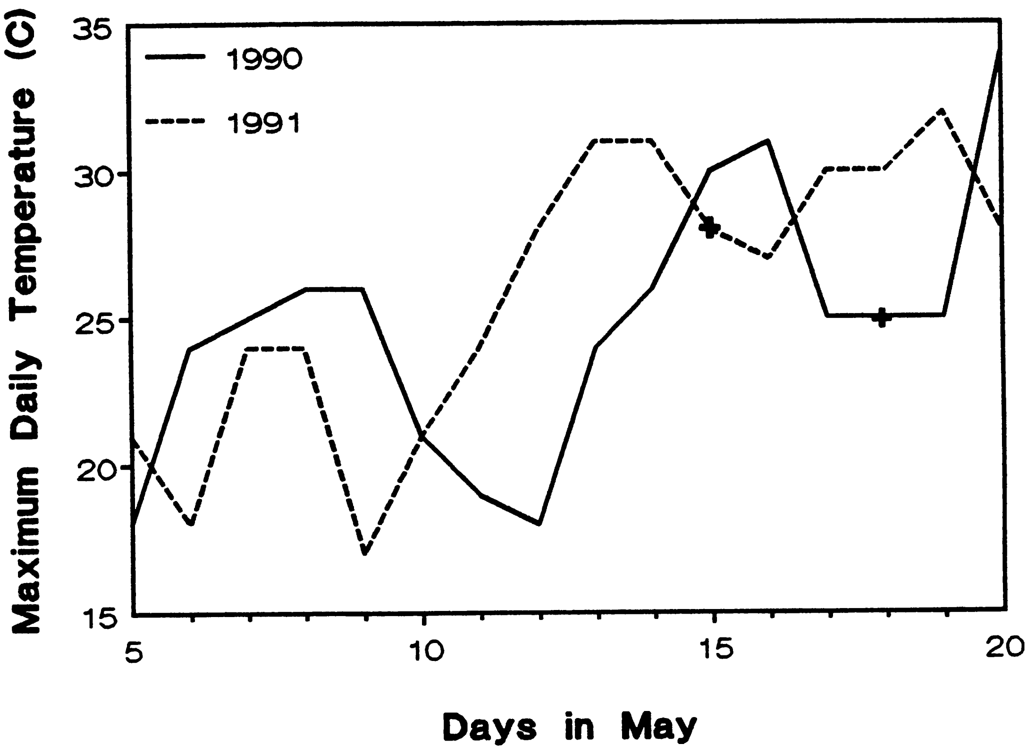

Figure 3. Maximum daily temperature from May 5 to May 20, 1990, and 1991, and the date flower petal color change was observed (+).

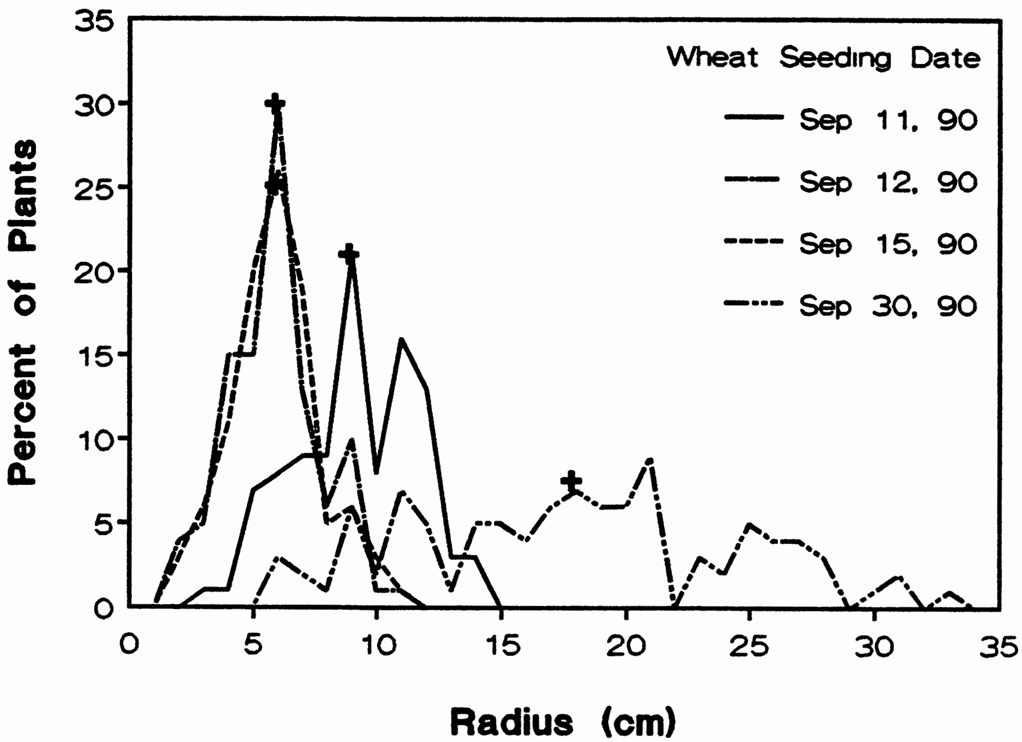

Figure 4. Red horned poppy size at four sites on April 12-13, 1991, (95% confidence intervals = ± 1.0 - Sep 11, ± 0.7 - Sep 12, ± 0.7 - Sep 15, and ± 2.3 - Sep 30), and mean (+) for each site.

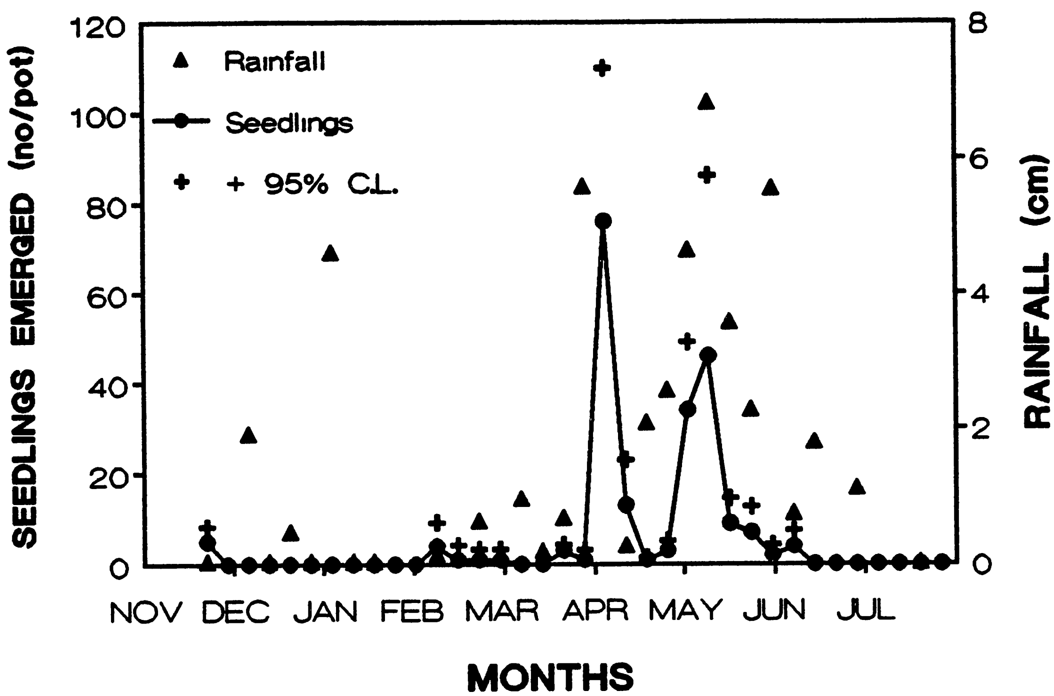

Figure 5. Red horned poppy germination from November 21, 1990, to July 31, 1991, + 95% confidence intervals, and rainfall events during that period.

VITA

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