VELVETLEAF (*ABUTILON THEOPHRASTI*) PHENOLOGY AND INTERFERENCE IN COTTON (*GOSSYPIUM HIRSUTUM*)

By

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VELVETLEAF (ABUTILON THEOPHRASTI) PHENOLOGY

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(GOSSYPIUM HIRSUTUM)

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INTRODUCTION

Each of the two parts of this thesis is a separate manuscript for publication in Weed Science, the journal of the Weed Science Society of America. Articles in that journal are peer reviewed and must report original experiments repeated over time and/or space.

PART I

VELVETLEAF (*ABUTILON THEOPHRASTI*) PHENOLOGY AS AFFECTED BY INTERFERENCE FROM COTTON (*GOSSYPIUM HIRSUTUM*)

Velvetleaf (*Abutilon theophrasti*) Phenology as Affected by Interference from Cotton (*Gossypium hirsutum*)

Abstract. Field experiments, with three planting dates were conducted for 2 years to document the phenological development of velvetleaf when grown with vs. without cotton. Velvetleaf plant height was reduced 0 to 5 cm by cotton at the first two planting dates and from 20 to 25 cm at the third planting date each year. Velvetleaf branches were reduced by cotton by 35 to 57%, 72 to 82%, and 73 to 90% at the three respective planting dates. Flowers were reduced by 46 to 47%, 72 to 75%, and 64 to 93%, respectively. Interference on the first, second, and third planting dates reduced velvetleaf capsules in 1987 by 56, 71, and 54%, respectively, and in 1988 by 49, 82, and 82%. the reproductive capacity of velvetleaf was also strongly influenced by planting date, with later plantings generally resulting in fewer branches, flowers, and capsules.

INTRODUCTION

Models which estimate the effects of weeds on crops are essential for developing weed management systems. Weed biological information, especially phenology data, can provide information necessary to create more accurate weed models that ultimately result in better management systems (2, 9). Competitive characteristics in weed growth and development, such as leaf expansion, plant height, and reproduction can be used to develop economic threshold models (7) relative to associated crops (14).

Research on developmental differences in weeds growing alone vs. in association with a crop is limited. Velvetleaf phenological research results are variable and suggest the plasticity of response the weed can attain under diverse growing conditions. Velvetleaf grown with soybean [Glycine max (L.) Merr.] produced fewer flowers 7 to 9 weeks after emergence than when growing independently on 1 m spacings (6). The number of main-stem nodes/plant and leaves were fewer when the weed was intercropped with soybean, compared to velvetleaf growing in a density of $5/m^2$ with no interspecific interference (10). In another study, flowering nodes of velvetleaf were not affected by the soybean, but branching was reduced in mixed stands compared to the weed growing in densities varying from 2.5 to 25 plants/m^2 (4). A reduction in velvetleaf capsules was reported when grown with corn, (Zea mays L.) (3). Therefore, a base of preliminary data exists on velvetleaf phenology when grown with soybean and corn (3, 4, 6, 10).

Data involving velvetleaf and interference with cotton are limited (1, 5). In Mississippi, velvetleaf leaf area increased to a peak at 10 weeks after emergence and produced 17,000 seed/plant (1). Results from greenhouse research found at 39 days after planting velvetleaf had a leaf area 16.44 dm^2, whereas velvetleaf with cotton had a leaf area 8.78 dm^2 (5). In consideration of previous research, the objective of this research was to document, under field conditions, the development of velvetleaf when grown with vs. without cotton at three planting dates for 2 years.

MATERIALS AND METHODS

Field experiments were established near Perkins in north central Oklahoma during the 1987 and 1988 growing seasons on a Teller fine sandy loam (Udic Argiustoll) with a pH of 5.9 and 0.5% organic matter. The site was fertilized each year according to soil test recommendations for cotton. An overhead, side-roll, sprinkler irrigation system was used to supplement rainfall when necessary. Rainfall and daily maximum and minimum temperatures were collected and electronically recorded at a weather station located about 1 km from the research site.

Treatments consisted of three planting dates and velvetleaf grown with and without cotton for 2 years. The experimental design was a randomized complete block within planting dates (June 2, June 24, and July 7 in 1987; May 20, June 8, and June 24 in 1988) and in strips between dates. The experimental unit was single velvetleaf plant growing alone or adjacent to a cotton row (Figure 1). Each treatment was replicated 10 times/planting date, except where otherwise noted. Velvetleaf was planted approximately in the middle of an area 3.6 m wide and 5 m long. This width allowed four cotton rows spaced 91 cm apart to be planted/plot. Velvetleaf plants grown alone were treated similarly except the cotton was removed from the plot within one week after cotton emergence.

Paymaster 145, a stripper harvested cotton cultivar, was planted at a seeding rate of 23 seed/m of row to obtain a final stand density of 15 plants/m. The soil was lightly tilled before the second and third planting dates each year. Twenty to 30 velvetleaf seed were hand planted/hill immediately after cotton planting. Velvetleaf and cotton emerged together approximately 1 week after planting. Cotton was removed from 10 plots/planting dates by hand hoeing, approximately 1 week after cotton emergence. Velvetleaf was thinned to one plant/hill before development of the weed's second true leaf. Poor emergence of the weed on the second and third planting dates in 1988 resulted in 6 replications at the second planting date and 5 replications at the third.

At each planting date, a preemergence application of 2.2 kg/ha of alachlor [2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide] was made. Before application, a 30 cm^2 wood cover was placed over each velvetleaf hill to prevent herbicide injury. A postemergence application of 0.21 kg/ha of fluazifop [(±)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid] was made once in 1988 to control Texas panicum (Panicum texanum Buckl.). All other weeds emerging throughout the growing season were removed by hand and hand hoeing.

When velvetleaf attained 5 to 10 cm in plant height, data collection began. Velvetleaf variables were collected until senescence and included plant height, number of branches, number of flowers, and number of seed capsules. Data were collected every 4 to 5 days; however, during peak flowering, counts were made every 2 days. To avoid counting the same plant parts more than once, a small spot of nonphytotoxic, acrylic paint was applied to those parts counted on each date. Branches were counted when two unfolded leaves had arisen from an axillary node. Flowers were counted (and painted on the sepal) if any yellow was evident on the petals. Capsules were counted and marked on the pedicel after the petals were shed. No data were collected on cotton as the objective was to measure velvetleaf with vs. without the crop.

Data were analyzed by SAS procedure GLM to obtain least squares means for all variables measured at all collection dates. Except for velvetleaf plant height, least squares means were averaged over collection dates to derive a 7-day interval for determining progressive development over the growing season. Observed significance levels (OSL) were calculated for testing differences between the least squares means of velvetleaf grown with vs. without cotton for each collection interval for each variable measured. Least squares means of cumulative branches, flowers, and capsules were determined and analyzed for interactions between years. Interactions of planting dates and treatments were judged significant. Therefore, analyses of each years data will be given separately.

RESULTS AND DISCUSSION

Velvetleaf plant height. By the end of the growing season each year at the first planting date, velvetleaf grown with cotton was approximately 5 cm shorter than velvetleaf grown alone (Figure 2A, 2B). The same was true for the second planting date in 1987 (Figure 2C), but not in 1988 (Figure 2D). Velvetleaf plant height at the third planting date in both years was more noticeably affected by the presence of cotton as it was 20 to 25 cm shorter than velvetleaf grown alone (Figure 2E, 2F).

Velvetleaf branch production. At the first planting date in 1987, branches were counted incorrectly until 8 weeks after weed emergence (WAE); therefore, the earlier data are not shown (Figure 3A). In 1988, branches were first observed 4 WAE at the first planting date (Figure 3B). Branches were first recorded for the second date at 3 and 4 WAE, in 1987 and 1988, respectively (Figure 3C, 3D). On the third date, branches were noted 4 WAE in both growing seasons (Figure 3E, 3F).

At the first planting date in 1987, maximum branch production from velvetleaf grown with vs. without cotton occurred 11 WAE (Figure 3A). In 1988, maximum branches for both were recorded 10 WAE, but velvetleaf growing alone averaged 15 more branches than velvetleaf with cotton (Figure 3B). With the second date, maximum branch production for velvetleaf occurred 8 and 9 WAE, and averaged 17 and 34 more branches than velvetleaf with cotton in 1987 and 1988, respectively (Figure 3C, 3D). At the third date, maximum branch production for velvetleaf was observed 9 WAE and, during this production period, had 17 and 32 more branches than velvetleaf with cotton in 1987 and 1988, respectively (Figure 3E, 3F).

Cumulative velvetleaf branches/plant were significantly reduced at all planting dates when grown with cotton (Table 1). Cotton in the second and third dates caused a greater percentage reduction in velvetleaf branches than it did in the first date. At the first date, velvetleaf with cotton produced 35 and 57% fewer branches than velvetleaf in 1987 and 1988, respectively. A 72 and 82% reduction in branches occurred at the second date and a 73 and 90% reduction occurred in the third planting date in 1987 and 1988, respectively. These data are comparable to previously reported research (6) where velvetleaf in soybean displayed a 50% reduction in branching nodes by 11 WAE. They also reported significant differences as early as 5 to 6 WAE. The number of primary and secondary lateral branches developed by velvetleaf depends largely on environment; shading has been proposed as a major factor inhibiting branching in the weed (15).

Velvetleaf flower production. As a consequence of the way the data were collected, abortion rates of the flowers could not be determined. Previous research reported that some flowers abscised 1 to 2 days after opening, particularly during the early season (15). Some flowers in this study were not counted, but did complete their reproductive cycle and produced capsules. This often resulted in lower flower counts than capsule counts (Table 1), a biologically improbable situation. This likely occurred either because some flowers were overlooked before petals were shed or flower counting intervals were not close enough and some bloomed between one count and the next.

On the first planting date in both years, the first flowers were produced 6 WAE for velvetleaf with vs. without cotton (Figure 4A, 4B). In both growing seasons at the second and third dates, velvetleaf with vs. without cotton produced first flowers 5 WAE (Figure 4C, 4D, 4E, 4F).

Maximum flower production on the first planting date for velvetleaf alone occurred 13 and 12 WAE in 1987 and

1988, respectively (Figure 4A, 4B) with velvetleaf averaging 140 and 135 more flowers in the two years than velvetleaf with cotton. Maximum flower production occurred 8 WAE in 1987 with an average of 63 more flowers for velvetleaf without cotton and 9 WAE in 1988 with an average of 168 more flowers (Figure 4C, 4D). On the third date, maximum flower production was reached 9 WAE in both years with velvetleaf averaging 48 and 146 more flowers than velvetleaf with cotton in 1987 and 1988, respectively (Figure 4E, 4F).

Cumulative flowers/plant produced by velvetleaf were greater than velvetleaf with cotton for all planting dates in both years (Table 1). Velvetleaf with cotton on the first date produced 46 and 47% fewer flowers/plant than velvetleaf in 1987 and 1988, respectively. On the second date, velvetleaf with cotton produced 72 to 75% fewer flowers/plant than velvetleaf in 1987 and 1988, respectively. On the third date, corresponding reductions were 64 and 93%, respectively. Planting date 1 vs. dates 2 and 3 strongly affected the initiation of flower production.

<u>Velvetleaf capsule production</u>. Capsule production in velvetleaf was strongly reduced by the presence of cotton (Figure 5). On the first and second planting dates in both years, capsules were first recorded 6 WAE (Figure 5A, 5B, 5C, 5D). On the third date in both seasons, capsules were first observed 5 WAE (Figure 5E, 5F).

In 1987, on the first planting date, maximum capsule production occurred 13 WAE, with 114 more capsules present on the average than with cotton (Figure 5A). In 1988, maximum production occurred 11 WAE with an average of 235 more capsules on velvetleaf without cotton (Figure 5B). At the second date in 1987, maximum capsule production was reached 8 WAE, with velvetleaf having an average of 61 more capsules than velvetleaf with cotton (Figure 5C). Maximum capsule production in 1988 was observed 10 WAE with velvetleaf producing an average of 223 more capsules without cotton (Figure 5D). Capsule production reached a maximum 10 WAE for velvetleaf at the third date in 1987, with 60 more capsules than velvetleaf with cotton (Figure 5E). On the third date in 1988, velvetleaf reached maximum capsule production 9 WAE with an average of 159 more capsules without cotton (Figure 5F).

In 1987, velvetleaf grown with cotton produced 56, 71, and 54% fewer capsules as a result of the plantings made on the three dates. In 1988, the reductions were 49, 82, and 82%, respectively. Earlier research reported that as velvetleaf densities increased, reproductive organ plasticity was exhibited in the number of capsules/plant (8). Although this research involved intraspecific interference, velvetleaf responded similarly. Number of seed/capsule and weight of 1000 seed were reported to remain constant (8). An early study reported 13 WAE was required for velvetleaf to reach maximum capsule production, with an average of 137 capsules/plant (1). This is considerably later and with fewer capsules than observed in our research. Location and cotton varieties may have influenced the differing responses.

The total number of branches, flowers, and capsules/plant were greater for velvetleaf alone in 1988. This trend is probably a result of earlier planting dates in 1988, which suggest velvetleaf's response to longer photoperiod. A sustained period of high temperatures occurred in July, 1987, but not in 1988, and may have been critical to optimum velvetleaf growth in that growing season (Figure 6). Rainfall was not as plentiful in 1988 as in 1987. However, because the experiments were irrigated, drought stress was minimized as a cause of growth differentials between the two seasons.

Velvetleaf is not as competitive with cotton the later it is planted. The effect of cotton, regardless of planting date and year, was to reduce the number of branches, flowers, and capsules of velvetleaf. Previous greenhouse research showed cotton was more competitive with velvetleaf at higher temperatures (32 day/23 night C), and relative growth of velvetleaf was depressed by cotton only at higher temperatures (5). Velvetleaf reproductive growth is delayed at 40 day/32 night C (13). In experiments subjecting cotton and velvetleaf to periods of drought stress, cotton retained a competitive advantage over velvetleaf once water was restored (12). Although our experiments were irrigated, less rainfall at later planting dates in both seasons, may have contributed to cotton's advantage over velvetleaf. Velvetleaf in a late planting of soybean did not cause yield reductions as large as in an earlier planting (11). They concluded that because of velvetleaf's photoperiodic response, late planted velvetleaf did not have an advantage over soybean.

Velvetleaf plant height was not greatly affected by cotton, particularly at the first and second dates in both seasons. Height is apparently not a growth variable of this weed exhibiting large plasticity. Large differences in reproductive characteristics demonstrate velvetleaf's plasticity for those traits under environmental stress. Further, interference from cotton was shown to be a strong deterrent to velvetleaf growth. Results of this research indicate the importance of considering crop and planting date on weed phenology as growth models are developed to better understand weed-crop interactions.

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Table 1. Cumulative number of velvetleaf branches, flowers, and capsules produced per plant during the growing season for three planting dates and 2 years.

	1987				1988			
Treatment	Planting date	Branches	Flowers	Capsules	Planting date	Branches	Flowers	Capsules
		--------(mean no./plant)---------				--------(mean no./plant)---------		
Velvetleaf	June 2	136	912	1003	May 20	231	1425	1589
Velvetleaf with cotton		89	489	440		99	750	808
OSL[a]		(0.0001)	(0.0001)	(0.0001)		(0.0001)	(0.0001)	(0.0001)
Velvetleaf	June 24	54	290	346	June 8	130	794	813
Velvetleaf with cotton		15	82	101		23	202	148
OSL[a]		(0.0008)	(0.0028)	(0.0019)		(0.0008)	(0.0006)	(0.0013)
Velvetleaf	July 7	44	194	262	June 24	97	452	515
Velvetleaf with cotton		12	69	120		10	32	95
OSL[a]		(0.0095)	(0.0835)	(0.0814)		(0.0262)	(0.0451)	(0.0371)

[a]Numbers in parentheses indicate the observed significance level (p-value) within a planting date when comparing velvetleaf without vs. with cotton.

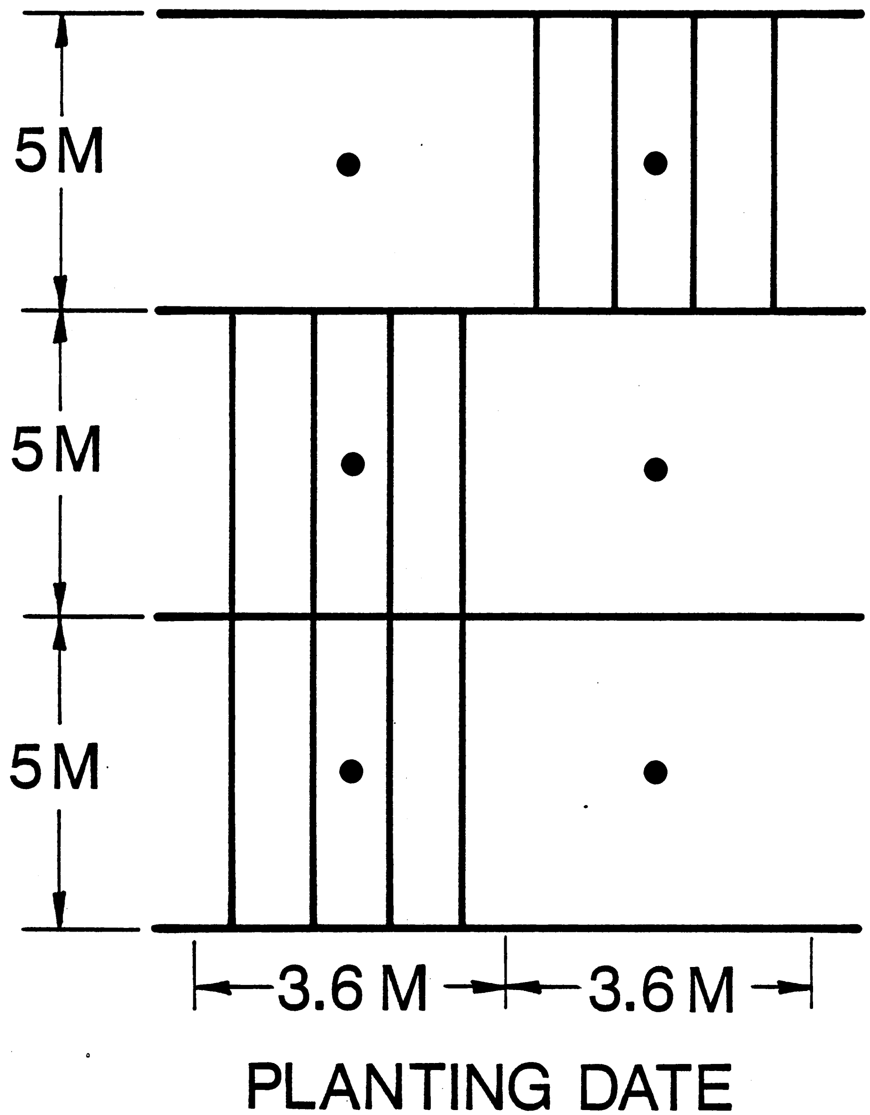


Figure 1. Diagram illustrating the design of individual plots within three replications of a single planting date. Velvetleaf plants are represented by the circles, cotton rows are indicated by the vertical lines.

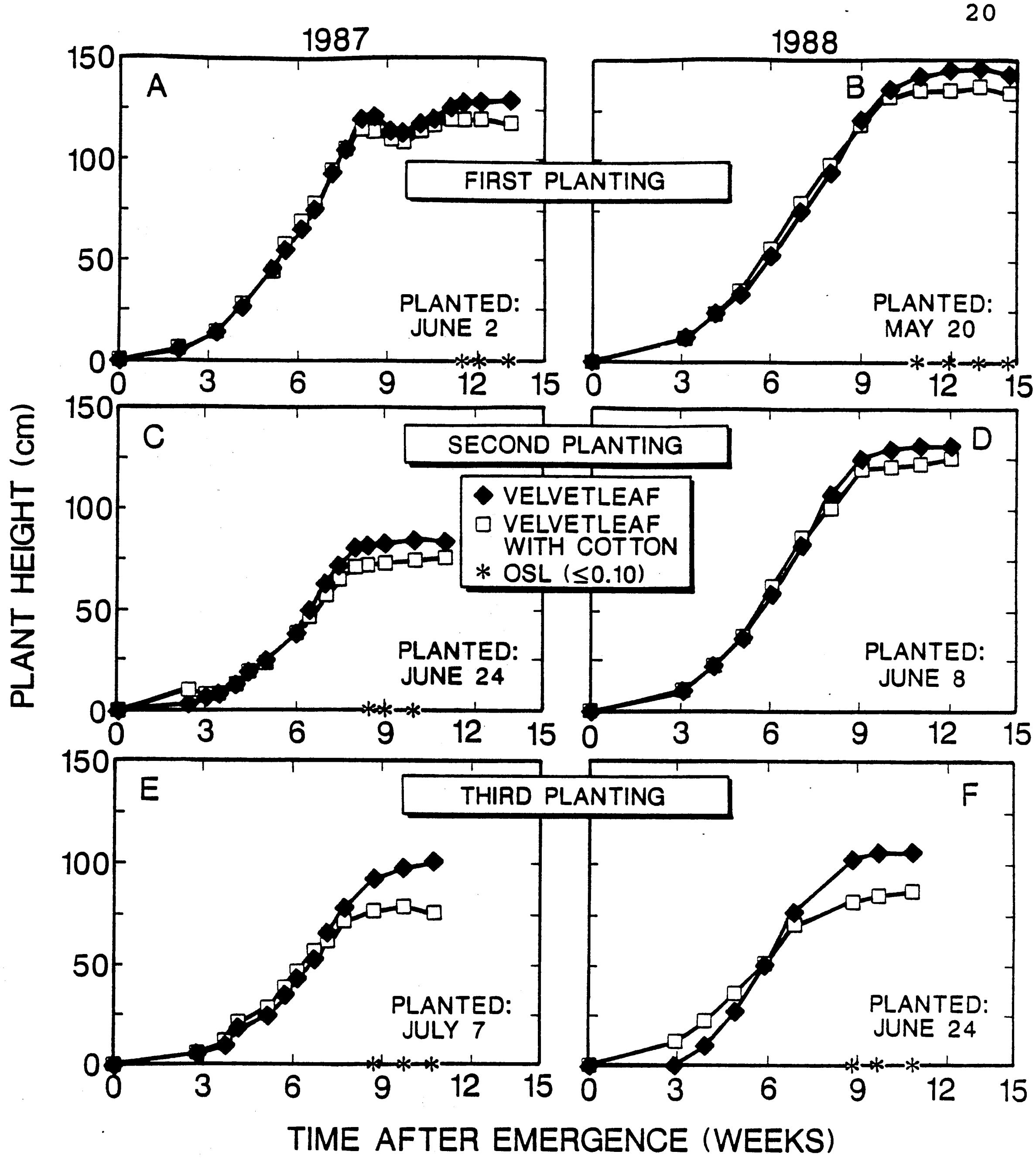


Figure 2. Velvetleaf plant height grown with and without cotton. (The * indicates an OSL range of 0.1 or lower between treatments.)

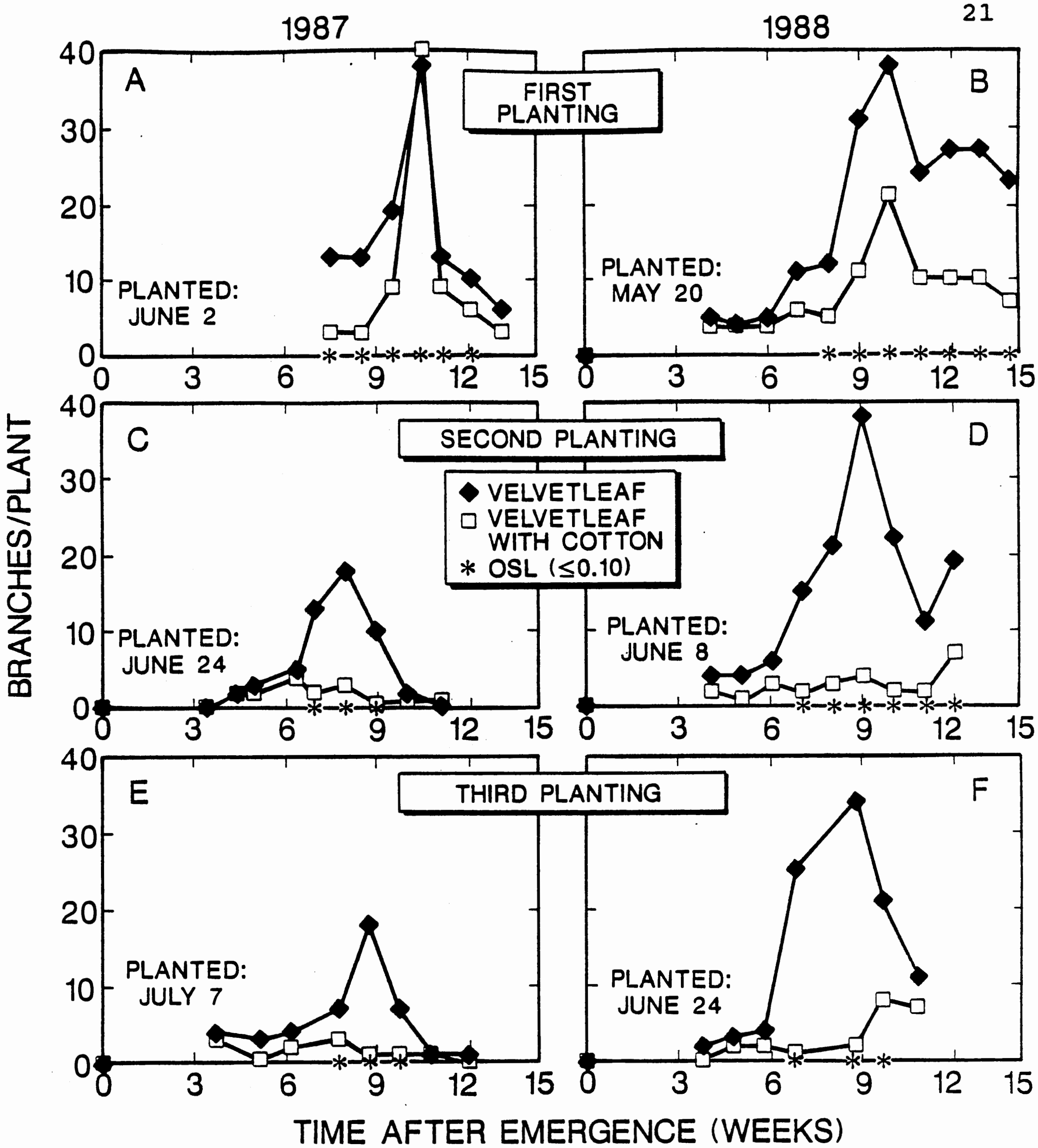
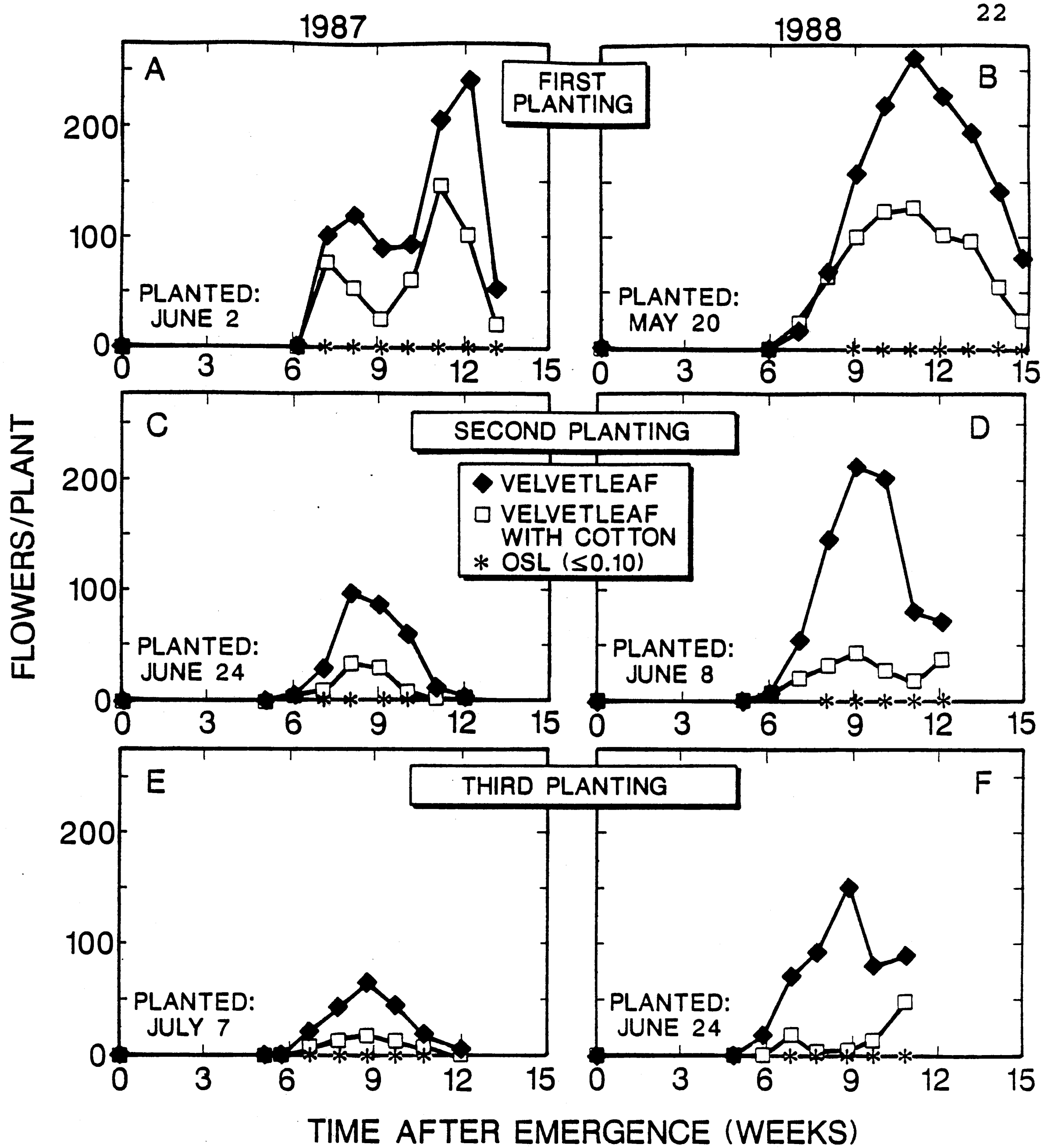


Figure 3. Weekly velvetleaf branch production grown with and without cotton. (The * indicates an OSL range of 0.1 or lower between treatments.)



<u>Figure 4</u>. Weekly velvetleaf flower production grown with and without cotton. (The * indicates an OSL range of 0.1 or lower between treatments.)

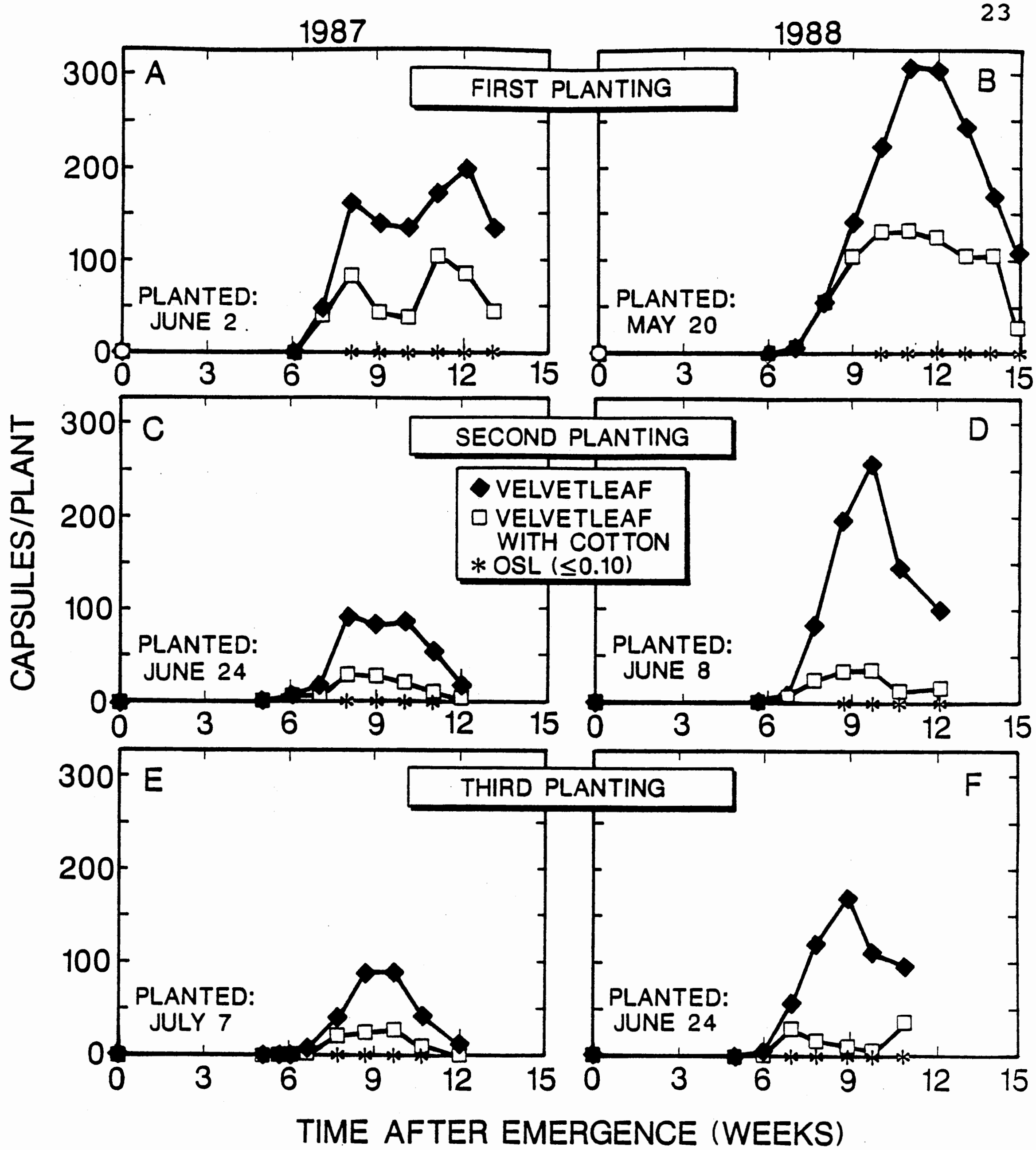


Figure 5. Weekly velvetleaf capsule production grown with and without cotton. (The * indicates an OSL range of 0.1 or lower between treatments.)

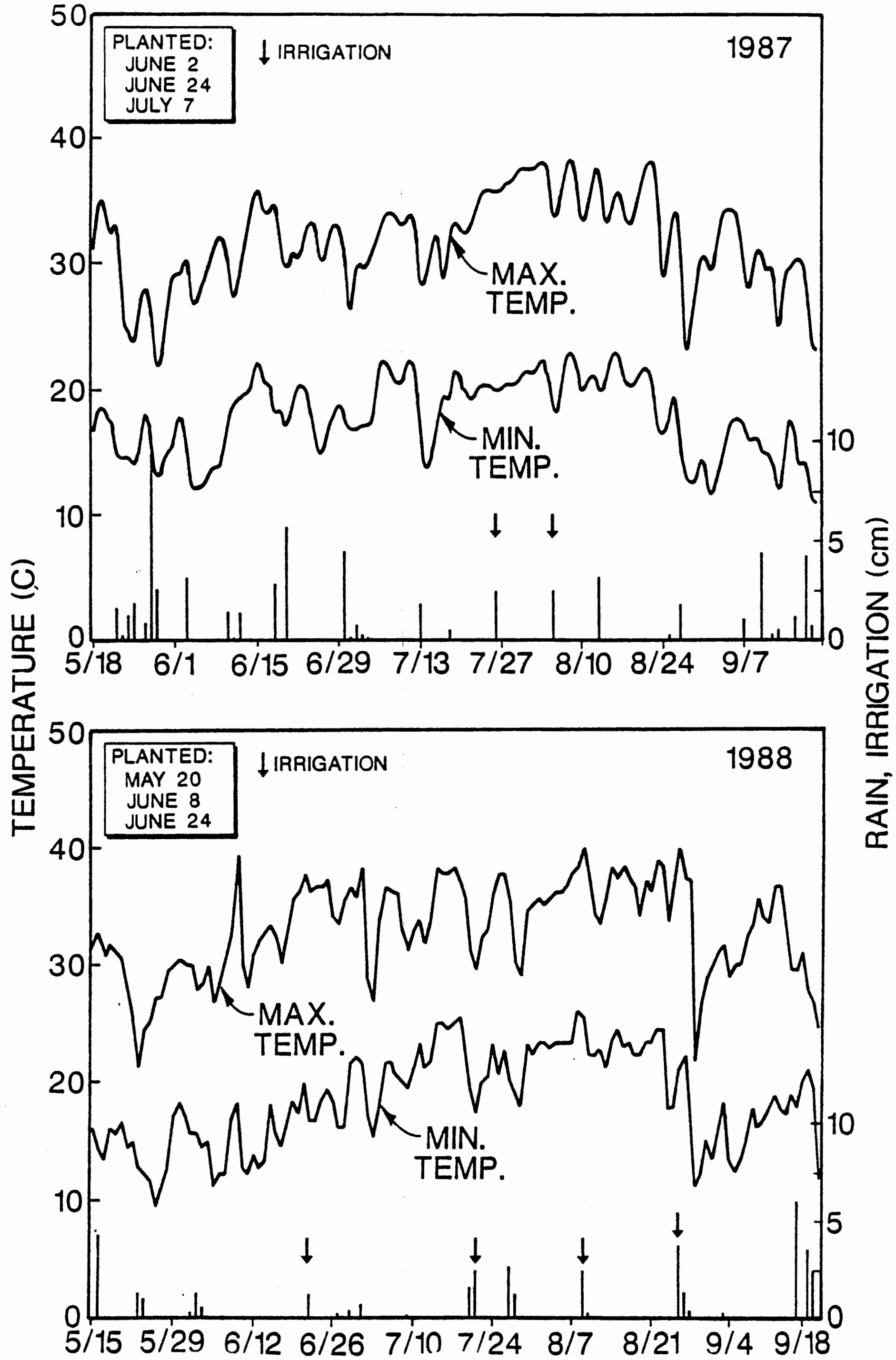


Figure 6. Average maximum and minimum temperature, and frequency and amount of rainfall and irrigation at Perkins, OK, in 1987 and 1988.

PART II

VELVETLEAF (ABUTILON THEOPHRASTI) INTERFERENCE WITH COTTON (GOSSYPIUM HIRSUTUM) LINT YIELD

Velvetleaf (*Abutilon theophrasti*) Interference with Cotton (*Gossypium hirsutum*) Lint Yield

Abstract. Field experiments were conducted for 2 years to evaluate the critical period for velvetleaf interference with cotton lint yield. Data were also collected on the weed growth every 15 days during the growing season to test the reliability of using weed growth variables as predictors of lint yield losses. A linear relationship existed between increasing velvetleaf dry weight and decreasing cotton lint yield. However, the relationship between the number of main-stem nodes or plant height with decreasing cotton lint yield was best described by quadratic regression equations. Weed dry weight appeared to be the most accurate followed by plant height and then by number of main-stem nodes. A nonlinear equation best described percent lint yield loss as a function of critical-period interference intervals. Several weed measurements can be used to predict cotton lint yield loss and have potential for practical weed management.

INTRODUCTION

Identifying critical periods of weed interference on crop yield facilitates the development of economic thresholds for use in weed management. "Critical periods" have been described as the maximum duration interval that weeds can be tolerated without affecting crop yield (15). Models developed with such components should lead to better control methods and yield loss predictions (2), predictability being a crucial aspect of weed management (9).

Critical-period research helps elucidate crop-weed relationships, an area difficult to describe because of variations in crops, locations, weed species, weed densities, and years (12). By relating crop-weed interactions to measurable weed growth variables, some environmental variation can be accounted for, thereby expanding research applicability crop-weed loss models. In research determining such relationships, relative plant size has often been judged to be a more accurate indicator than many other growth variables (8). Further, individual physiological and morphological traits which help attain differential plant size better describe the responses observed than do integrated growth variables such as leaf area ratio (8).

Velvetleaf has become a formidable weed in soybean [Glycine max (L.) Merr.], corn (Zea mays L.), and cotton due to few available control measures, seed dormancy, and the seed's ability to emerge from deep in the soil (11). Soybean yield was not affected if maintained weed-free for 20 days after emergence (5). An economic threshold model has been proposed for corn (14). One velvetleaf plant/76 cm caused a significant yield reduction in cotton (3). Yield losses in the field resulting from velvetleaf emerging with cotton and interfering with it for various intervals throughout the season have not been estimated. Greenhouse research, however, has documented that when grown together, the crop and weed exhibit equivalent interference capabilities in the first 5 weeks after emergence (6).

The objectives of this research were to determine in the field velvetleaf growth variables could be utilized to develop practical models to predict cotton lint yield loss and to determine how critical-period interference levels affect cotton lint yield.

MATERIALS AND METHODS

Field experiments were initiated on June 15, 1987, and on June 6, 1988, in north-central Oklahoma near Perkins on a Teller fine sandy loam (Udic Argiustoll). Plots were fertilized each year, according to Oklahoma State Univ. soil test recommendations for cotton. Irrigation was applied by an overhead, side-roll, sprinkler system to supplement rainfall when necessary.

The experimental design was a randomized complete block with four replications. Individual plots were four rows wide by 10 m long, and row spacing was 91 cm. Treatments tested were velvetleaf interference periods of 0, 15, 30, 45, 60, 75, and 90 days after emergence plus full-season interference.

Paymaster 145, a stripper-harvested cotton cultivar, was planted on beds using a conventional planter at the rate of approximately 23 seed/m to obtain a final stand density of 15 plants/m of row. Immediately after cotton planting, velvetleaf was hand planted in hills 5 cm from cotton to the south of three of the four plot rows. The fourth row served essentially as a border between three-row plots. Approximately 15 velvetleaf seed/hill were planted. In both years, velvetleaf emerged with cotton 7 days after planting. Velvetleaf was thinned to 32 plants/10 m of row before the development of the second true leaf of the weed. Previous research (3) with cotton showed that full-season interference from 16 velvetleaf plants/12 m of row reduced seed cotton yields and that 64 plants/12 m caused intraspecific interference. On the basis of that information, a single intermediate density of 32 plants/10 m of row was used herein.

A preemergence application of 1.7 kg/ha of alachlor [2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl)acetamide] and 2.2 kg/ha of dipropetryn [6-(ethylthio)-N,N'-bis(1-methylethyl)-1,3,5-triazine-2,4-diamine] was made in 1987 to control unwanted weeds. In 1988, dipropetryn was replaced with 1.4 kg/ha of prometryn [N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine]. A protective paper cover 23 cm in diameter was placed over each velvetleaf hill to prevent herbicide injury. All other weeds were removed by hand and hand hoeing throughout the growing season.

Weed and crop plant height were measured from soil surface to apex from 5 random plants in the two center plot rows before velvetleaf sampling dates. Velvetleaf was hand harvested from the center two rows by clipping at the ground level. The number of nodes present on the central stem (main-stem nodes) were counted from a random sample of 10 plants/plot. Velvetleaf were dried at 55 C for 72 to 120 hours, depending on the amount of biomass harvested; and the resulting dry weights were recorded.

Cotton was machine harvested with a brush type stripper on December 7, 1987, several weeks after a killing freeze. In 1988, after velvetleaf senescence and when cotton had approximately 80% open bolls, a boll opener, ethephon [(2-chloroethyl) phosphonic acid], and a defoliant [S,S,S-tributyl phosphorotrithioate] were applied. Ten days later, on October 27, 1988, the center two rows of each plot were harvested.

Predicting lint yield loss using weed variables. Velvetleaf dry weed weights, number of main-stem nodes, and plant height plus cotton lint yield were analyzed first for interactions between years using ANOVA. Interactions were not detected; therefore, data were combined over years.

Linear and curvilinear regression techniques were then used to describe the relationships.

Predicting lint yield loss using critical-period intervals. Cotton lint yield, in plots containing velvetleaf, were converted to a percentage of the weed-free plot in that treatment. Further, each interference interval was converted to a percentage of the total interference season of velvetleaf, i.e., a period judged to extend to 95 days after emergence. A nonlinear equation was developed for each year using the procedure NLIN of SAS.

RESULTS AND DISCUSSION

Predicting lint yield loss using weed variables. Linear regression best described lint yield loss as a function of weed dry weight; however, curvilinear regression best described lint yield as a function of main-stem nodes and plant height (Figures 1, 2, 3). Cotton lint yield showed a strong relationship (R^2 = 0.95) with velvetleaf biomass (Figure 1). The equation predicted that for each increasing 0.5 kg of velvetleaf dry weight/10 m^2, a corresponding 178 kg/ha (16.3%) cotton lint yield loss would occur.

When cotton lint yield was regressed as a function of velvetleaf main-stem nodes per plant, the addition of a quadratic term was significant at the 0.03 probability level (Figure 2). Additionally, 96% of the variation in lint yield losses were accounted for changes in main-stem nodes/plant. At 28 main-stem nodes on a average plant a 67% yield reduction was predicted.

Velvetleaf plant height also provided a good relationship ($R^2 = 0.99$) at this weed density for estimating cotton lint yield loss (Figure 3). As with main-stem nodes, a quadratic equation provided a more accurate relationship. Weed height may be useful as a simple-to-estimate variable to predict yield loss.

Other researchers have reported the best predictor of crop yield loss to be weed biomass per unit area (13). Although weed dry weight in this study was an excellent predictor of interference on crop yield, the variable is difficult to use in practical weed management as producers would better utilize a measure more easily determined. To use biomass, producers would need to harvest a weed sample, determine its dry weight, and then decide whether action was warranted. This takes more time and effort than most would be willing to invest for that purpose. The number of main-stem nodes per plant and weed plant height are much more easily and promptly collected variables for estimating cotton yield loss. While dry weed weights are probably more widely applicable, the estimators for main-stem nodes and plant height are applicable in the strict sense only at the weed density utilized in this study.

<u>Predicting lint yield loss using critical-period intervals.</u> Research assessing the relationship between critical period

interference and crop yield through the use of models is limited; but when evaluated, the relationship is usually best described through regression analysis (10). If equations are used to quantify differences, the model choice is crucial (4). For example, a limitation of linear regression is the assumption that for each incremental interval, equivalent yield losses occur. Likewise, as an artifact of curvilinear equations, a slight increase in yield may be indicated at the highest interference interval. Biologically, this effect is difficult to interpret. In evaluating increasing weed densities vs. crop yield, that relationship has been commonly described by a rectangular hyperbola (1). It is not clear if the relationships between density and crop yield and between critical-period interference intervals and crop yield are similar. Interference intervals and density are not independent (7), but research is required to determine if yield is affected by each in the same manner.

An equation of the form:

$$Y = \frac{1 - e \dfrac{-A(1-X)^{B}}{X^{C}} + D}{1 + D}$$

was used to study weed interference effects on cotton lint yield (Figure 4). Four nonlinear regression coefficients (A, B, C, D) were estimated in order to fit the equation and X is a given weed interference interval. We chose this form to have an asymptote so that yield would not decrease to zero. D/1 + D is the fraction of yield under maximum weed interference intervals. With limited departure from actual data each year, initially the curves for each year are flat; yield decreased at a greater rate in midseason, and the curves finally reached an asymptote of 25 and 33% near the end of the season where further yield reductions did not occur regardless of increasing weed interference. Residual mean square errors (deviation of predicted points from data points) were 8% in 1987 and 10% in 1988. Cousens et al. (4) reported nonlinear equations, using a rectangular hyperbola form for fitted equations of increasing weed density. However, a rectangular hyperbola was judged to be inappropriate for studying the relationship of crop yield vs. critical-period interference relationships.

An examination of plant height sampling intervals throughout the two seasons provides further support for a nonlinear curve (Figure 5). During the first half of the growing season, velvetleaf plant height increased rapidly and appeared to be linear. This period of the growing season coincided with the nonlinear equations in Figure 4 where cotton lint yield began to decline at an increasing rate. Previous research reported that velvetleaf dominates cotton if a height differential is established early in the growing season (3). As shown in Figure 5, an early height differential between velvetleaf and cotton was established;

and at the end of the season, velvetleaf was more than twice as tall as cotton with or without velvetleaf.

The purpose for developing an equation to utilize critical periods of interference is to increase one's ability to discern mechanisms of crop-weed interactions. If accomplished, the possibility then exists to incorporate that information with weed density models for practical use in weed management. A primary goal would be to first combine weed density information and critical-period information into a model to estimate the effects of the interaction on crop yield.

Critical-period interference research has evolved beyond estimating necessary weed-free periods to produce maximum crop yields. Although only one weed density was utilized in our research, velvetleaf growth variables provided good estimates of yield loss in cotton. The use of such growth variables provides a degree of practicality for potential use in weed management.

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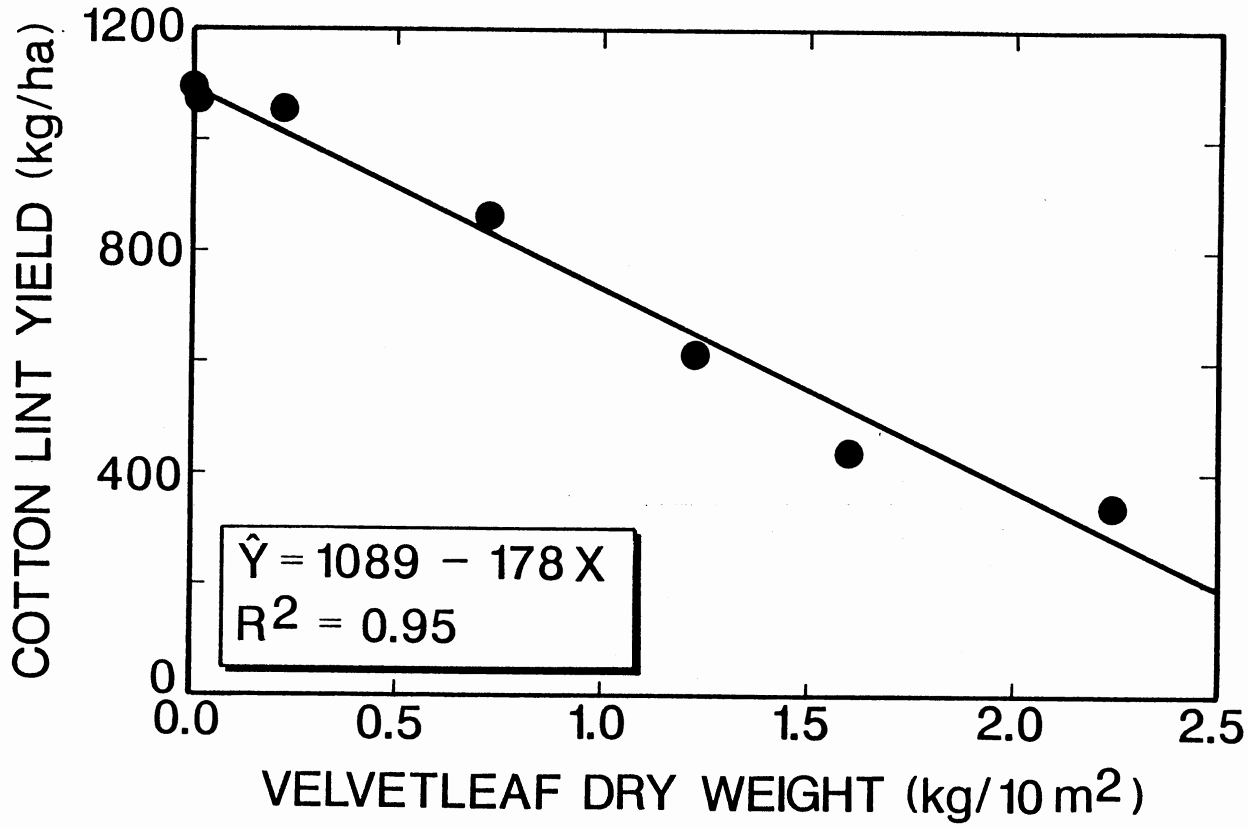
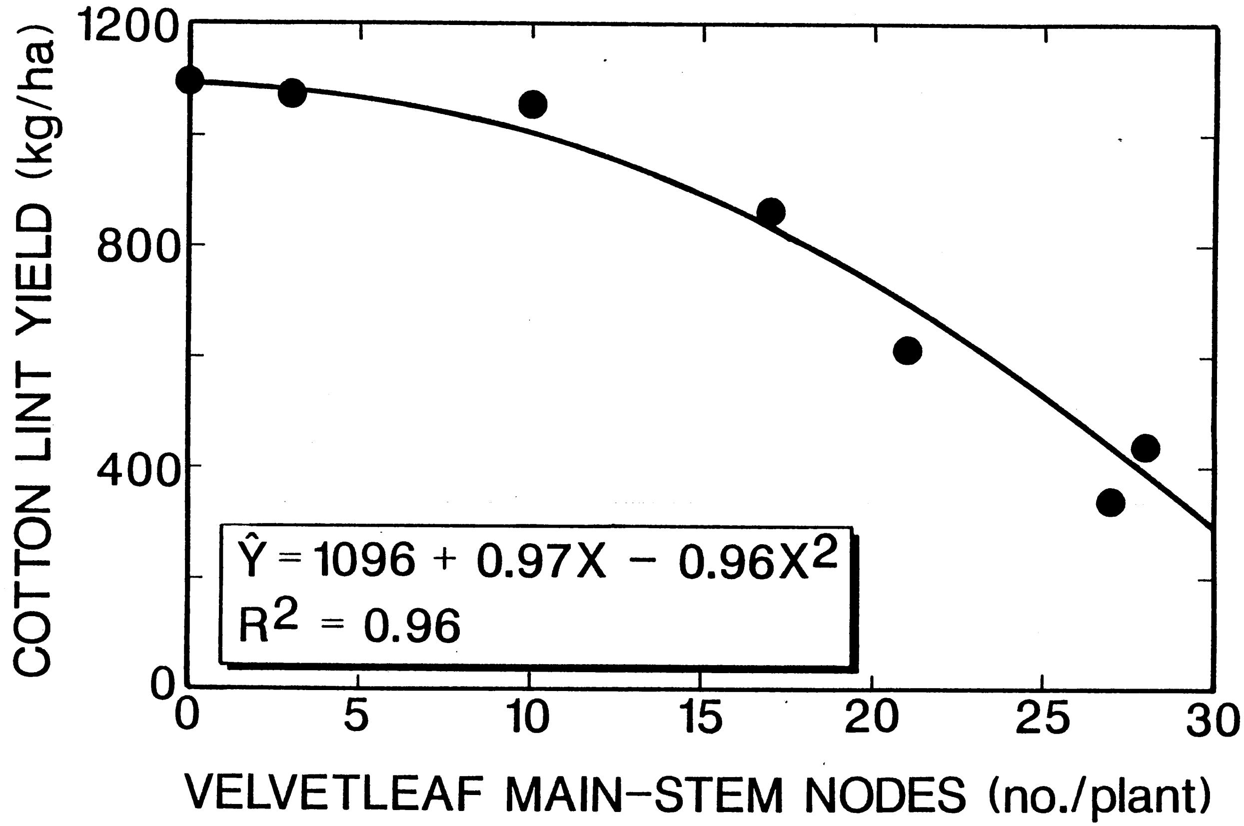


Figure 1. Linear relationship over years of cotton lint yield to velvetleaf biomass.



<u>Figure 2</u>. Quadratic relationship over years of cotton lint yield to velvetleaf main-stem nodes.

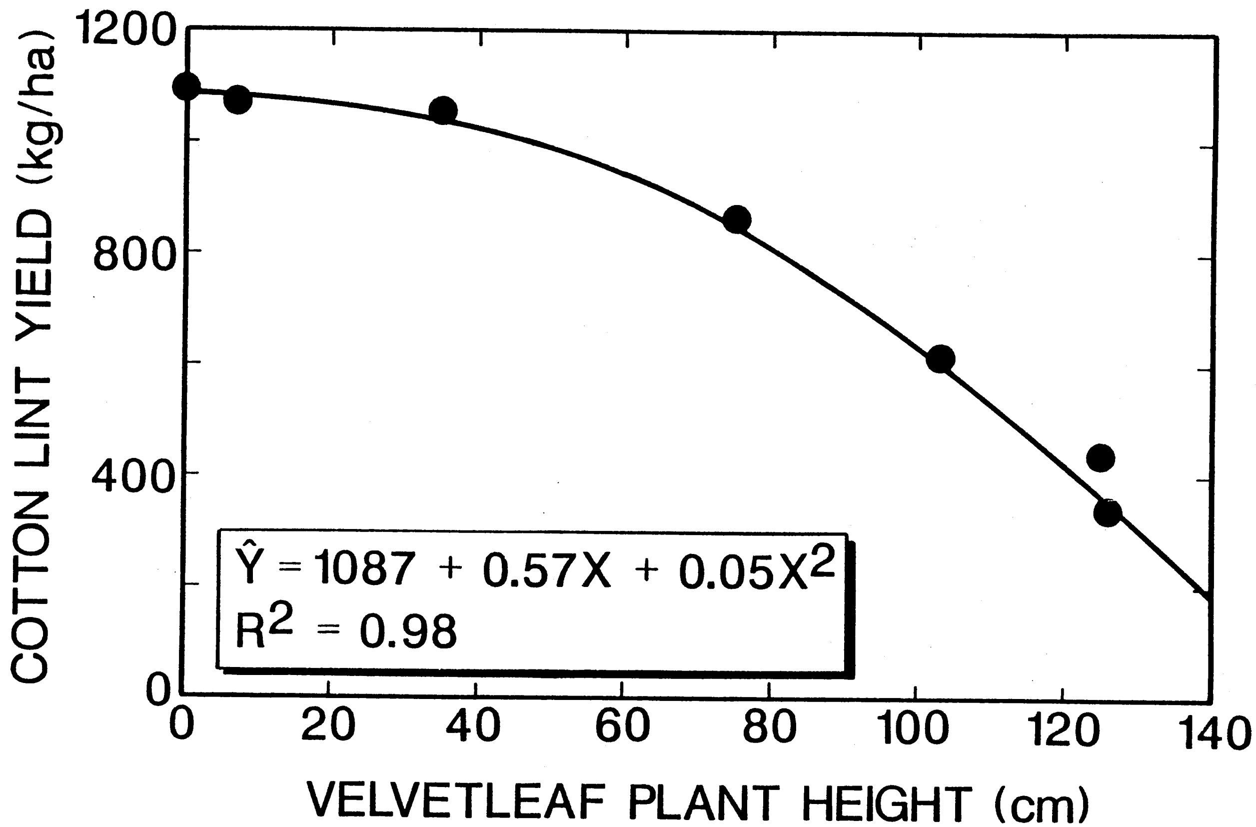


Figure 3. Quadratic relationship over years of cotton lint yield to velvetleaf plant height.

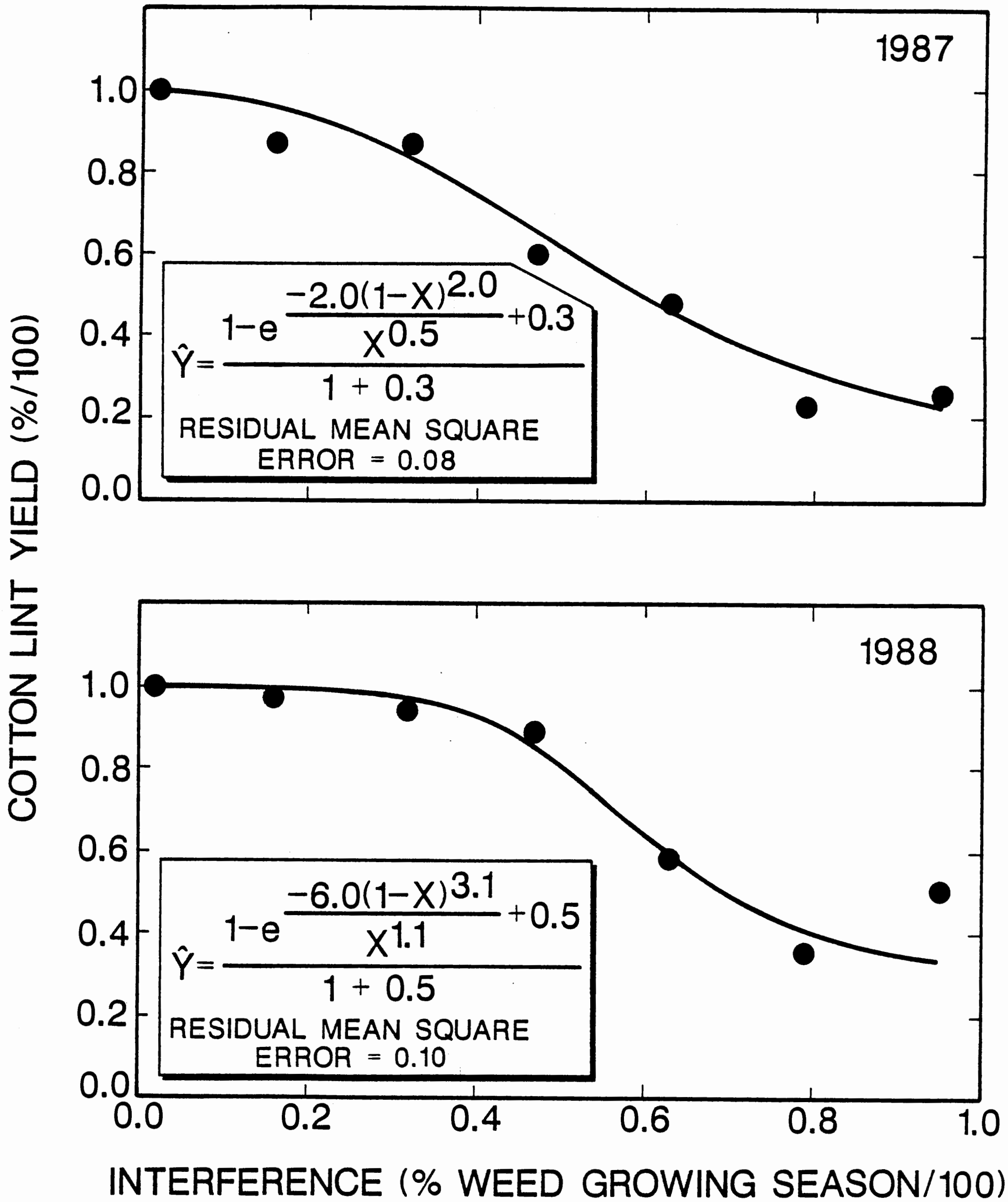


Figure 4. Nonlinear relationship of cotton lint yield to critical-period interference from velvetleaf in 1987 and 1988 (where X = percent of growing season, i.e., 95 days).

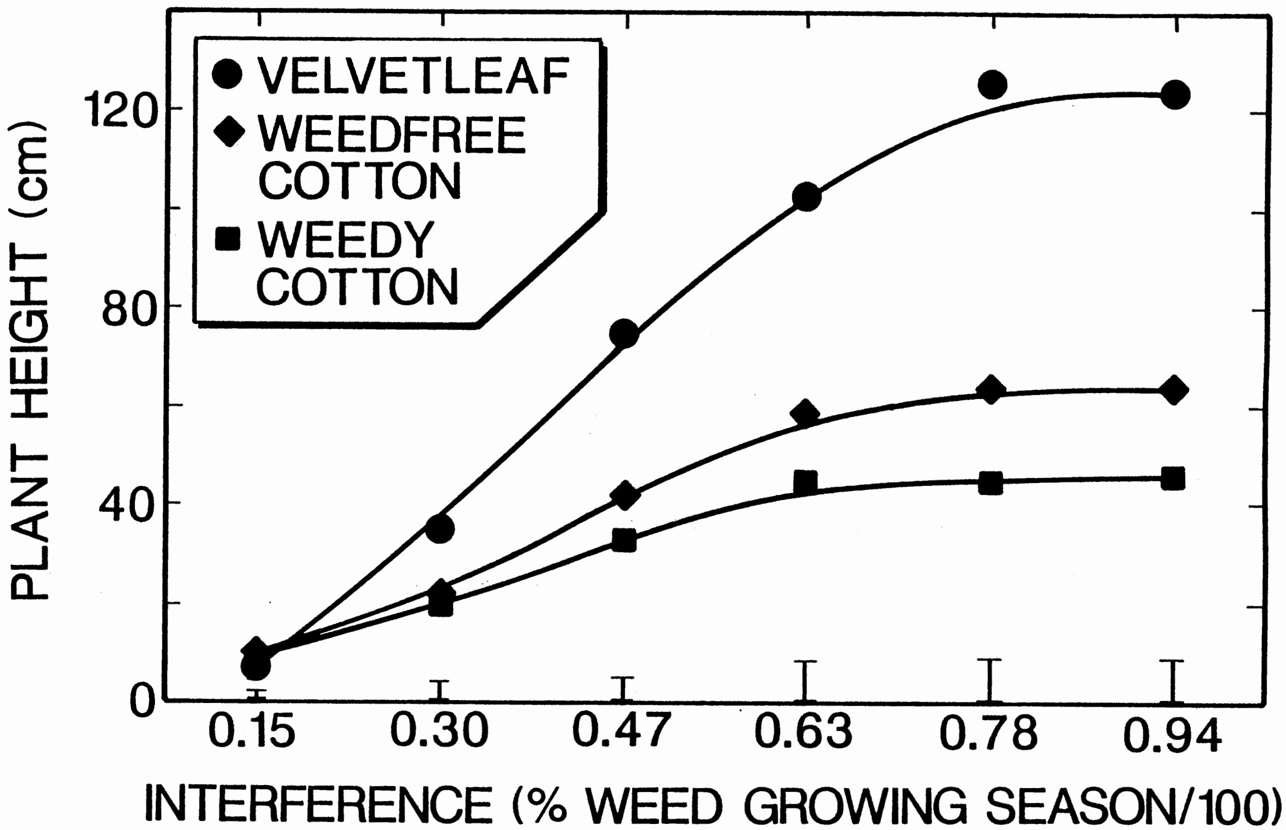


Figure 5. Plant height over years at sampling intervals of the weed growing season (i.e., 95 days) for velvetleaf, cotton with the weed and weed-free cotton. (Vertical lines represent protected LSD's at the 0.01 probability level).

VITA

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