GROWTH AND DEVELOPMENT OF JIMSONWEED (*DATURA STRAMONIUM*) AS INFLUENCED BY DEGREE DAYS AND TIME

By

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INTRODUCTION

Each part of this thesis is a separate manuscript to be submitted for journal publication. Part I will be submitted to Weed Science, and Part II will be submitted to Weed Technology. Both are journals of the Weed Science Society of America. Articles in these journals are peer reviewed and must report experiments repeated over time and/or space.

PART I

USE OF DEGREE DAYS VS. DAYS AFTER EMERGENCE TO MODEL THE GROWTH OF JIMSONWEED (*DATURA STRAMONIUM*)

Use of Degree Days vs. Days After Emergence to Model the Growth of Jimsonweed (*Datura stramonium*)

Abstract. Jimsonweed was chosen for growth-model investigations because of its wide distribution and its relative importance as a weed and because its morphological characters are conducive to accurate measurement. Germination studies were conducted to arrive at a base temperature of 10.5 C for jimsonweed growth. Field studies were conducted for 2 years to evaluate the use of degree days (DD), rather than days after emergence (DAE), to model jimsonweeds growth. Use of DD improved models for leaf and flower number under unusual temperature regimes as well as dry-weight production compared to models using DAE. Both methods resulted in highly accurate models (R^2 = 0.92 for DD and 0.93 for DAE) for predicting plant height. Seed capsule production was not significantly related to either variable. Nomenclature: Jimsonweed, *Datura stramonium* L. var. *tatula* Torr. #[1] DATST.

Additional index words. Thermal unit, temperature, DATST.

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street., Champaign, IL 61820.

INTRODUCTION

Effects of temperature on plant growth and development have been documented by many scientists (5, 8, 15). Models utilizing temperature have been developed for yields of cotton, Gossypium hirsutum L. (26); wheat, Triticum aestivum L. (9); and corn, Zea mays L. (3). Models utilizing temperature have also been developed to predict phenological development of the southern pea, Pisum sativum L. (12); corn (4, 7); and soybean, Glycine max Merr. (11). Models, such as SETSIM, were developed by weed scientists to predict carbohydrate flow in both robust purple, Setaria viridis var. robusta-purpurea Schreiber # SETVP, and robust white, Setaria viridis var. robusta-alba Schreiber # SETVL, foxtails, as well as the period of most active growth, plant height, leaf area, and stem to leaf ratio (21). One of the parameters examined in SETSIM was "degree days" (DD). Degree days are a subjectively appealing measure of temperature because they compensate for temperatures below the base and above the optimum for a particular species. Degree days have also been effectively utilized in modeling phenological parameters such as shoot extension in the ericaceous shrubs, Ledum groenlandicum Oeder., Chamaedaphne calyculata (L.) Moench., and Kalmia polifolia Wang. (22) and vegetative and reproductive stages of various grass species (1).

Models utilizing temperature to predict plant growth

and development have been restricted by the lack of adequate means to determine the threshold temperature. A method was developed by Arnold (2), but the time required in this method was restricting. That limitation was subsequently removed with the development by Wiese and Binnings (28) of a rapid method for determining the threshold temperature of development, also referred to as the "base temperature" by.

The basic premise for DD to model biological systems revolves around the kinetics of poikilotherm development (15). Sharpe and DeMichele (24) demonstrated the existence of a temperature region for a wide range of organisms in which a proportional increase in enzymatic activity occurs with a corresponding increase in temperature. They also determined that the low temperature at which enzymatic activity ceases effectively establishes the true threshold temperature of development. The theoretical threshold is the temperature at which growth would cease if the linear portion of the growth curve were extrapolated to a zero rate of development. The true threshold is the temperature at which physiological activity is stationary. Because developmental rate is nonlinear near the lower temperature extreme, the true threshold temperature is invariably lower than the theoretical. However the theoretical threshold temperature allows more accurate predictions of growth with DD when temperatures near the true threshold are not encountered. High temperatures at which enzyme activity does not increase effectively establish the optimal

temperature (23).

Temperatures above the optimum have a negative effect on the rate of development (5, 6, 25). In the past, scientists have commonly imposed a penalty for temperatures above a certain level; however, several researchers have found that this procedure did not increase the predictive capacity of their models (6, 20). Both the threshold and optimal temperatures change with the developmental phase of the plant's life cycle (25). Constant temperatures, however, have commonly been used throughout the growing season because of the lack of critical data at the different developmental phases as well as for simplicity of the model (16, 19, 22).

Considerable potential exists in modeling plant growth and development to gain a better understanding of biological systems (14), including weeds. Models utilizing temperature could benefit the weed scientist directly and indirectly. Directly, they could predict the period of most active weed growth which would likely correspond to the period of greatest interference. Indirectly, models could be used to predict invasion and subsequent proliferation of weeds in geographic regions before they actually infest the region (21). Potential also exist to interface weed models with existing crop models to predict yield losses due to weeds (21).

Jimsonweed's long petioles and large flowers are conducive for measuring growth and development. Due to the

weeds broad geographical distribution (23) and relative importance, as well as its morphological characteristics, jimsonweed was chosen as a benchmark to assess the feasibility of using degree days (DD) vs. days after emergence (DAE) to model weed growth.

MATERIALS AND METHODS

Base temperature determination. Germination studies were conducted to establish the base and optimal temperatures for jimsonweed development. Experimental methods were those developed by Wiese and Binning (28). A 14 day germination period was used in this experiment in place of 21 days used by Wiese and Binning (28). Jimsonweed seed was collected locally from approximately 2000 plants the year previous to the beginning of this study. Six replications of 50 locally collected jimsonweed seed were placed between two sheets of filter paper, moistened with 5 ml of 0.1 M KNO_3, and placed in a dark, constant-temperature germinator for 14 days. Eleven germination temperatures, ranging from 8 to 36 C, were used. Filter papers were moistened, and germinated seed were removed on a daily basis. Seed were considered germinated when the radicle had reached 1 mm in length. Percent germination/day was plotted against temperature. The linear portion of the data was extrapolated to the x-axis through regression analysis, and this temperature was used as the base temperature. Optimal temperature was determined as that at which maximum germination occurred.

Leaf, flower, and plant height development. Field studies were initiated in April of 1986 and 1987 on a Teller fine sandy loam (Udic Argiustoll) on the Agronomy Research Station located near Perkins, OK. These experiments were conducted to determine the relationship between DD and DAE on jimsonweed leaf and flower production as well as plant height. Locally collected jimsonweed seed were planted in a randomized design with six replications. An individual plot consisted of a single plant spaced 3 m from other plants in the same and between adjacent rows. Planting dates were April 15, May 1, May 15, June 1, June 15, and July 1 in 1986 and April 15, May 1, May 15, June 4, June 15, and July 6 in 1987. Approximately 40 seeds/plot were hand planted on each date. When five of the six replications had at least one seedling in the cotyledonary stage, plots were thinned to one plant/plot; and the date of emergence was recorded. Replications of a planting date which did not emerge within a 24 hour period of the rest were not used.

Prior to planting, a 30.5 cm^2 area in which each plot was to be planted was covered and herbicides were applied broadcast over the entire experimental area to prevent emergence of undesirable weeds. A preemergence tank-mixture of 1.1 kg ai/ha of oryzalin, 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide, and 1.1 kg ai/ha of prometryn, N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine, were applied in 1986. In 1987, alachlor, 2-chloro-N'-(2,6-diethylphenyl)-N-(methoxymethyl) acetamide,

at 2.2 kg ai/ha and prometryn at 1.1 kg ai/ha were applied preemergence over the experimental area. Undesirable weed escapes were removed by hoeing or hand pulling throughout the growing season in both years. Permethrin, 3-phenoxyphenyl)methyl(±)-cis, -trans,-3-(2,2-dichloroethenyl)-2,2-dimethylcycopropanecarboxylate, in 1986 and Carbaryl, 1-napthyl N-methylcarbamate, in 1987 were used throughout the growing season to control the Colorado potato beetle, *Leptinotarsa decemlineata* Say, which attempted to feed on the weed. Supplemental irrigation was applied with a overhead side-roll sprinkler system when judged necessary to prevent drought stress.

Leaf and bloom production, as well as plant height, were recorded on a twice weekly basis from emergence until the onset of senescence. To minimize counting time and to maximize accuracy, leaves and blooms were marked with a small spot of nonphytotoxic[2] acrylic paint[3] when leaf petioles reached 0.5 cm in length or flower-bud sepals reached 2.5 cm in length. This procedure prevented duplicate counting of leaves and flowers. Plant height was measured in cm from the soil surface to the apex of the uppermost leaf.

Temperature data were recorded hourly at a weather station located approximately 20 m and 60 m from the center

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[2]Personal communication W. W. Witt.

[3] Liquitex acrylic artist color. Binney & Smith Inc., Easton, PA 18042.

of the experimental area in 1986 and 1987, respectively. The mean hourly temperature (MHT) was determined electronically by averaging 20 readings per hour. When MHT data were not available, daily minimum and maximum temperatures were obtained from a weather station located about 800 m from the experimental area; however MHT data were missing for 13 days in 1986 and for 9 days in 1987. Those temperatures were used to estimate MHT with the function:

$$MHT = 0.5\ (Tmax + Tmin) + [(Tmax - Tmin)/2]\ [\cos(H \times 0.2618)]$$

where:

Tmax = maximum daily temperature, Tmin = minimum daily temperature, H = hour of estimate. Cosine is expressed in radians. Tmax and Tmin were assumed to occur at 1200 and 2400 hours, respectively. Logan and Boyland (17) found a sine function used with the Tmin and Tmax to calculate DD preformed more consistently than the use of Tmin and Tmax alone. Hourly temperatures were used to calculate DD in the following formula:

$$DD = (MHT - Base)/24$$

to calculate degree days. Restrictions were placed on the formula to compensate for temperature extremes below that of

the base temperature and for those exceeding the optimum. When MHT fell below that of the base temperature, no DD were accumulated for that period. This restriction did not allow the accumulation of negative DD and thus prevented one having to assume negative growth at temperatures below the base temperature. This procedure is probable valid, because the true threshold temperature is below that of the base temperature derived through regression analysis. Other researchers have found this restriction decreases the coefficient of variation and therefore have used the restriction on DD (10). When temperatures above the optimal were encountered, optimal temperature was used in the equation. Models have also been developed using a penalty of -2 C from the MHT for each 1 C the MHT exceeded the optimal, this corrected temperature was then used to calculate DD.

Regression analyses were conducted on DD, photoperiod accumulation, and DAE vs leaf production, bloom production, and plant height to derive models predicting jimsonweed growth and development.

Dry-weight and capsule production. Jimsonweed dry-weight accumulation and capsule production studies were initiated on May 15 of 1986 and 1987 on the same general site as the leaf, flower, and plant height experiments. All soil, general environmental, and moisture conditions, as well as chemical treatments were identical to those of the previously described experiments. Six replications of

approximately 40 jimsonweed seed were planted/plot for each of five harvest dates. When four replications had at least one seedling in the cotyledon stage, plots were thinned to one plant/plot; and the date of emergence was recorded. This occurred on June 25 and July 5 in 1986 and 1987, respectively. Plants were harvested at 14-day intervals ± 2 days from July 15 to September 15 in both years. Dry weight in grams and seed capsule number were recorded for each plant.

RESULTS AND DISCUSSION

Base temperature determination. The base temperature for jimsonweed growth was established through regression analysis. Percent germination/day was regressed against the temperatures at which germination occurred (Figure 1). High and low temperature extremes resulted in a nonlinear fit and these extremes therefore were deleted from the analysis (closed ▲ in Figure 1). Sharpe and DeMichele (24) as well as Wiese and Binnings (28) concurred that such data points must be excluded from the analysis to derive an accurate estimate. Regression analysis of the remaining linear portion of the data indicated the base temperature of development for jimsonweed to be approximately 10.5 C. Because maximum germination occurred at 30.5 C, that temperature was chosen as the maximum temperature for growth and development. Some researchers have developed working DD models assuming no upper threshold temperature (11, 19).

However the need for a maximum threshold temperature should increase as the frequency of above optimal temperatures increases.

Leaf, flower, and plant height development. Models predicting jimsonweed leaf and flower production, as well as plant height, were derived through regression analyses with DD and DAE.

Photoperiod was not utilized in the models due to the high degree of multicollinearity occurring between the independent variables DD and photoperiod. The degree of multicollinearity was deemed intolerable after comparing the square root of the correlation coefficient for those independent variables to the R^2 for each parameter model (13).

Models which assessed a penalty for temperatures above the optimal were judged inferior, in terms of R^2 and coefficient of variation (data not shown), to models without the penalty assessment; therefore such models were not considered further.

Two and three uniform emergence dates were obtained from the six planting dates in 1986 and in 1987, respectively. Regression analyses showed years, as well as emergence dates within years, were significant at the 0.001 probability level for all growth parameters in both the DD and DAE models. Although interactions existed between emergence dates and all measured parameters, emergence dates were pooled to obtain models which could be used over a

broad time range. Models were developed by regressing DD vs. each measured parameter for individual emergence dates as well as for all pooled dates. Corresponding models were developed for DAE to evaluate its effectiveness relative to the DD model. Linear, quadradic and cubic terms for DD and DAE were test in each model. Since the values of the measured parameters should be 0 at 0 DD and DAE, the intercept terms were forced through the origin. Negative portions of the regression lines are not shown.

The pooled DD model for leaf production resulted in an R^2 of 0.70, compared to individual emergence date models with R^2s ranging from 0.74 to 0.98 (Figure 2). The pooled DAE model provided an R^2 of 0.74 with individual emergence date models with R^2s ranging from 0.52 to 0.98 (Figure 3). Thus, the pooled DAE model resulted in a slightly superior model compared to that for DD. Because of changing variances as the growing season progressed, 95% confidence intervals were calculated for 500-DD increments in the DD pooled models and for 35-day increments in the DAE pooled models using the sum of the random variance components, i.e., year, time of year, replication in time of year, and mean square error (MSE) for each increment in the leaf, flower, and plant height models. At 750 and 1250 DD, predicted leaf production for all emergence dates were contained within the confidence interval of the pooled model. At 52.5 and 87.5 DAE the confidence interval contained all individual emergence date lines. The

variability of the pooled DD and DAE models were rather large resulting in two-sided confidence intervals with lower bounds which extended to the x-axis. The pooled DD model indicates a 95% probability that a random population of jimsonweed will have under 1785 leaves/plant on the average at 750 DD and under 4338 leaves/plant on the average at 1250 DD. The pooled DAE model indicated essentially the same predictive capacity as the DD model; however, the DAE model would not be as effective as the DD model under certain temperature regimes. This was illustrated by the July 2, 1986, emergence date which had an R^2 of only 0.52 for the DAE model compared to 0.78 for the DD model. The MHT for the first 30 days after that emergence date was 1.8 C higher than the same time interval for any other emergence date. The DD model was capable of utilizing that information and thereby gave a higher R^2 value than the DAE model. DD was highly correlated (R^2 = 0.98) with DAE over the course of the growing season; therefore, overall DAE gave models of similar quality to DD. However, when unusual temperatures are encountered, the DAE model becomes less accurate.

The pooled DD model for flower production resulted in an R^2 of 0.73, compared to individual emergence date models with R^2s ranging from 0.60 to 0.97 (Figure 4). The pooled DAE model resulted in an R^2 of 0.75, compared to individual emergence date models with R^2s ranging from 0.68 to 0.93 (Figure 5). The 95% confidence interval contained all individual emergence date predictive lines at all three

intervals in the DAE model. The large variability of both pooled models again resulted in confidence intervals which extended to the x-axis. The pooled DD model indicates a 95% probability that a random population of jimsonweed will have under 580 flowers/plant on the average at 750 DD and under 1319 flowers/plant on the average at 1250 DD. The pooled DAE model again indicated essentially the same predictive capacity as the DD model; however, like the leaf model, the flower DAE model will not be as effective under unusual temperature regimes. The July 2, 1986, emergence date, had an R^2 of 0.55 for the DAE model compared to an R^2 of 0.77 for DD.

The pooled DD model for plant height resulted in similar R^2s of 0.92 vs. 0.93, for DD (Figure 6) and DAE (Figure 7), respectively. Individual emergence dates for DD and DAE models had R^2s ranging from 0.90 to 0.99. The pooled DD model indicated a 95% probability that a random population of jimsonweed would be under 73 cm in height on the average at 250 DD, under 148 cm on the average at 750 DD, and between 48 and 163 cm on the average at 1250 DD. The DAE model for plant height was not affected by the 1.8 C increase in MHT during the first 30 days after emergence. Plant height was apparently not as sensitive to temperature deviations as were leaf and flower production.

<u>Dry weight and capsule production</u>. Jimsonweed dry-matter production was related very highly (R^2 = 0.88) with DD (Figure 8). A quadratic relationship was demonstrated

between dry-weight production and DD. No interaction ($p = 0.98$) occurred between years and DD with respect to dry-weight production. Due to changing variance as the growing season progressed, the variance for each harvest period was determined and used to construct 95% confidence bands. Dry matter production also correlated strongly with DAE, however interaction ($p=0.02$) was present between dry matter and years (data not shown). The use of DD eliminates that complication and provides a means of predicting dry matter accumulation regardless of temperature variation between years.

Seed capsule production was not significantly related with DD or DAE (data not shown). Weaver et al. (27) have observed that even vigorously growing jimsonweed often aborts flowers. Other environmental variables than were studied here are likely more related to seed production.

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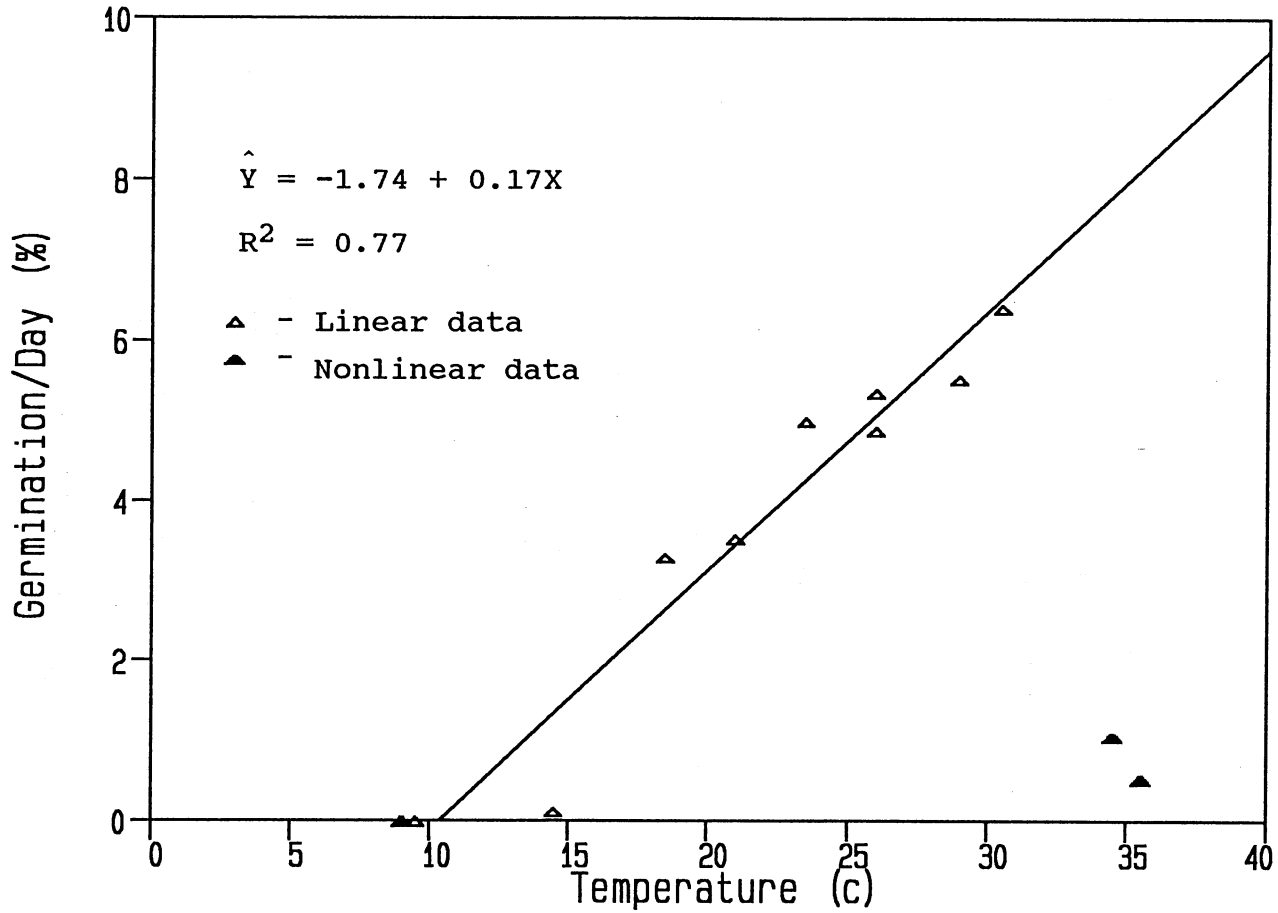

Figure 1. Base temperature determination using percent germination of jimsonweed seed subjected to 11 constant temperatures.

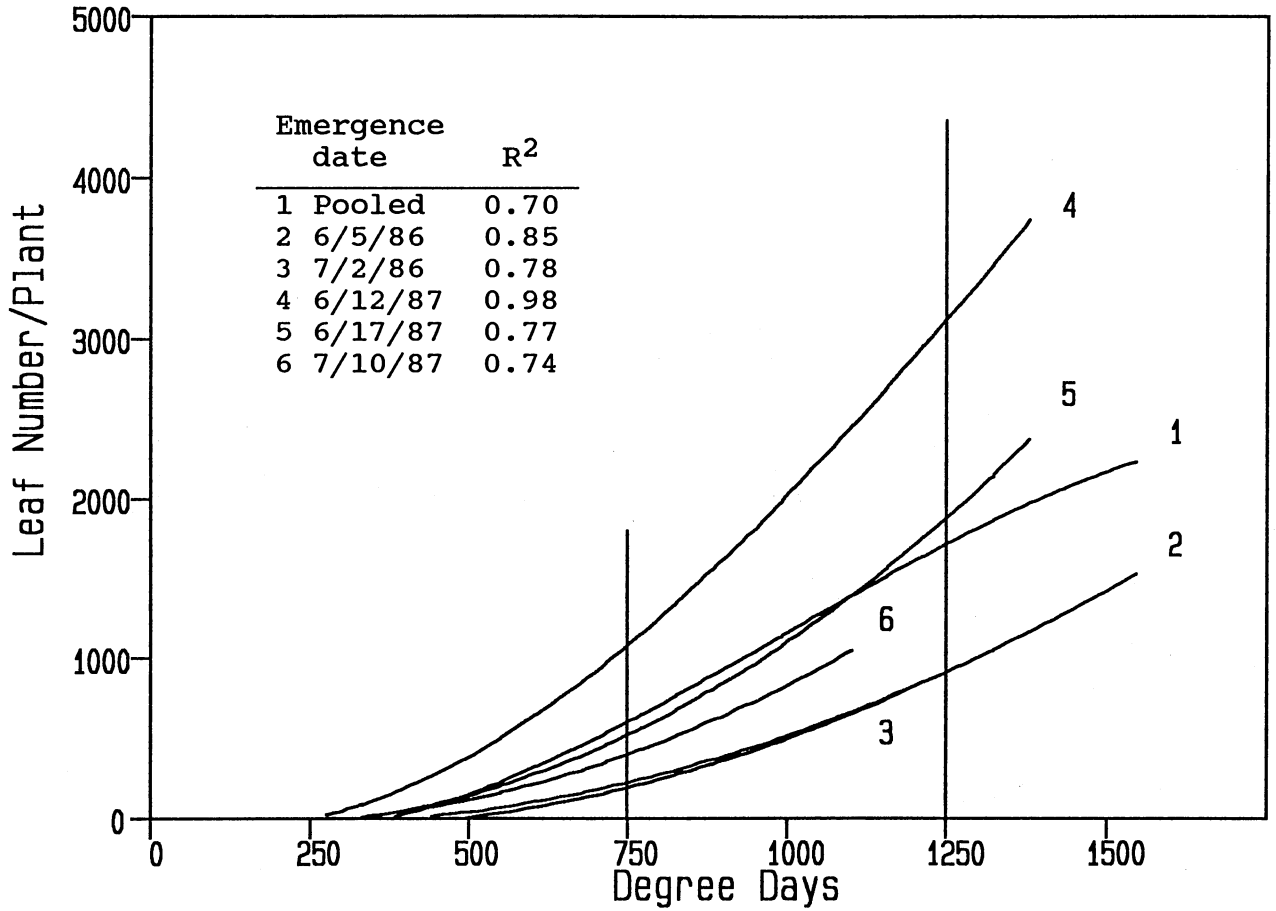

Figure 2. Jimsonweed leaf production vs. degree days for pooled and individual emergence dates (with 95% confidence intervals at 750 and 1250 degree days for the pooled model). Curves on graph are predicted values from the following regression equations where X = 100 degree days. Line 1, $\hat{Y} = -111.45X + 0.03X^2 - 0.0001X^3$, Line 2, $\hat{Y} = -35.01X + 0.09X^2$, Line 3, $\hat{Y} = -46.47X + 0.10X^2$, Line 4, $\hat{Y} = -87.41X + 0.34X^2 - 0.0001X^3$, Line 5, $\hat{Y} = -52.44X + 0.16X^3$, Line 6; $\hat{Y} = 62.58X$.

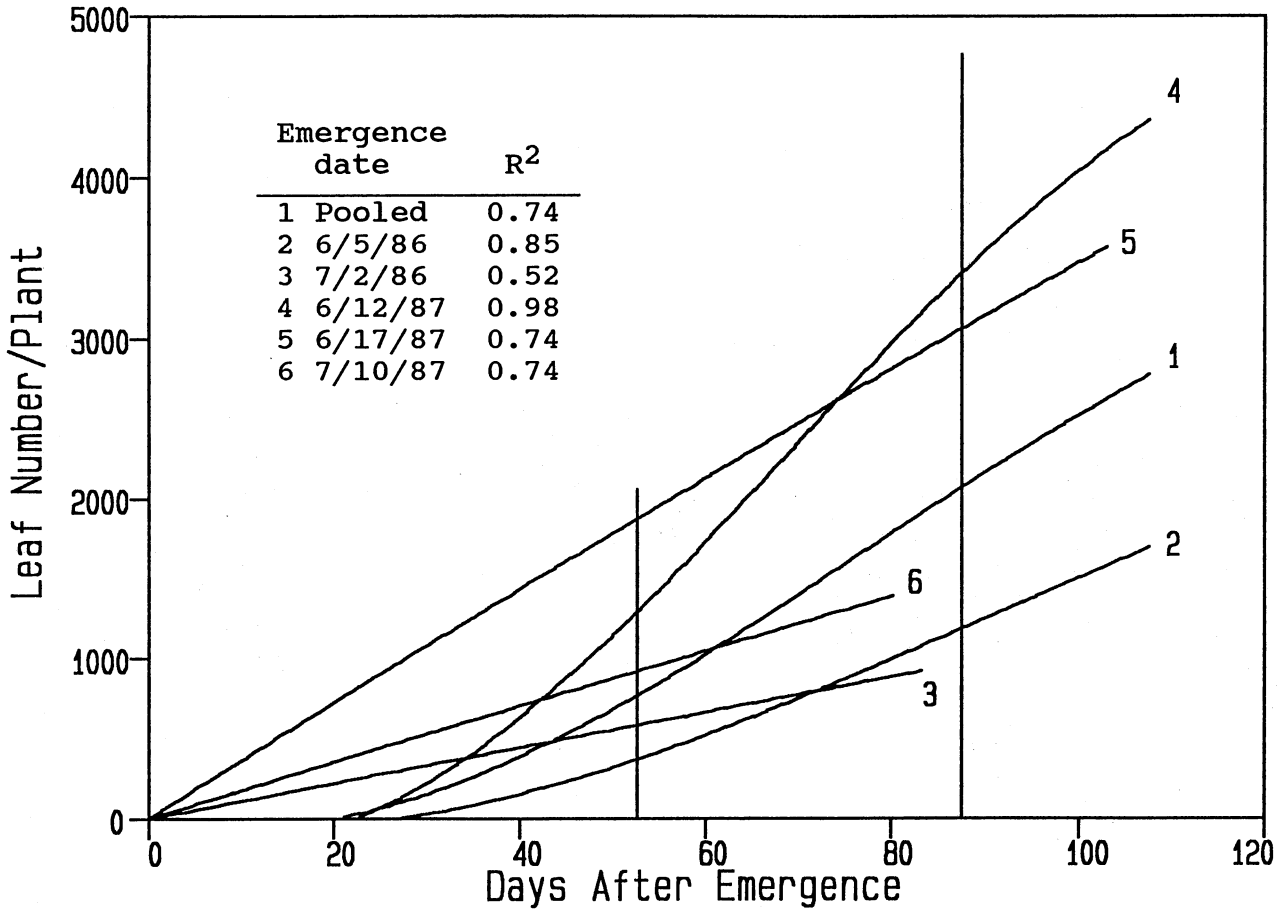

Figure 3. Jimsonweed leaf production vs. days after emergence for pooled and individual emergence dates (with 95% confidence intervals at 52 and 87 days after emergence for the pooled model). Curves on graph are predicted values from the following regression equations where X = days after emergence. Line 1, $\hat{Y} = -11.89X + 0.65X^2 - 0.003X^3$, Line 2, $\hat{Y} = -9.27X + 0.38X^2 - 0.001X^3$, Line 3, $\hat{Y} = 11.05X$, Line 4, $\hat{Y} = -24.94X + 1.26X^2 - 0.006X^3$, Line 5, $\hat{Y} = 36.58X + 0.018X^2$, Line 6, $\hat{Y} = 17.79X - 0.01X^2$.

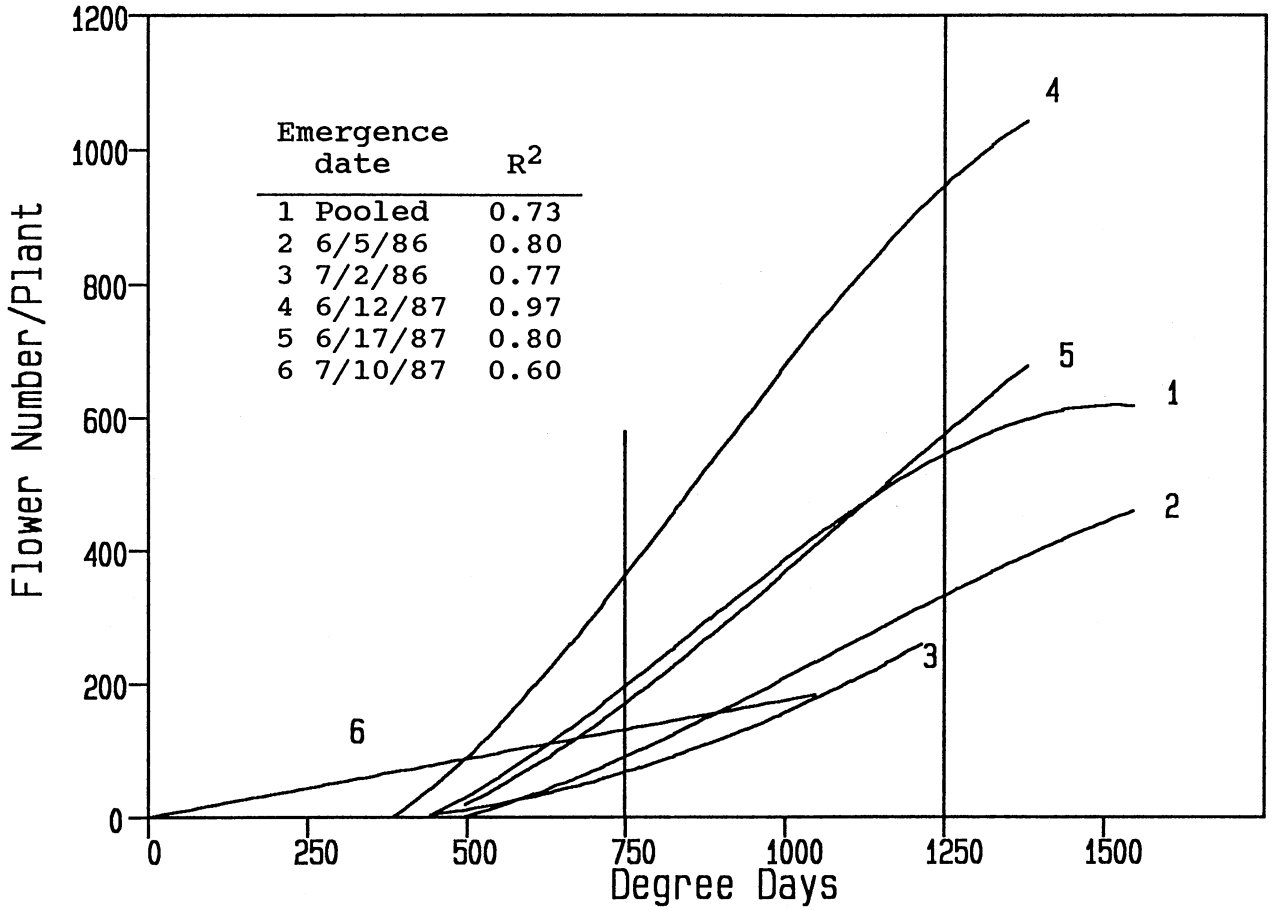

Figure 4. Jimsonweed flower production vs. degree days for pooled and individual emergence dates (with 95% confidence intervals at 750 and 1250 degree days for the pooled model). Curves on graph are predicted values from the following regression equations where X = 100 degree days. Line 1; $\hat{Y} = 55.61X + 0.15X^2 - 0.0001X^3$, Line 2, $\hat{Y} = -31.97X + 0.08X^2 - 0.0002X^3$, Line 3, $\hat{Y} = -11.00X + 0.027X^2$, Line 4, $\hat{Y} = -76.28X + 0.23X^2 - 0.0001X^3$, Line 5, $\hat{Y} = -46.65X + 0.12X^2 - 0.00004X^3$, Line 6, $\hat{Y} = 17.48X$.

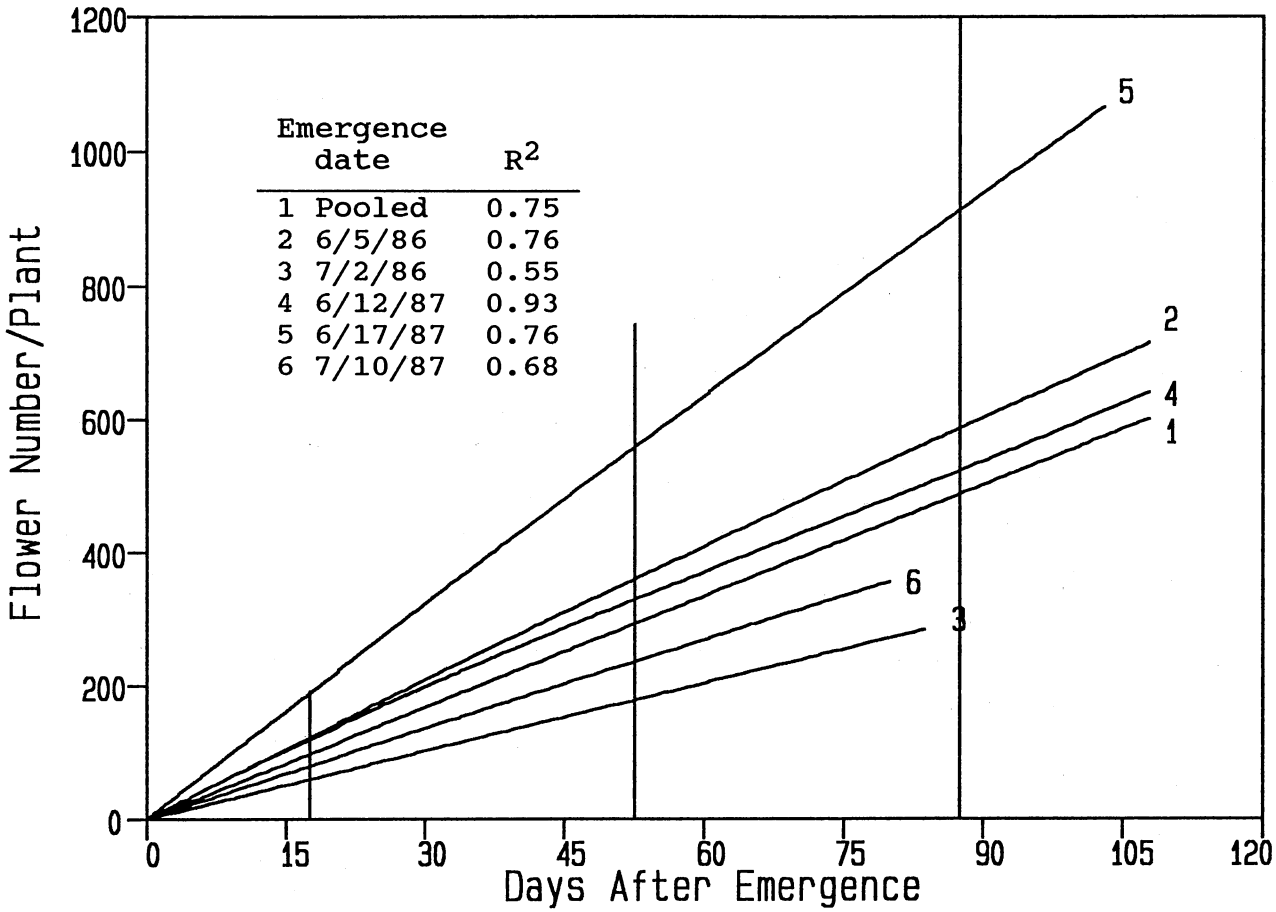

Figure 5. Jimsonweed flower production vs. day after emergence for pooled and individual emergence dates (with 95% confidence intervals at 17, 52, and 87 days after emergence for the pooled model). Curves on graph are predicted values from the following regression equations where X = days after emergence. Line 1, $\hat{Y} = -7.18X + 0.33X^2 - 0.002X^3$, Line 2, $\hat{Y} = 7.08X - 0.004X^2$, Line 3, $\hat{Y} = 3.39X^2$, Line 4, $\hat{Y} = 7.23X - 0.02X^2 + 0.0001X^3$, Line 5, $\hat{Y} = 10.92X - 0.01X^2$, Line 6, $\hat{Y} = 4.57X - 0.001X^2$.

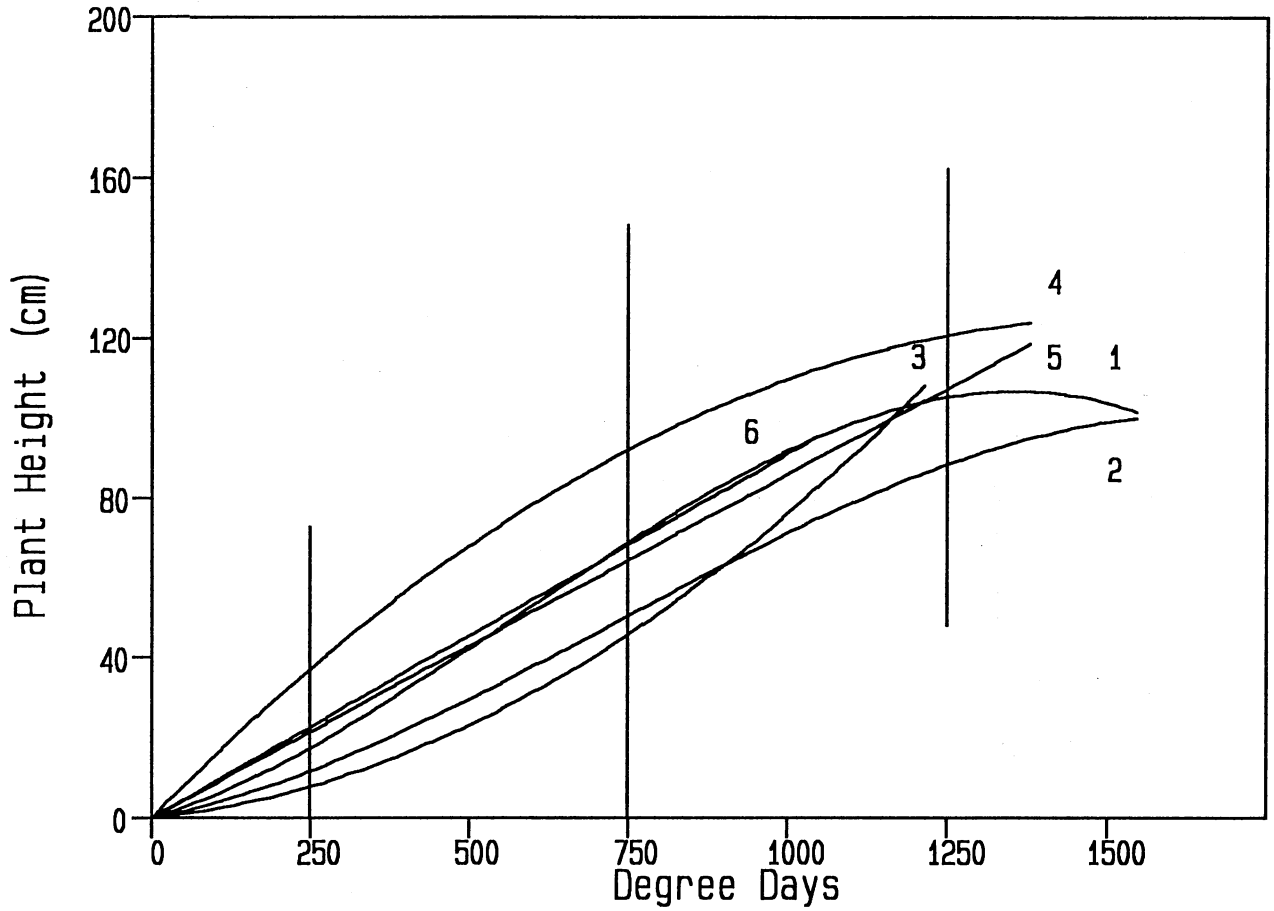

Figure 6. Jimsonweed plant height vs. degree days for pooled and individual emergence dates (with 95% confidence intervals at 250, 750, and 1250 degree days for the pooled model). Curves on graph are predicted values from the following regression equations where X = 100 degree days. Line 1, $\hat{Y} = 47.84X + 1.03X^2 - 0.001X^3$, Line 2, $\hat{Y} = 29.97X + 0.08X^2 - 0.00003X^3$, Line 3, $\hat{Y} = 162.43X + 0.05X^2$, Line 4, $\hat{Y} = 112.97X + 0.06X^2 - 0.0001X^3$, Line 5, $\hat{Y} = 86.02X$, Line 6, $\hat{Y} = 91.08X$.

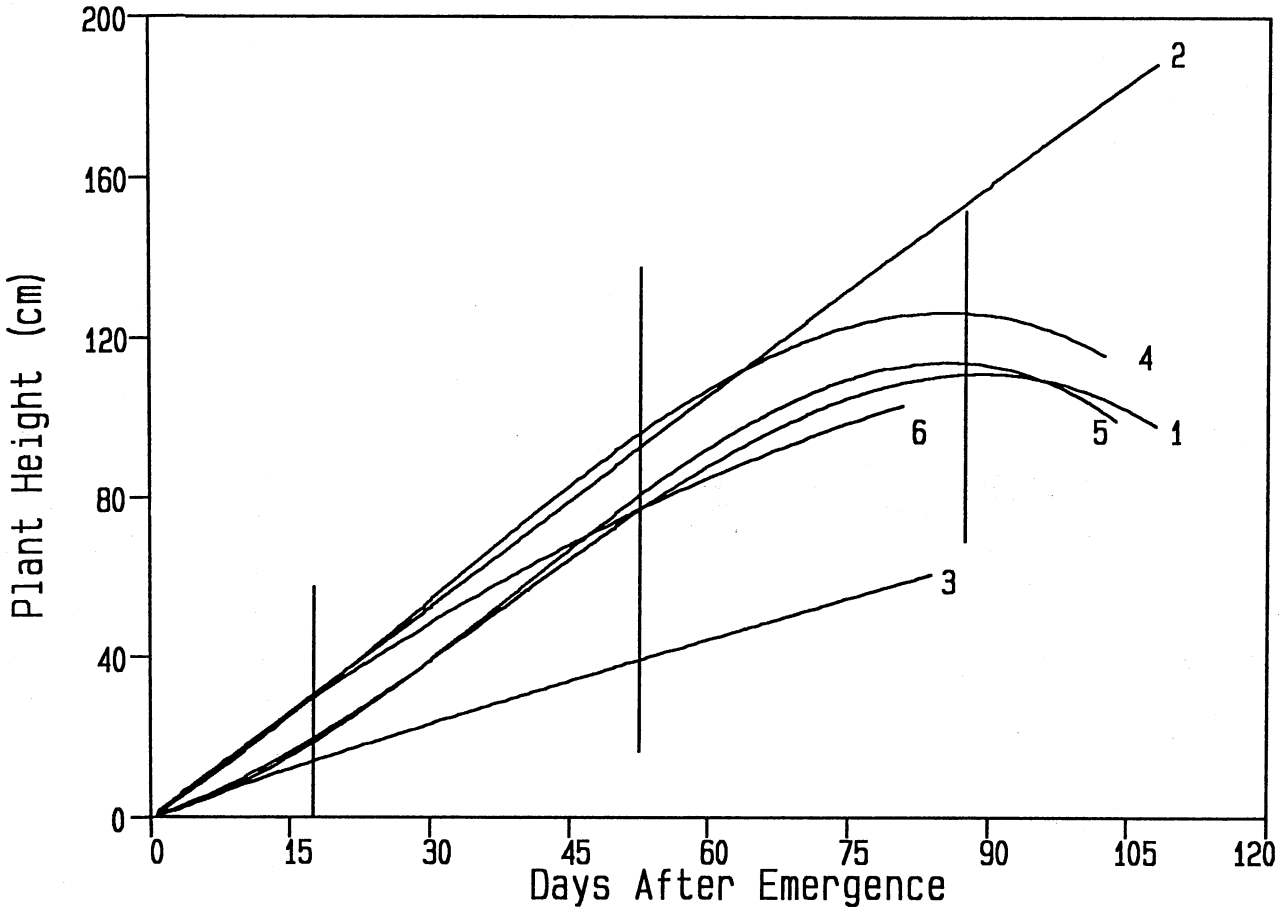

Figure 7. Jimsonweed plant height vs. days after emergence for pooled and individual emergence dates (with 95% confidence intervals at 17, 52 and 87 days after emergence for the pooled model). Curves on graph are predicted values from the following regression equations where X = days after emergence. Line 1, $\hat{Y} = 7.66X + 0.25X^2 - 0.002X^3$, Line 2, $\hat{Y} = 17.34X + 0.01X^2 - 0.00008X^3$, Line 3, $\hat{Y} = 8.34^X$, Line 4, $\hat{Y} = 36.056X + 0.05X^2 - 0.0003X^3$, Line 5, $\hat{Y} = 5.74X + 0.33X^2 - 0.003X^3$, Line 6, $\hat{Y} = 4.57X - 0.001X^2$.

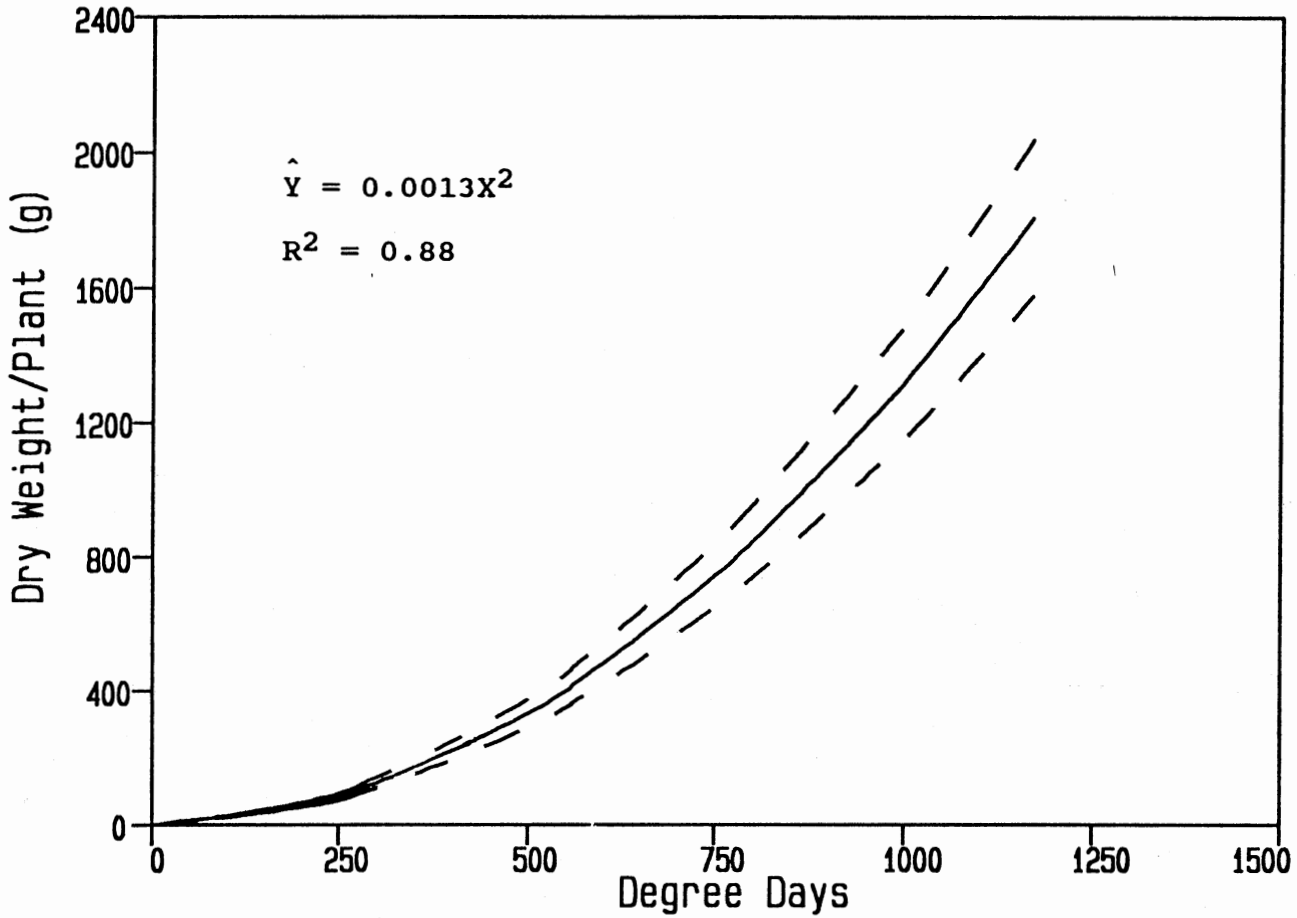

Figure 8. Jimsonweed plant dry weight vs. degree days (with 95% confidence bands).

PART II

INFLUENCE OF CAPSULE AGE ON THE GERMINATION OF NONDORMANT SEED OF JIMSONWEED (*DATURA STRAMONIUM*)

Influence of Capsule Age on the Germination of Nondormant Seed of Jimsonweed (*Datura stramonium*)

Abstract. Seed capsules of various ages were harvested from field-grown jimsonweed. Capsule age was measured as weeks following anthesis. Degree day (DD) accumulation from anthesis and weeks after anthesis preformed equally well in predicting the time required for viable nondormant jimsonweed seed production and to predict changes in seed dry weight. Seed germination increased as capsule age increased from 2 to 6 weeks. No additional increase in germination was observed in seed collected from capsules older than 6 weeks. Maximum seed weight was obtained from 4 and 6 weeks of age in 1986 and 1987, respectively. Sub-optimal moisture conditions were believed responsible for decreased seed weight at the 4 week harvest in 1986, compared to the same time period in 1987. Increased germination was highly correlated with increased seed weight.

Nomenclature: Jimsonweed, *Datura stramonium* L. var. *tatula* Torr. #[1] DATST.

Additional index words. Degree days, thermal unit, temperature, weed biology, DATST.

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street., Champaign, IL 61820.

INTRODUCTION

Weeds have a detrimental impact on crop production the year of weed growth and interference, but they can also adversely affect crop yields in succeeding seasons. Many weed species are prolific seed producers. Redroot pigweed, Amarantus retroflexus L. # AMARE, produces over 100,000 seed/plant; and many other common weeds produce well over 10,000 seed/plant (11). Therefore, a few escape weeds can produce enough seed to keep a field infested with that weed for many years. Egley and Chandler (5) reported velvetleaf, Abutilon theophrasti Medic. # ABUTH, seed retained 36% viability after burial in the field for 5.5 years in the southeastern U.S.

Temperature during seed formation also has an influence on seed viability (1, 9). Schreiber (9) found giant foxtail, Setaria faberii Herrm. # SETFA, produced a higher percent of viable seed when grown at higher temperatures, within the 10 to 27 C temperature range.

Plants vary in their ability to produce viable seed when the parent plant's growth has been terminated. Walker (12) harvested sweet corn, Zea mays L., from 13 to 55 days after silking to determine the potential of viable seed production from immature plants. Germination ranged between 14 and 100% for seed harvested 13 and 55 days after silking, respectively. However, germination of 90% or greater was obtained from all seed harvested 31 days after silking. Further data showed germination was highly correlated to seed dry weight. Other researchers

reported percent emergence to be highly correlated with seed dry weight among 10 grass species (6). Increased seed dry weight of carrot, Daucus carota L., and snap bean, Phaseolus vulgaris L., have also been reported to correlate well with increased germination (2, 3).

After ripening may also influences percent germination in some species. Cochran (3) found only 5 to 6% emergence from seed harvested from green, mature pimiento, Cassicum spp., which were immediately planted. Seed harvested at the same time, but stored in the fruit and planted 30 days later, had an emergence rate of 95%, which was equal to the germination of seed taken from fully ripened fruit.

If the time required to produce viable seed were known, an effort could be made to remove those plants to reduce further infestation. The objectives of this research were to determine jimsonweed capsule age, in weeks after anthesis and degree days, which would produce viable seed and determine the relationship between seed weight and percent germination.

MATERIALS AND METHODS

Field studies were initiated in May of 1986 and 1987, on a Teller fine sandy loam (Udic Argiustoll), on the Agronomy Research Station near Perkins, OK. Locally collected jimsonweed seed were planted on May 15 of each year in a randomized design with 4 replications. Individual plots consisted of single plants spaced 3 meters within and between rows. Approximately 40 seed were planted in each of 40 plots. Seedlings were thinned to five

plants/plot 3 days after emergence and to one plant/plot 10 days after emergence. In each year, all plants used in the experiment emerged within a 24 hour period of each other. Temperature data were recorded hourly with a weather station located approximately 20 m and 60 m from the center of the experimental area in 1986 and 1987, respectively. Degree days were calculate using a base temperature of 10.5 C, an optimal temperature of 30.5 C, and no penalty for temperature higher than the optimum (7).

Herbicides were applied to control undesirable weeds; however, a 31 cm^2 area where jimsonweed was to be planted, was covered to prevent herbicide treatment to these areas. A preemergence tank mixture of 1.1 kg ai/ha of oryzalin, 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide, and 1.1 kg ai/ha of prometryn, N,N'-bis(1-methylethyl)-6-(methylethylthio)-1,3,5-triazine-2,4-diamine, were applied in 1986. In 1987, alachlor, 2-chloro-N'-(2,6-diethyl phenyl)-N-(methoxymethyl)acetamide, at 2.2 kg ai/ha and prometryn at 1.1 kg ai/ha were applied preemergence over the experimental area. Escape weeds were removed by hoeing or hand pulling throughout the growing season in both years. Permethrin, (3-Phenoxyphenyl) methyl(±)-*cis*, -*trans*-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-carboxylate, and carbaryl, 1-naphthyl N-methylcarbamate, were used throughout the growing season in 1986 and 1987, respectively, to control the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), which was feeding on the weed. Overhead supplemental irrigations were applied with a side-roll sprinkler

system when needed to prevent drought stress.

To record capsule age, flowers in anthesis were marked on the receptacle area with a 0.5 by 1 cm stripe of nonphytotoxic[2] acrylic paint[3]. Jimsonweed flowers are open for 1 day only (10); therefore, the date of anthesis could easily be recorded. Flowers were marked at 14-day intervals starting on July 6 and 7, in 1986 and 1987, respectively, and continued until 2 weeks prior to harvest. Different colors of paint were used at each marking date to identify the date of anthesis. All seed capsules were harvested on September 15 and 16, in 1986 and 1987, respectively. Seed capsules were collected and sorted by anthesis dates. Capsule age was measured as the time following anthesis. Sufficient capsules and seed were collected from 2, 4, 6, and 10 weeks after anthesis to conduct germinations studies. Adequate capsules were not available for week 8 in both years due to a failure to accurately identify a sufficient number of marked capsules from that anthesis date. Seed capsules were dried at 32 C for 14 days and then placed at 0 C for a minimum of 5 months before germination tests were begun. All seed, regardless of size, were removed from the capsules and stored in double paper envelops until germination tests were conducted. Each envelope contained the seed from 1 capsule. Four envelopes from each harvest date plant were randomly selected. All selected envelopes were then divided into two sets of four replications of

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[2]Personal communication from W. W. Witt.

[3]Liquitex acrylic artist color. Binney & Smith Inc., Easton, PA 18042.

50 seed/replication. Seed weight was determined by randomly counting 50 seed/envelope and weighing. The weighed seed were then placed between two sheets of 13 cm Whatman filter paper placed in 15 cm glass petri dishes. To promote germination, all petri dishes were placed in a dark germinator under a constant temperature of 30.5 C for 14 days and filter paper were moistened with 5 ml of 0.1 M KNO_3. Seed were considered germinated when the radicle reached 1 mm. Germinated seed were counted and removed and filter papers were remoistened daily. Analysis of variance was conducted with date of anthesis and DD as independent variables. Dependent variables consisted of percent germination and seed weight. The correlation coefficient between seed weight and germination was also determined.

From the remaining seed, 4 replications of 50 randomly selected seed from 4-, 6-, and 10-week-old capsules, and two replications from 2-week-old-capsules, were separated into three weight classes by means of an air-column seed blower[4]. Number of seed/weight class was used to determine variation in seed weight within individual capsules. Weight classes consisted of seed heaver than 300 mg/50, lighter than 100 mg/50 seed, and between those two levels.

RESULTS AND DISCUSSION

Maximum germination was reached by 6 weeks after anthesis (Figure 1). Seed collected from capsules 2 weeks after anthesis

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[4]South Dakota Seed Blower, E. L. Ericson Products, Brookings, SD 57007.

showed only 10% germination (Figure 1). The seed which germinated were generally heavier than the seed which did not germinate (Data not shown). Preliminary data indicates individual seed weight within capsules under 6 weeks old vary from under 100 to over 300 mg/50 seed. All seed from capsules greater than 6 weeks of age weighted greater than 300 mg/50 seed. Satina and Rielsema (8) have reported varying rates for Datura spp. seed development within the same seed capsule; this source of variability was likely responsible for the differences in seed size and germination from the 2-week-old-capsules. A correlation coefficient of 0.85 between seed weight and percent germination indicated a strong relationship between the two variables.

Seed weight increased as the time following anthesis increased (Figure 2). Seed weight from 2 and 4 weeks after harvest increased at an accelerated rate in 1987, compared to 1986. Seed collected at 2 and 4 weeks following anthesis in 1986 weighed less than seed collected at those times in 1987. Differences were not found at 6 vs 10 weeks, indicating final seed weight is relatively constant. Maximum seed weight was reached at 4 weeks in 1987, but 6 weeks were required in 1986. Seed were harvested 3 days earlier in 1987, compared to 1986. DD had reached 589 at harvest in 1987 compared to 516 at harvest in 1986, which may at least partially account for the differences in seed dry weight. It is also possible that the three extra days prior to harvest in 1987 were partly responsible for increased seed weight, regardless of DD accumulation. Satina and Rietsema (8) have reported increased seed weight three weeks after

anthesis due to accumulation of food reserves. The relationship of seed weight to DD (R^2 = 0.82) and days after anthesis (R^2 = 0.78) were similar. Similarities in their coefficients of determination indicate either method can be used equally as well. Environmental factors other than temperature may have influenced seed dry-weight accumulation. Moisture conditions during seed development for the 4-week harvest treatment in 1986 were inferior to moisture conditions for the same treatment during 1987 (Figure 3); however, no visual drought stress, as determined by leaf wilt, was observed in either year. Suboptimal moisture conditions were judged to be the factor responsible for lower seed weights in the 4-week harvest treatment in 1986. However, reduction in seed weight for the 4 week treatment did not adversely affect germination, indicating that seed maturation had progressed sufficiently to produce viable seed. Salter and Goode, as cited by Austin (2), have reported reduced seed weight due to drought occurring after fertilization.

Removal of jimsonweed seed capsules 2 weeks after anthesis reduces nondormant seed production 82%, compared to seeds allowed to reach full maturity. Suboptimal moisture conditions were believed to reduced 4-week-old seed dry weight 54% compared to 4-week-old seed grown under optimal moisture conditions. Capsules allowed to remain on growing plants for 6 weeks or longer produced the maximum number of viable seed.

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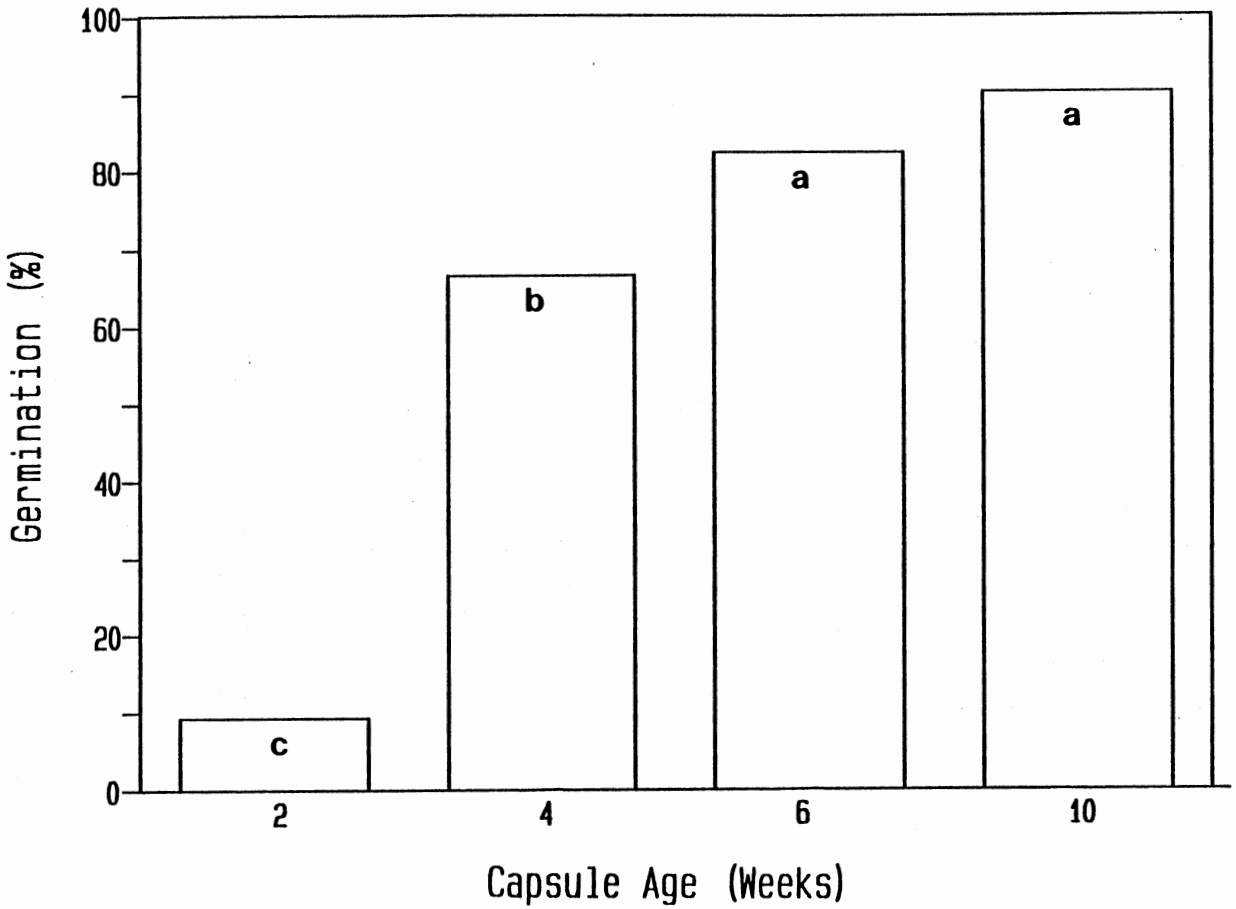

Figure 1. Jimsonweed seed germination from capsules harvested 2, 4, 6, and 10 weeks after anthesis. Bars containing different letters are significantly different at the 5% level according to protected LSD test.

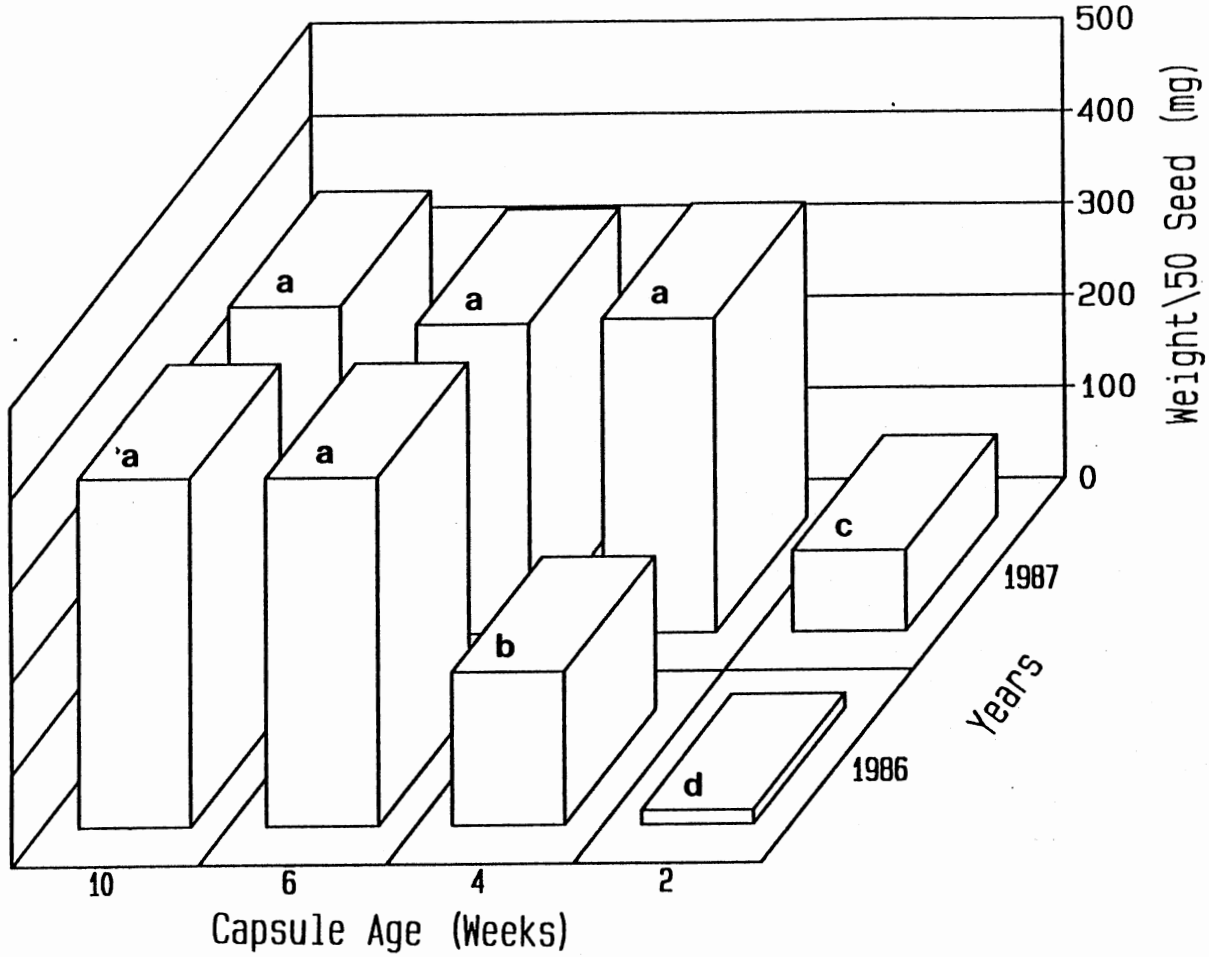

Figure 2. Jimsonweed weight/50 seed for capsules harvested 2, 4, 6, and 10 weeks after after anthesis. Bars containing different letters are significantly different at the 5% level according to protected LSD test.

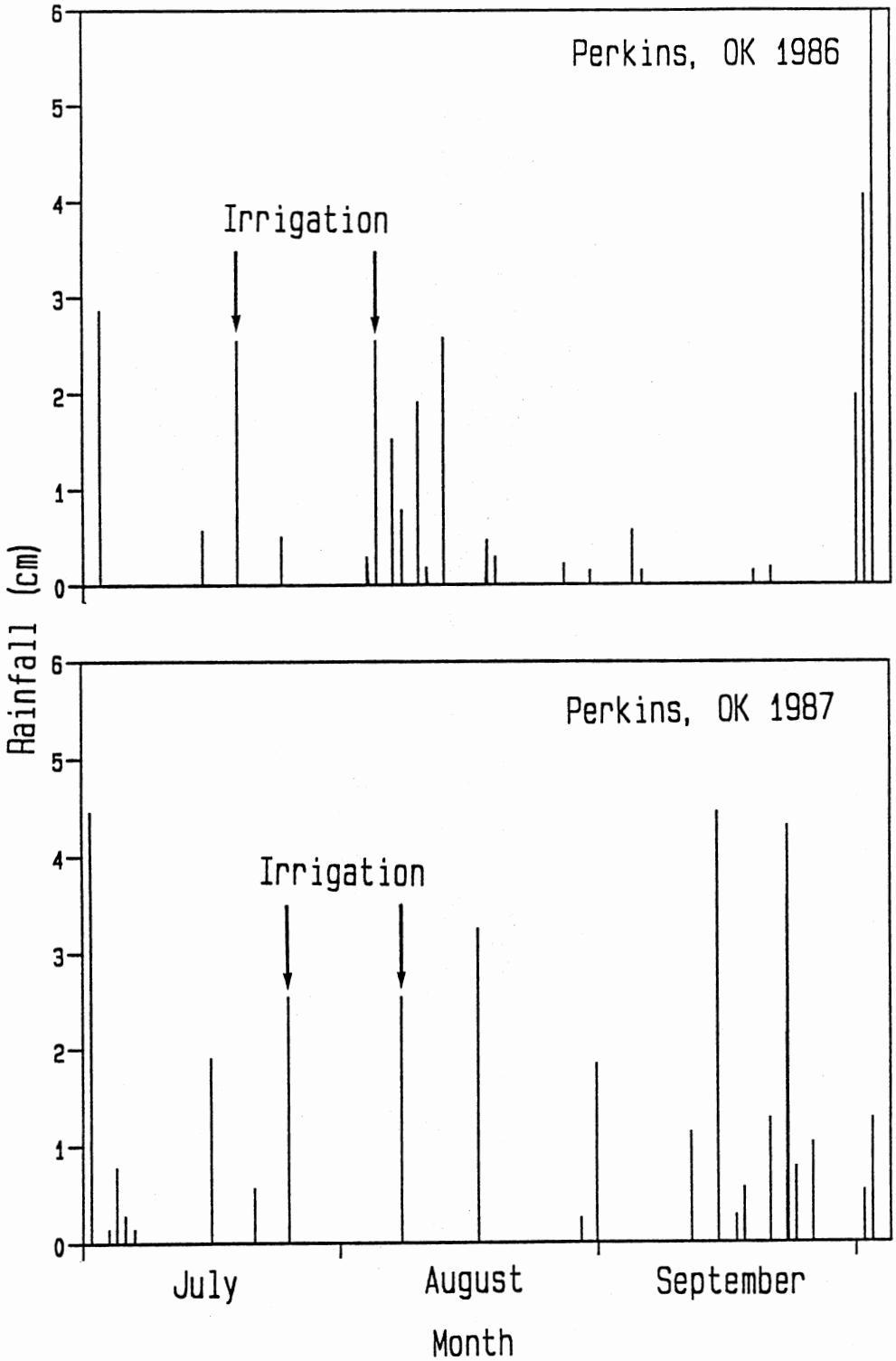

Figure 3. Frequency and amount of rainfall and irrigation at Perkins, OK, in 1986 and 1987.

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VITA

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Doctor of Philosophy

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