GROWTH AND DEVELOPMENT OF SIX

SELECTIONS OF COMMON COCKLEBUR

(<u>XANTHIUM</u> <u>STRUMARIUM</u> L.)
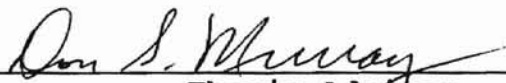

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(XANTHIUM STRUMARIUM L.)

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ACKNOWLEDGEMENTS

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GROWTH AND DEVELOPMENT OF SIX
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GROWTH AND DEVELOPMENT OF SIX SELECTIONS OF COMMON COCKLEBUR (XANTHIUM STRUMARIUM L.)

Abstract. Field experiments were conducted in 1993 and 1994 to examine the growth and development of six common cocklebur [Xanthium strumarium L.] selections collected from agricultural systems. A common garden grown under non-competitive conditions was established with these selections: TX1 and TX2 from College Station TX; AR1 from Little Rock, AR; AR2 from Mississippi County, AR; KY from Lexington, KY; and OK from Chickasha, OK. Plant height and width were measured and the nodes/main axis were counted weekly. Midseason and season-ending biomass harvests were performed, and date of floral initiation was noted. Root tip cells from each selection were examined to determine chromosome number. In both years, significant differences in growth and development of the common cocklebur selections were found. In the 1993 season, the TX1 and OK selections were typically the tallest, widest, and produced the most biomass. In the 1994 season, the OK selection was typically the tallest, widest, and produced the most biomass. In both years the TX2 and KY selections were the smallest in most measurements, and the two Arkansas selections were intermediate in most measurements both years. The OK and KY selections typically produced the most pistillate heads in both years, while the TX2 selection produced the fewest

heads. In both years, the TX1 heads were among the largest, along with the OK selection in 1993, and the TX2 selection in 1994. The floral initiation corresponded to latitude of origin, with the most northern selection, KY initiating flowering the earliest, and the most southern selections, TX1 and TX2, initiating flowering the latest. No difference in chromosome number was found. Results indicate differences in many facets of growth and development of these common cocklebur selections when grown under Oklahoma conditions. These results indicate that ecotypes of common cocklebur are present. These ecotypic differences could have important implications for weed control, and soil seed bank dynamics could also be affected by the varied head production of the different selections.

Nomenclature: Common cocklebur, Xanthium strumarium L. #[1] XANST.

Additional index words. Biology, common garden, ecotype, Oklahoma, phenology.

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 1508 W. University, Champaign, IL 61821-3133

INTRODUCTION

Competition between common cocklebur and field crops such as cotton (Gossypium hirsutum L.) and soybeans [Glycine max (L.) Merr.] have been investigated (1, 3, 4). It is one of the most troublesome weeds in the cotton producing regions of the southern U.S. (5). In a three-year study conducted from 1979 through 1981, Snipes et al. (20) found cotton yield losses ranged from 17 to 70% at densities of 2 to 32 common cocklebur plants/15 m of row. In a study conducted in Oklahoma[2], yield losses also were accompanied by harvest difficulties caused by common cocklebur plants, even at densities as low as 2 plants/10 m of row. Furthermore, the harvested cotton was heavily contaminated with pistillate heads of common cocklebur, commonly known as burs, which are referred to as heads in this paper.

Common cocklebur has also been the subject of intense botanical scrutiny over the past 75 yrs (6, 7, 11, 16, 22, 25). Studies examining differences in plants growing in different environmental conditions have been conducted. Kaul (10) studied differences in the "monsoon" and "summer" selections of common cocklebur occurring in India and found considerable differences in many traits, although these differences became less distinct when they were grown under

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[2]A.C. Bennett, unpublished research. Oklahoma State University, Stillwater, OK 74078.

similar conditions. Blais and Lechowicz (2) analyzed variation in traits related to reproductive success in common cocklebur selections from natural and ruderal habitats. They found few differences in plants from the different habitats, but noted considerable phenotypic plasticity in growth and development based on resource availability. Studying photoperiodic adaptation to latitude, Ray and Alexander (17) reported that the night length required was shorter in plants from northern latitudes than those from the southern latitudes.

Variation in morphology, and its relation to taxonomic classification have also been studied (12, 18, 23). In 1915, Shull (19), observed that there were several distinct phenotypes of common cocklebur in Kansas. He found that when grown in a common garden, they remained genotypically homogeneous and constant. He concluded this was due to the inability of the phenotypes to cross pollinate because of different flowering times.

As many as 50 specific epithets have been used for what is now considered a single species that exhibits a large amount of morphological variation (12). Twenty different species names were used regularly for common cocklebur as late as the 1950's. Love and Dansereau (12) hypothesized that the different phenotypes should be grouped into six complexes within a single species, Xanthium strumarium L. These complexes, although still containing variability, were

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relatively uniform and easily identifiable. They attributed the variability to long-term inbreeding within complexes, accompanied by occasional outcrossing among populations of different complexes existing in close proximity to each other. The outcross progeny are stabilized after several generations of inbreeding, thus producing a localized pattern of variation different from the parents.

Botanists also have examined the genetic variation and mode of pollination in common cocklebur. Moran and Marshall (15) reported that although common cocklebur is monoecious, it is highly self pollinated, exhibiting little allozyme variation within population. This phenomenon produces homogeneous populations, even when they grow in close proximity to one another. Moran and Marshall (15) also noted there were large amounts of allozyme variation among the different populations studied, suggesting significant genetic variability. They concluded that the variation in success of common cocklebur selections in Australia was due to the large genetic differences present among populations. Hicks (8) indicated that apomixis could not be used to explain the homogeneity of common cocklebur selections. Weaver and Lechowicz (24) reported that all plants exhibited no sterility barriers, and that all were tetraploids, 2n=36.

Studies examining the existence of ecotypes of several plant species based on geographic origin have been performed. McMillan (13) demonstrated that when several

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prairie grass species from varied geographic locations were grown in a common garden, they demonstrated traits which adapted them to their region of origin such as bloom timing, height, and growth response to temperature. Solbrig (21) showed that in populations of snakeweed [Gutierrezia sarothrae (Pursh) Britton & Rusby], when other factors were held equal, northern plants were taller than southern plants, eastern plants were smaller than western plants, and plants from lower altitudes were shorter than those from higher altitudes at the same latitude.

These studies suggest that differences in the phenology of plants from different locations may be present. However, there are no published reports comparing the phenology of common cocklebur selections from agricultural systems to find if these phenological differences could have an effect on the agronomic characteristics of the weedy species common cocklebur. Therefore, the objective of this research was to observe and measure growth and development of common cocklebur selections collected from natural populations in agricultural systems and grown without competition.

MATERIALS AND METHODS

Field experiments were conducted in 1993 and 1994 at the Agronomy Research Station near Stillwater, OK (36 N, 97 W) on a Kirkland clay loam (fine, mixed, thermic, Udertic Paleustolls) with 1.9% organic matter, 34% sand, 36% silt, 30% clay, and a pH of 6.8.

Heads of common cocklebur were obtained from Lexington, KY (38 N, 84 W), Little Rock, AR (34 N, 92 W), Mississippi County, AR (35 N, 90 W), Chickasha, OK (35 N, 98 W), and College Station, TX (30 N, 96 W). One sample was collected from each location except College Station, TX, where two samples were collected. At this location, the collecting scientist observed two distinct phenotypes, a large, robust type, and a much smaller type. The heads were taken from several morphologically similar plants in each area.

Fifteen replications of each selection[3] were planted in a completely randomized design. Seeds were pregerminated to improve emergence in the field, and to provide root tips for chromosome counts. Treatment to induce germination consisted of soaking the heads in distilled water for 24 hours, followed by a 24 hour period at 1 C. The heads were then half-buried in a sand medium, and placed in a

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[3]Non-specific term to refer to each collection of common cocklebur heads used.

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germinator at 30 C until the radicle emerged from the head.

Six pregerminated heads were planted in each replication, and thinned to one plant/replication 2 wks after emergence. Plants in some replications did not emerge; however, there were at least 10 replications of each selection after thinning. Planting dates were June 16, 1993 and May 20, 1994. Plants were spaced 3 m apart, both within and between rows, to minimize competition. Each year the experimental area was fertilized with 44 kg/ha actual N, irrigation was provided throughout the season as needed to prevent water stress, and weeds were controlled throughout the season using hand hoeing and mechanical cultivation. Degree days (14) accumulated were calculated for the data presented using raw average daily temperature with 60 degrees F, or DD60, as a base.

Periodic measurements. From the 10 to 15 replicate plants, height to the highest point, width at the widest location, and the number of nodes/primary axis were recorded weekly throughout the growing season.

Midseason biomass. A harvest of midseason biomass was completed 73 days after planting in 1993, and 105 days after planting in 1994. A minimum of three replications from each selection was harvested each year. Plants were cut at ground level; separated by hand into leaves, stems, and heads; air dried for 21 days; and weighed.

Season-ending biomass. The remaining replications were

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harvested after senescence. The first season, each replication was separated into stems and heads by hand. A peanut thresher[4] was used to mechanically separate the stems and heads the second season. Leaves were not included because the harvest occurred after senescence. The parts were air dried for 21 days, then weighed to find stem and head biomass, which was combined to obtain total biomass.

The number of heads present per replication was determined by taking approximately a 1 kg sample from each replication in the season-ending biomass, determining the average weight/head, and extrapolating.

Floral initiation. All selections were examined on a weekly basis for initiation of heads. The date of initiation was noted for each replication, and a average date of floral initiation for each selection calculated.

Complex identification. Using the six-complex classification of Love and Dansereau (12) each selection was identified. The classification system is based on the morphology of the pistillate heads.

Chromosome analysis. Root tips were collected from pregerminated heads of each selection, fixed using Carnoy's solution (9), and chromosomal squashes made using a modified

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[4]Seedburo Peanut Thresher. Seedburo Equipment Co., Chicago, IL 60606.

Rayburn Technique[5]. Prepared squashes were then examined

using a phase-contrast microscope[6], and chromosomes counted.

Statistical analysis. All data were analyzed using SAS[7]

PROC ANOVA. The Least Significant Difference (LSD) was then

used as a mean separation test at a (P>0.05) significance

level. Because the number of replications present in most

case were unequal, the sample sizes from individual

selections were used to create a separate LSD for each

comparison between each pair of selections.

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[5]Tyrl, R. J. 1995 Personal Communication. Department of
Botany, Oklahoma State University, Stillwater, OK 74078.

[6]Olympus Model Vanox-T Phase Microscope, Olympus Optical
Co., LTD., Japan.

[7]SAS, Version 6.0, SAS Institute Inc., Box 8000, Cary,
NC 27511.

RESULTS AND DISCUSSION

Periodic measurements. Two dates of measurement, 66 days after planting and 106 days after planting were selected as representative dates for presentation of data.

1993. The TX1 selection was the tallest, and the TX1 and OK selections were the widest, while the TX2 and KY selections were typically the shortest and most narrow (Table 1). There was no difference in the number of nodes/main axis. At 66 days after planting, 1446 degree days had accumulated, and at 106 days after planting, 1977 degree days had accumulated.

1994. The OK selection was taller and wider than the other selections in most cases, while the TX2 and KY selections were the shortest and most narrow (Table 1). There was no difference in the number of nodes/main axis. At 66 days after planting, 1278 degree days had accumulated, and at 106 days after planting, 2011 degree days had accumulated.

Midseason biomass. 1993. No differences were found in stem and leaf weight (Table 2). The KY selection had a larger head weight than all selections except AR1, and the TX2 selection had a smaller head weight than all selections except TX1 and AR2. There was no difference in total weight. At the time of the midseason biomass, 1616 degree days accumulated.

1994. The OK selection had a greater stem weight than all selections except AR2, and the largest head weight (Table

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2). The AR2 and TX2 selections had a smaller head weight than the OK and KY selections. The OK selection had the greatest total weight. At the time of the midseason biomass, 1999 degree days had accumulated.

Season-ending biomass. 1993. The OK and AR1 selections had the most heads/plant, while the TX2 selections had the fewest (Table 3). The TX1 selection had the largest stem weight and total weight. The TX1 and OK selections produced the largest head weight. The heads of the TX1 selection were larger than all selections except OK. At the time of the first killing freeze, 2069 degree days accumulated.

1994. The OK and KY selections had the most heads/plant, while the TX2 selection had the fewest (Table 3). The OK selection had the greatest stem weight, head weight, and total weight. The heads of the TX1 selection were larger than all selections except TX2. At the time of the first killing freeze, 2417 degree days accumulated.

Floral initiation. 1993. The KY selection, which originated in the most northern latitude, initiated flowering earliest (Table 4). The TX1 and TX2 selections, which were from the most southern latitude, initiated flowering latest in the growing season.

1994. The KY selection again initiated floral structures in the fewest days after planting (Table 4). The TX1 and TX2 selections required the most days after planting before floral initiation.

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Complex identification. Using the Love and Dansereau (12) classification, the KY, AR1, and AR2 selections belong to the <u>chinense</u> complex, the TX1 selection to the <u>oviforme</u> complex, and the OK and TX2 selections belong to the <u>hybrid</u> complex. The two selections in the hybrid complex can be divided into subcomplexes, with the TX2 selection belonging to <u>italicum</u> and the OK belonging to <u>pensylvanicum</u>. A representative head from each selection is shown in Figure 1.

Chromosome analysis. Plants were all 2n=36. Karyotypes of the OK and KY selections are shown (Figure 2). These selections were used for demonstration because they showed large differences in growth and development. However, all selections had the same number of chromosomes.

Differences were found in the growth and development of common cocklebur selections in both 1993 and in 1994 when grown under Oklahoma conditions. These included differences in the number and size of heads produced, midseason and season-ending plant biomass, bloom timing, height, and width.

The results show these common cocklebur selections display the characteristics of ecotypes, with adaptation to photoperiod based on the latitude of origin. Previous research by Ray and Alexander (17) showed a similar relationship between floral initiation and latitude of origin, with the plants from northern locations initiating

floral structures earlier than those from southern locations. The previous work carried out on ecotypes (13, 21) suggests that the differences found in height, width, and head production may also be ecotypic adaptations of the common cocklebur selections studied to their native environments.

The number of heads/plant found for almost all the selections in this study exceeded the 5400 head/plant level reported by Weaver and Lechowicz (24) in their review of common cocklebur. The increased head production found in this study could be attributed to ecotypes adapted to the longer growing season found in the southern U.S., as compared to Canada, where their research originated.

The differences in growth and development found in this study provide important insight into the differences between common cocklebur selections. The presence of ecotypes suggests that different agronomic practices may be required in different locations. This could be especially true if future research indicates competitive differences are also present. The large differences in head production shown in this study could also have an important implications for soil seed bank dynamics.

ACKNOWLEDGEMENTS

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Table 1. Periodic measurements from the 1993 and 1994 growing seasons.

	66 DAP[a]			106 DAP		
	Height	Width	Nodes[b]	Height	Width	Nodes
			1993			
	cm		no.	cm		no.
AR1	69 ab	140 a	17 b	110 bc	260 b	29 a
AR2	69 ab	130 a	19 ab	120 ab	250 b	27 a
OK	72 ab	150 a	20 ab	110 bc	262 ab	26 a
TX1	75 a	130 a	19 ab	140 a	300 a	30 a
TX2	61 b	150 a	20 a	100 c	220 b	29 a
KY	60 b	130 a	18 ab	100 c	210 b	30 a
			1994			
AR1	60 bc	150 b	18 a	110 b	300 b	28 a
AR2	67 b	140 bc	17 a	100 bc	290 b	27 a
OK	71 a	190 a	18 a	120 a	360 a	27 a
TX1	77 a	150 b	17 a	100 bc	320 b	29 a
TX2	52 c	150 b	16 a	110 b	260 c	27 a
KY	60 bc	130 c	16 a	90 c	290 b	28 a

[a]Days after planting.

[b]Nodes/main axis.

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Table 2. Midseason biomass harvest, 1993 and 1994.

	Stem	Heads	Leaf	Total
		1993		
		g/plant		
AR1	470 a	32 ab	500 a	1002 a
AR2	480 a	5 bc	550 a	1035 a
OK	360 a	13 b	450 a	823 a
TX1	500 a	3 bc	540 a	1043 a
TX2	340 a	2 c	420 a	762 a
KY	500 a	59 a	510 a	1069 a
		1994		
AR1	2000 b	790 bc	1670 ab	3960 b
AR2	2580 ab	430 c	1290 ab	4300 b
OK	3360 a	2210 a	1800 a	7360 a
TX1	2050 b	870 bc	1140 b	4060 b
TX2	1820 b	480 c	1150 ab	3440 b
KY	1700 b	1100 b	1030 b	3840 b

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Table 3. Season-ending biomass, 1993 and 1994.

	Stem	Head	Total	Weight/100 heads	Burs/plant
			—1993—		
		—g/plant—		g	no.
AR1	1080 b	1230 b	2310 b	260 b	9600 a
AR2	1150 b	960 bc	2110 b	250 b	6900 b
OK	1250 b	2230 a	3480 b	262 ab	10700 a
TX1	2060 a	1950 a	4010 a	300 a	6500 b
TX2	900 b	970 b	1870 b	220 b	4000 c
KY	940 b	820 c	1760 b	210 b	8600 ab
			—1994—		
AR1	1450 bc	1430 bc	2880 b	120 c	10200 b
AR2	1210 c	1590 b	2800 b	120 c	8000 bc
OK	2960 a	2620 a	5580 a	210 b	13300 a
TX1	1880 bc	1320 bc	3200 b	270 a	7400 bc
TX2	1265 c	1670 bc	2930 b	230 ab	5600 c
KY	1900 b	1100 c	3000 b	130 c	13500 a

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Table 4. Days after planting
before appearance of first
pistillate heads.

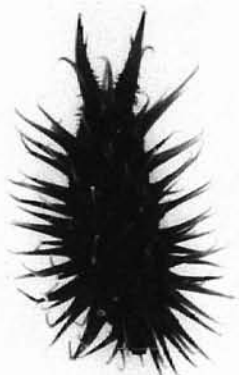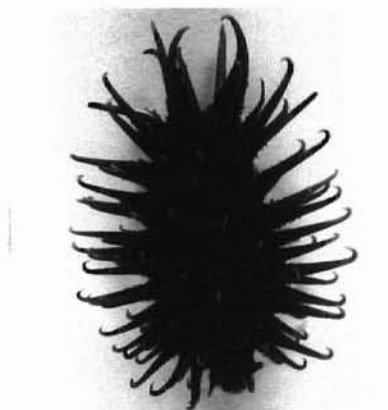|	1993	1994
	—————DAP[a]—————	
AR1	72	68
AR2	72	68
OK	72	68
TX1	79	83
TX2	79	83
KY	65	62

[a]Days after planting.

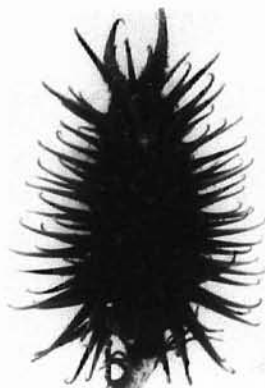LR1 (34 N, 92 W)
chinense

LR2 (35 N, 90 W)
chinense

OK   (35 N, 98 W)
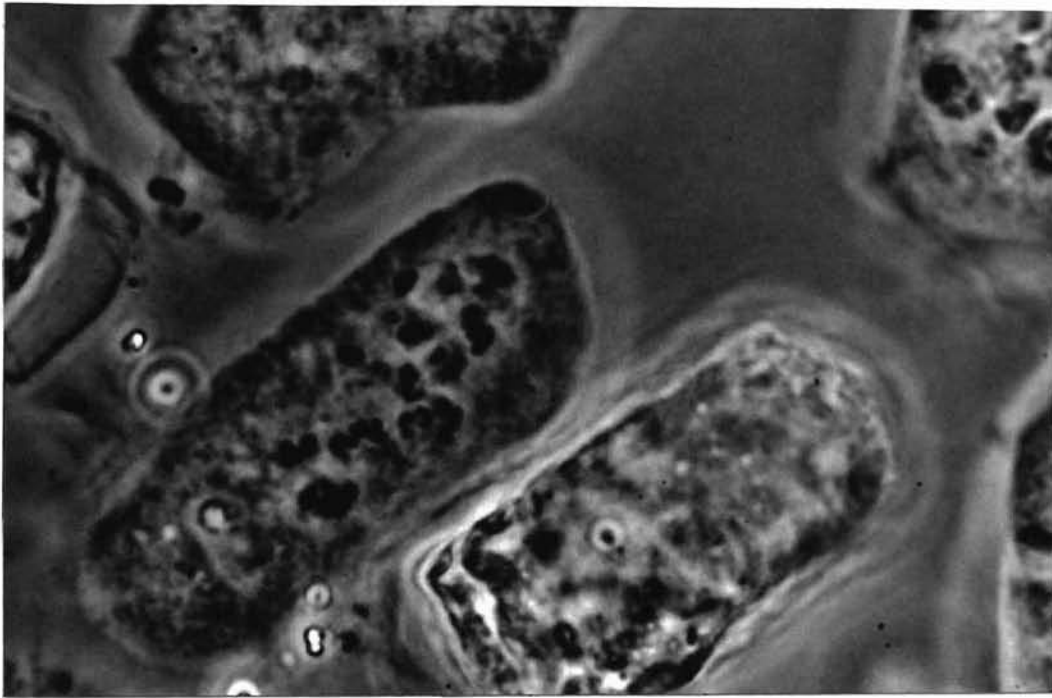pensylvanicum

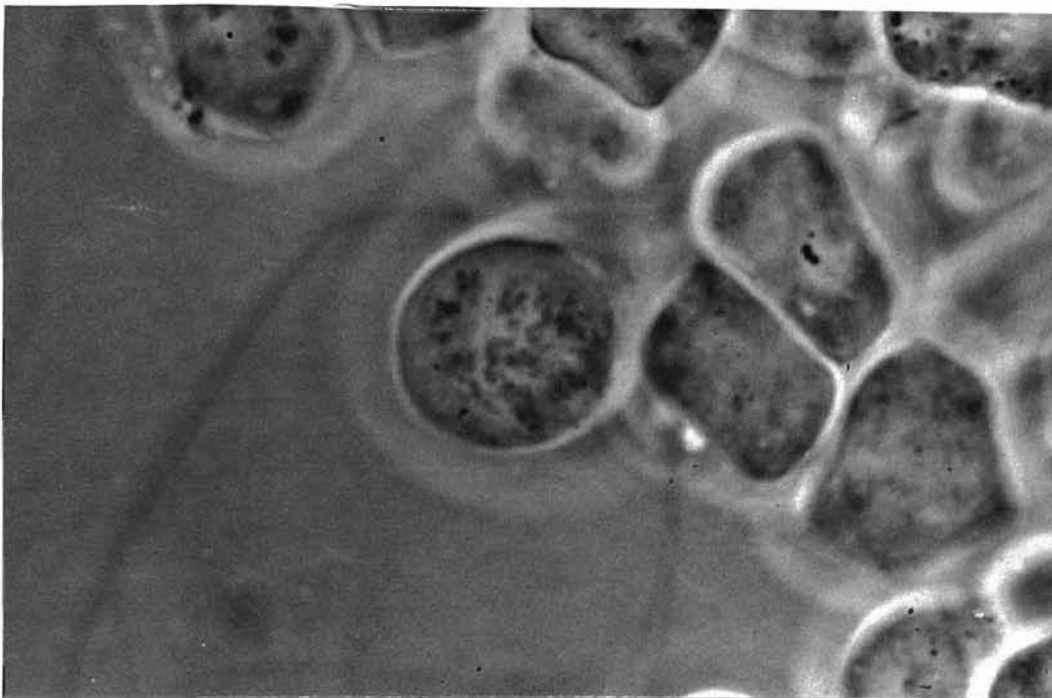TX1 (30 N, 96 W)
oviforme

TX2 (30 N, 96 W)
italicum

KY   (38 N, 84 W)
chinense

Figure 1.   Pistillate heads (burs) from each selection.

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OK

KY

Figure 2. Karyotypes of the OK and KY selections. 1000X.

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VITA

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Thesis: GROWTH AND DEVELOPMENT OF SIX SELECTIONS OF
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