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The response of Upland and Pima cotton to date of planting in southern Arizona

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THE RESPONSE OF UPLAND AND PIMA COTTON TO DATE OF PLANTING IN SOUTHERN ARIZONA

By

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APPROVAL BY THESIS DIRECTOR

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES - Continued

LIST OF FIGURES

ABSTRACT

A field experiment was conducted at the University of Arizona Marana Agricultural Center to evaluate the effect of planting date on Upland as a short staple (Gossypium hirsutum L.) and Pima cotton as a long staple (Gossypium barbadense L.) cotton.

Planting dates were 27 April, 13 May, 27 May, and 9 June, 1988. Cotton varieties consisted of three maturity groups: early maturity Delta and Pine Land 20 (DPL 20) and full season Delta and Pine Land 90 (DPL 90) from G. hirsutum L., and Pima S-6, a variety of the more indeterminate type G. barbadense L.

Parameters such as plant height, number of mainstem nodes, flowers, plant population, and yield were used to evaluate the relationship of plant development and heat unit (H.U.) accumulation during the growing season as a function of planting date.

A number of cold periods at Marana in the early spring of 1988 created unfavorable conditions for all cotton varieties on the early planting date. This condition resulted in lower H.U. availability during germination, especially 5 and 10 days after the planting date, and significantly altered the usual pattern for flowering on planting date (PD) 1. The amount of H.U. accumulation for PD 2, especially during germination, was higher than for PD 1, which contributed to better stand development and the highest yield on PD 2 for all cotton varieties.

CHAPTER 1

INTRODUCTION

Two important species of cotton are grown in Arizona: short staple Upland (Gossypium hirsutum L.) and long-staple Pima (G. barbadense L.). Each species contains several varieties of cotton. Both species are perennial but are planted and grown as annuals (Dennis and Briggs, 1969). In recent years the smooth leaf Deltapine (Delta and Pine Land Co.) varieties of Upland cotton have become predominant, and superior yielding ability has encouraged their widespread use. Deltapine 90 (DPL 90), considered to be full season, and Deltapine 20 (DPL 20), an early maturity type of cotton, are two important varieties of Upland cotton grown in Arizona. The average yield for Upland cotton reported from 1984 to 1988 was between 1336 to 1583 kg/ha harvested from 101,809 to 173,684 ha (1988 Arizona Agricultural Statistics, 1989).

American Pima or extra-long staple (3.81 to 4.44 cm staple length) cotton produces a fiber much longer than short staple Upland varieties (1.90 to 4.44 cm staple length). Eleven varieties of extra-long staple cotton have been developed, released, and grown in New Mexico, Arizona, and, to some extent, California. Pima S-6 was released in 1983 (Turcotte and Feaster, 1988). The average yield for Pima cotton reported from 1984 to 1988 was between 944 to 1264 Kg/ha harvested from 20,364 to 51,821 ha (1988 Arizona Agricultural Statistic, 1989).

For many years planting dates have been of interest in the study of cotton production because of the relationship of planting dates to crop management, pest control, and cost reduction. Information about differences associated with specific varietal planting dates is especially useful to cotton growers faced with a delayed planting or replanting situation. Growers in Arizona take advantage of the 3561 to 4513 heat unit (H.U. with 30/12.7 C thresholds) at high and low elevations (Safford and Yuma), respectively, from 15 Feb. to 1 Oct. by commonly using a two-fruit set regime. Planting in late March and early April brings peak blooming in early July. Cut-out occurs in early to mid-August, and new bloom production resumes in early September. Top crop maturation typically requires 240 to 270 total days in the growing season with 3800 H.U. (Tollefson, 1987).

Since 1985, a series of field experiments have been conducted at several locations (Yuma Valley, Maricopa, Marana, and Safford; University of Arizona Agricultural Centers) to evaluate the effect of planting date on lint yield of several varieties of cotton (Kittock and Hofmann, 1987; Kittock et al., 1988; and Silvertooth et al., 1989). An experiment conducted in 1988 at the Marana farm used three varieties (DPL 20, DPL 90, and Pima S-6) on four planting dates (27 April, 13 May, 27 May, 9 June) to evaluate the effect of planting date as a function of heat units in the growth and development of cotton.

The results of an earlier study by Kittock and Hofmann (1987) showed higher yield with early planting (late April at Marana). However, the results of the 1988 experiment at the Marana farm show more vegetative growth (plant height, mainstem nodes) with less yield for the early planting date (27 April). For each planting, temperature data available at Marana were used to determine the influence of the H.U. accumulation on the three cultivars.

The objectives of this study were:

1. To evaluate the effect of planting dates of different cotton varieties possessing varying degrees of indeterminate growth habit on optimum growth and yield.
2. To evaluate the relationship of time (days) and H.U. accumulation on the growth and development of DPL 20, DPL 90, and Pima S-6 varieties of cotton.

CHAPTER 2

LITERATURE REVIEW

A review of literature shows a direct relationship between potential yield and the number of growing days (Bilbro and Ray, 1973) . Since 1985 a series of field experiments have been conducted at four University of Arizona Agricultural Centers (Yuma Valley, Maricopa, Marana, and Safford) to determine the effect of planting dates on yield of several varieties of Upland and Pima cotton (Kittock and Hofmann, 1987; Kittock et al., 1988; Silvertooth et al., 1989). Data collected from 1985 to 1987 by Kittock et al. showed that full-season Upland varieties and Pima cotton reach greatest yield potential when planted early with sufficiently warm conditions. However, the yield potential of full-season varieties diminishes quite rapidly with delayed planting (late April through May).

Silvertooth et al. (1989) reported a similar result for several varieties of Pima and Upland cotton at four locations (Maricopa, Marana, Safford , and Yuma, University of Arizona Agricultural Centers). Higher yield potential was found for full-season varieties, particularly when planted at an earlier date. Yield potential of full-season varieties diminishes quickly with delayed planting in comparison to varieties that are considered mid or shorter season varieties. Research done at the Texas A&M Research Center by Waissman et al. (1984) showed that delayed planting after April significantly decreased the intervals between emergence, flowering, and boll maturation. For Upland cotton, the interval between emergence and the onset of boll maturation was between 121 and 126 days; for Pima cotton the interval was between 132 and 141 days.

The experimental results found by Taylor et al. (1984) indicated that a warmer than average spring or fall should result in higher yield. Temperature is especially important during the seedling stage. Change of temperature directly affects plant metabolic activity, which is ultimately related to plant growth and development (Integrated Pest Management, University of California, 1984). A report by Deterling and El-Zik (1982) showed that under favorable conditions, seedlings emerge 5 to 15 days after the seed are planted. Temperatures below 16.5^0 C will slow germination, emergence and seedling growth. During the first 60 to 100 hours of germination, the radicle tip is easily damaged by chilling, and lack of oxygen in the soil. The influence of temperature on cotton in relation to proper date of planting has been studied extensively by Bilbro and Ray (1973); Chlichlias et al. (1977); and Christiansen and Thomas (1969). They found the sensitivity of cotton to low temperature especially during the seedling stage.

Although temperature is certainly not the only environmental factor influencing cotton production, it is an important one, and has the distinct advantage of being relatively easy and inexpensive to measure. The concept of heat units, which is a measure of temperature over time, has been used to study certain developmental aspects of cotton (Pegelow and Fisher, 1986). Temperatures too hot or too cold will not allow proper growth and development of cotton; therefore, planting should be scheduled to take advantage of the optimal thermal range (Brown, 1989). One way to determine this optimal thermal range is to study H.U. accumulation patterns.

An experiment by Waissman et al. (1984) studying the relationship between H.U. accumulation and growth development indicated that a combination of temperature and time measurements can be used to monitor crop progress of long-season cotton in west Texas. Summation of H.U. and days from 60% emergence effectively predicted the first effective bloom and open boll, and may also be a coarse indicator of lint yields. This study concluded that H.U. accumulation at the beginning of the season influences bloom and boll production at the end of season and could be used as an indicator of optimal cotton planting dates.

CHAPTER 3

MATERIALS AND METHODS

One Pima and two Upland cotton varieties were planted in four row plots on four planting dates at the University of Arizona Marana Agricultural Center in 1988. The experimental design was a split plot within a randomized complete block, with planting dates as main plots (27 April, 13 May, 27 May, and 9 June, 1988). Three varieties were subplot treatments (DPL 90, DPL 20, Pima S-6), with all treatment combinations replicated four times.

Row spacing was 1 meter, plot length 12 m, and four rows in width All plots were seeded at a rate of 160,000 seed per hectare, with a final plant population ranging from 92,000 to 135,000 plants per hectare. The fertility, water, and insect control were managed in a conventional full-season format; full benefit of yield expression was given to all varieties before irrigation termination date (Sep. 14).

On each sampling date parameters were measured in 1-m subplots samples at random from each distinct experimental unit (varieties*planting date).

The parameters measured were:

1. Number of plants per meter
2. Plant height (cm)
3. Mainstem nodes per plant

4. Flowers per meter sample
5. Yield of each planting date for each variety (end of season only)

The soil on the experimental site at Marana is a Pima clay loam (Thermic Torriflurent). Planting dates (PD) are notated as follows: 27 April (PD 1), 13 May (PD 2), 27 May (PD 3), and 9 June (PD 4). Sampling for the previously stated parameters was made on :

25 June

2, 18, 23, July

13, 25, Aug.

13 September

8 and 26 Oct. .

The seed cotton was harvested with a mechanical picker from the center two rows of each plot on 17 Nov. The yield for each variety was weighed separately according to planting date, and average yield of all four replications was reported for each variety and planting date combination.

Analysis of variance (ANOVA) was computed for the data with planting date as the main plot (whole unit) and three cultivars as subplots (subunits) for each specific date of sampling (Gomez and Gomez, 1984).

Heat Units

Daily H.U. accumulation was provided by the AZMET station site at the Marana Agricultural Center with upper and lower threshold temperatures of 30^0 and 12.7^0 C, respectively. The H.U. accumulation per centimeter plant height and per node was calculated by dividing H.U.

accumulation since planting date by the measurement of plant height and number of mainstem nodes on each specific sampling date. Treatment means were tested with a Fisher 's LSD test on each sampling date (Ott, 1984).

CHAPTER 4
RESULTS AND DISCUSSION

Analysis of Variance in Plant Height and Mainstem Node Production

Plant height is an important parameter for measurement because of its relationship to canopy geometry, light interception and ultimate yield in both Pima and Upland varieties. In this experiment plant height for the three varieties of cotton (DPL 20, DPL 90, and Pima S-6) was measured on nine sampling dates throughout the growing season. An ANOVA of plant height was run for each of the four planting dates. An early sampling (25 June, 1988) detected height differences within each variety related to the planting date (Table 1). According to a Fisher's LSD method of means comparisons (Ott, 1984) significant differences were found for DPL 20 between PD 1 and all other three planting dates. The results of average plant height analysis for DPL 90 shows significant differences among all four planting dates. Pima S-6 shows no significant differences between PD 1 and PD 2, but significant differences for PD 's 1 and 2 versus 3 and 4, which is not unusual in an early sampling date. The average plant height sampled on 13 Aug. still indicated differences among planting dates for DPL 20 and Pima S-6 (Table 2). By the end of the growing season, plant height was uniform for some varieties (Table 3). A series of cold periods early in the season, especially during germination, resulted in lower H.U. accumulation than required for optimum growth. This condition resulted in delayed plant height for PD 1 compare to PD 2 (Table 3). An earlier study by Kittock et al. (1987) showed the same results, with the chilling cotton during germination and emergence, which reduced final plant height.

The second parameter considered was the number of mainstem nodes produced per plant. As the number of mainstem nodes increased so did the number of reproductive branches, and thus potentially the number of bolls and fruit. As with plant height, significant differences were noted in the early sample for the average number of mainstem nodes (Table 4). By 13 Aug., the average number of mainstem nodes still varied (Table 5). This parameter, too, became uniform near the end of the growing season (Table 6). In general there were differences in plant height and mainstem node production at the early sampling, and uniform plant height and mainstem node number by the end of season (Tables 1 to 6). Christiansen and Thomas (1969) reported the same result for chilling of cotton seed during the germination and emergence stage which resulted in reduced final plant height and delayed fruiting development. As a result of cold conditions in the early season for PD 1, the average number of plant height and mainstem nodes became lower for PD 1 compare to PD 2 (Table 3 and 6).

The H.U. accumulation per unit of plant height and mainstem node were calculated to determine any relationship to plant height and mainstem node development (Tables 7 to 12). On 25 June the total H.U. accumulation for PD 's 1, 2, 3, and 4 were 1236, 998, 679, and 412, respectively. The average H.U. accumulation per unit of plant height and mainstem node on 25 June was higher for PD 2 than for PD 1 (Tables 7 and 10). More research is needed to find out the exact range or threshold for H.U. accumulation per unit plant height and mainstem node which causes vegetative development. Significant differences for H.U. accumulation per unit of plant height and mainstem node appear in the early season, especially June and July and by the end of the season these differences became insignificant as plant height and mainstem node production became more uniform (Table 7 to 12). From this experience, H.U. accumulation especially during germination and early sampling was lower per unit of plant height and mainstem node for PD 1 compare to PD 2 (Table 7 and 10). This resulted in a delay of plant height and mainstem node production for PD 1 compare to PD 2 in the end of season (Table 3 and 6).

Table 1. Average plant heights in several cotton varieties at four planting dates, sampled 25 June, 1988.

VARIETY	PLANT HEIGHTS						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
	cm						
DPL 20	32.9A*	18.3 B	9.3 B	4.7B	13.7	.032	13
DPL 90	37.3A	18.2 B	9.9 C	5.5D	3.6	.005	3
PIMA S-6	28.7A	23.1 A	10.1 B	4.6B	5.9	.004	5

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
§ PD = Planting date.

Table 2. Average plant heights in several cotton varieties at four planting dates, sampled 13 Aug., 1988.

VARIETY	PLANT HEIGHTS						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
	cm						
DPL 20	130.6AB*	139.5A	117.2BC	108.4C	13.7	.01	6.9
DPL 90	100.2	112.7	104.0	98.7	NS	.06	5.2
PIMA S-6	123.2A	122.0A	101.9B	93.6B	10.8	.00	6.1

*Means followed by the same letter within a row are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS=Not significant.
§ PD = Planting date.

Table 3. Average plant heights in several cotton varieties at four planting dates, sampled 26 Oct., 1988.

VARIETY	PLANT HEIGHTS						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
	cm						
DPL 20	147.4	157.2	148.2	170.5	NS	.20	5.2
DPL 90	116.4C*	115.1C	128.7B	140.1A	4.2	.00	1.0
PIMA S-6	161.5	150.4	149.4	144.8	NS	.40	5.2

*Means followed by the same letter within a row are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS=Not significant.
§ PD = Planting date.

Table 4. Average mainstem nodes per plant in several cotton varieties at four planting dates, sampled 25 June, 1988.

VARIETY	NUMBER OF MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	10.8A*	7.2AB	3.4BC	3.0C	4.5	.03	25
DPL 90	11.3A	6.2B	3.3C	2.0C	1.5	.00	9
PIMA S-6	11.3A	8.4B	3.1C	3.0C	2.0	.00	10

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
§ PD = Planting date.

Table 5. Average mainstem nodes per plant in several cotton varieties at four planting dates, sampled 13 Aug., 1988.

VARIETY	NUMBER OF MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	23.5A*	22.3A	19.0B	17.3B	1.7	.01	5
DPL 90	19.7	21.0	18.9	18.0	NS	.06	8
PIMA S-6	21.9A	20.9AB	19.0BC	17.9C	2.6	.00	8

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS = Not significant.
§ PD = Planting date.

Table 6. Average mainstem nodes per plant in several cotton varieties at four planting dates, sampled 26 Oct., 1988.

VARIETY	NUMBER OF MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL*	CV%
DPL 20	25.0	25.0	26.2	24.1	NS	.90	10
DPL 90	24.2	22.9	25.8	25.3	NS	.80	10
PIMA S-6	25.8	25.1	25.0	27.4	NS	.40	5

*Observed significance level (probability of a greater F value).
NS = Not significant.
§ PD = Planting date.

Table 7. Average H.U. accumulation since planting date per cm plant height in several cotton varieties at four planting dates, sampled 25 June, 1988.

VARIETY	H.U./CM PLANT HEIGHT						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	38.3	78.2	77.3	109.4	NS	.29	34
DPL 90	34.2B*	62.1AB	80.1A	88.1A	30	.04	14
PIMA S-6	44.1B	44.4B	71.0AB	116.3A	45	.04	20

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS = Not significant.
§ PD = Planting date.

Table 8. Average H.U. accumulation since planting date per cm plant height in several cotton varieties at four planting dates, sampled 13 Aug., 1988.

VARIETY	H.U./CM PLANT HEIGHT						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	19.4	16.7	17.3	16.1	NS	.07	7
DPL 90	29.3A*	20.7A	19.3B	18.2B	5.9	.02	17
PIMA S-6	20.8A	19.1AB	19.9AB	18.7B	1.8	.01	5

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS = Not significant.
§ PD = Planting date.

Table 9. Average H.U. accumulation since planting date per cm plant height in several cotton varieties at four planting dates, sampled 26 Oct., 1988.

VARIETY	H.U./CM PLANT HEIGHT						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	27.5	24.3	24.5	19.4	NS	.08	7
DPL 90	35.7A*	34.4A	27.5AB	19.7B	9	.04	9
PIMA S-6	27.8	26.8	24.3	17.3	NS	.12	11

*Means followed by the same letter within a row are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS = Not significant.
§ PD = Planting date.

Table 10. Average H.U. accumulation since planting date per mainstem node in several cotton varieties at four planting dates, sampled 25 June, 1988.

VARIETY	H.U./MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL**	CV%
DPL 20	116.1B*	124.5B	215.9A	285.8A	73	.10	12
DPL 90	111.5	232.8	225.6	394.8	NS	.11	29
PIMA S-6	110.3	123.0	254.6	343.3	NS	.13	32

*Means followed by the same letter within a row are not significantly different (P≤0.05) according to pairwise comparisons using a Fisher's LSD.
**Observed significance level (probability of a greater F value).
NS=Not significant.
§ PD = Planting date.

Table 11. Average H.U. accumulation since planting date per mainstem node in several cotton varieties at four planting dates, sampled 13 Aug., 1988.

VARIETY	H.U./MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL*	CV%
DPL 20	110.5	105.9	107.9	102.2	NS	.26	5
DPL 90	133.5	111.8	107.9	100.2	NS	.05	10
PIMA S-6	119.6	113.1	106.4	97.7	NS	.16	9

*Observed significance level (probability of a greater F value).
NS=Not significant (OSL>.05).
§ PD = Planting date.

Table 12. Average H.U. accumulation since planting date per mainstem node in several cotton varieties at four planting dates, sampled 26 Oct., 1988.

VARIETY	H.U./MAINSTEM NODE						
	PD §1	PD 2	PD 3	PD 4	LSD(.05)	OSL*	CV%
DPL 20	160.5	154.1	140.2	134.7	NS	.34	10
DPL 90	172.7	180.5	138.7	110.7	NS	.11	13
PIMA S-6	162.8	154.3	145.4	103.4	NS	.10	11

*Observed significance level (probability of a greater F value).
NS=Not significant (OSL>.05).
§ PD = Planting date.

Flowers

Flowers are often an important parameter to cotton researchers because of their relationship to yield. The relationship between number of flowers per meter of row and H.U. accumulation for each specific planting date was studied in 1988. First bloom count was 1200 to 1300 H.U. accumulation for PD 2, 3, and 4, but PD 2 started blooming with a 1425 H.U. accumulation (Figures 1 to 4). Peak bloom was observed as shown in Figures 1 to 4 with 2557, 2319, 2000 (2300), and 2000 H.U. since planting accumulation for PD 1, 2, 3, and 4, respectively.

In 1988 a series of cold periods early in the season, especially during germination, resulted in lower H.U. accumulation than required for optimum growth. This resulted in delayed flower production for PD 1. Figure 1 shows that both Upland and Pima cotton started flowering with 1425 H.U. accumulation and reached peak bloom between 2001 to 2557 H.U. Huber (1981) studied the H.U. accumulation at first flower production for short staple cotton for 6 years at several locations in Arizona (Marana, Maricopa, Safford, and Yuma). He reported that for short staple cotton, 1190 ± 50 H.U. are needed after planting to ensure flowering. The number of flowers in Figure 1 indicates delayed flowering for PD 1. Even with 1236 H.U., there were still no flowers on the first sampling date.

Figure 2 (PD 2) shows early flower production with only 1187 H.U. available compare to PD 1 which start flowering with 1425. Favorable conditions at early planting for PD 2 allowed flowering within the H.U. boundaries described in Huber's experiments. The highest number of flowers per meter was found for PD 2 with peak bloom occurring within a H.U. range of 1763 to 2319 for all varieties. Favorable germination conditions and high H.U. accumulation related to a more rapid flowering patterns for all three varieties of cotton in PD 2.

Figures 3 and 4 show early peak bloom with 2000 to 2323 H.U. for all varieties which indicated of unfavorable flower patterns compared to PD 2.

FIGURE 1. RELATIONSHIP OF FLOWER NUMBER PER METER AND H.U. ACCUMULATION FOR PD 1; DPL 20,90, AND PIMA S-6

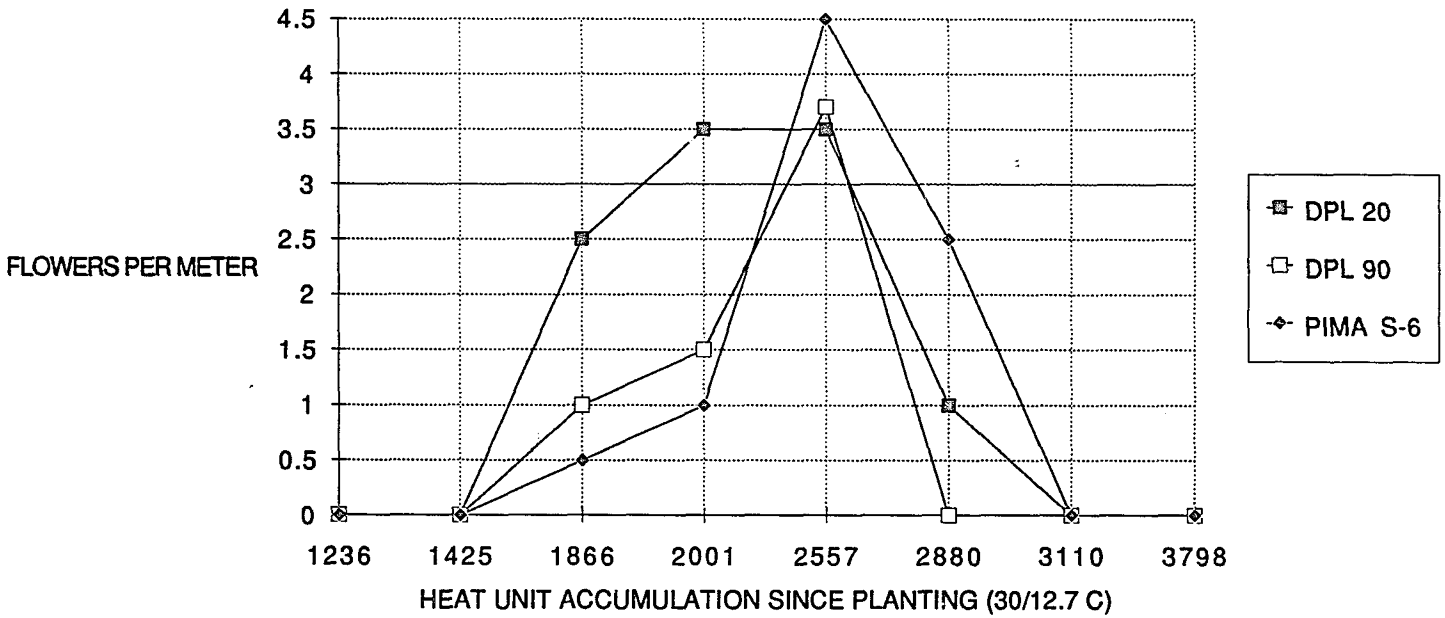


FIGURE 2. RELATIONSHIP OF FLOWER NUMBER PER METER AND H.U. ACCUMULATION FOR PD 2; DPL 20, 90, AND PIMA S-6

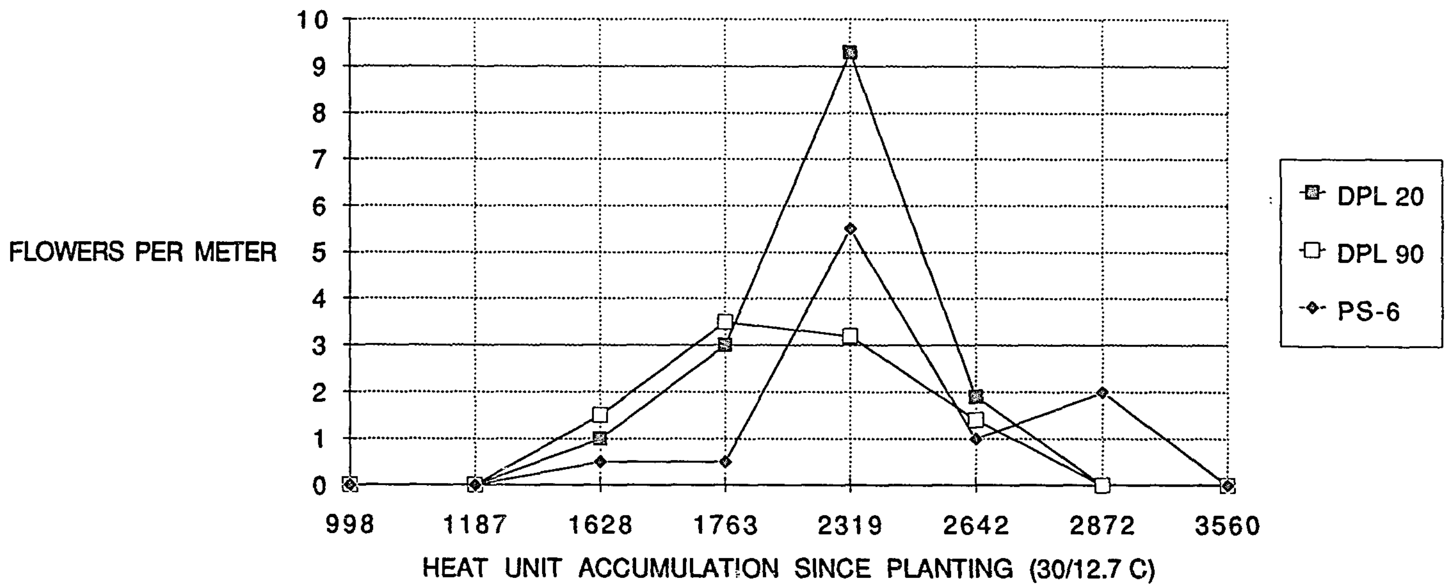


FIGURE 3. RELATIONSHIP OF FLOWER NUMBER PER METER AND H.U. ACCUMULATION FOR PD 3; DPL20, 90, AND PIMA S-6

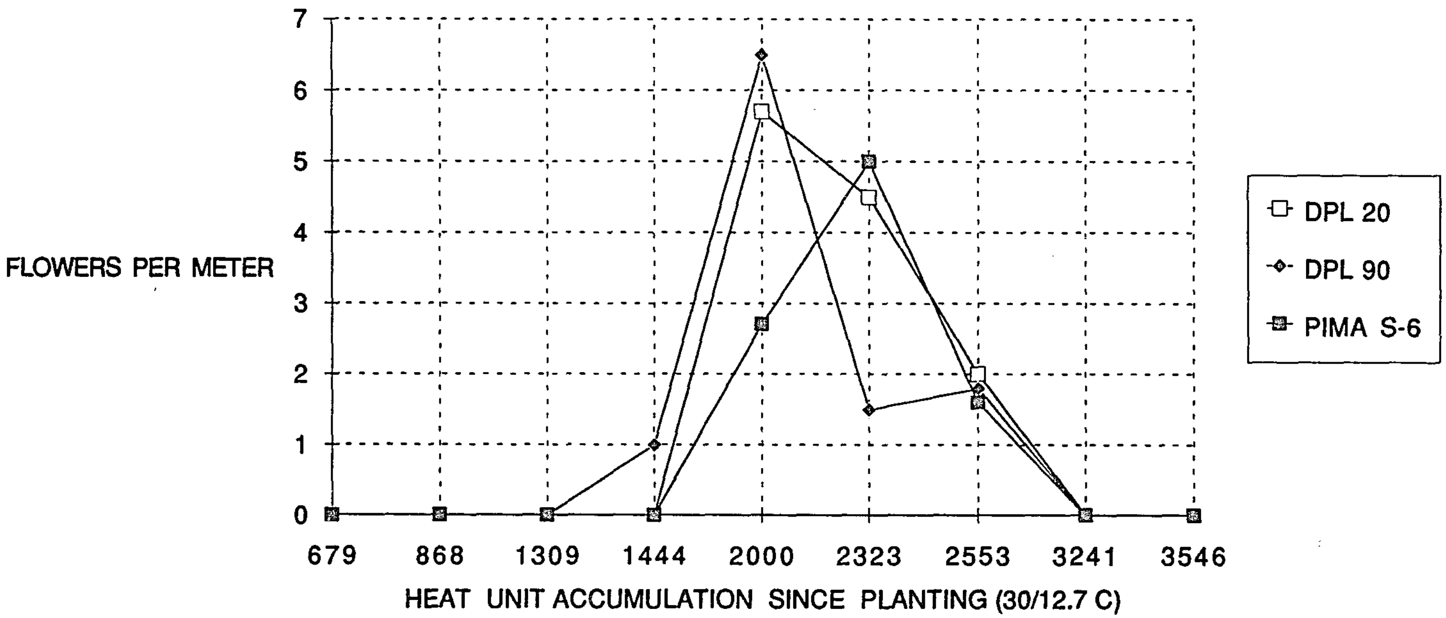
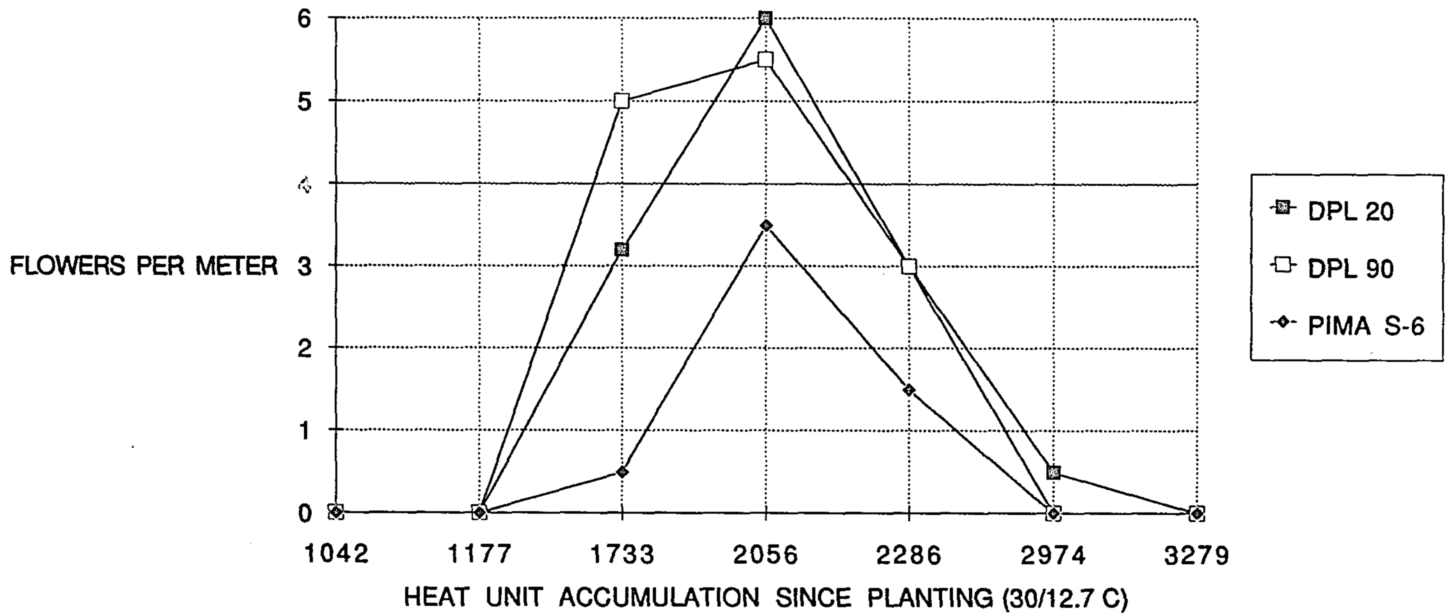


FIGURE 4. RELATIONSHIP OF FLOWER NUMBER PER METER AND H.U. ACCUMULATION FOR PD 4; DPL 20, 90, AND PIMA S-6



Effect of Planting Date on Yield

A number of cold periods at Marana in the early spring of 1988 created unfavorable conditions for all cotton varieties on the early planting date. This condition resulted in lower H.U. availability during germination, especially 5 and 10 days after the planting date, and significantly altered the usual pattern for flowering and final yield. Figure 5 shows H.U.'s accumulated 5 and 10 days after planting for DPL 20, DPL 90 and Pima S-6 at Marana. PD 1 had 75 and 125 H.U. accumulated 5 and 10 days after the planting date, respectively, which was low for cotton development compared to PD 2 with 125 and 225 for 5 and 10 days after planting (Kerby et al., 1989). As the result of better growing conditions in the early season, all varieties showed the highest yield for PD 2 (Figure 6). DPL 20 had the highest yield for PD 2 compared to other PD 's. Full season DPL 90 and Pima S-6 also showed highest yield on PD 2, but the yield of these two varieties decreased rapidly after PD 2 compared to DPL 20. Table 13 shows statistical differences among varieties for each planting date. Differences among varieties were hardly statistically significant at the PD 1. PD 2, 3, 4, showed significant differences for some varieties. The coefficient of variation, observed significance level, and least significant differences on Table 13 were computed with one Pima and eleven Upland varieties for reliability of the experimental error and obtained from data analysis indicated by Silvertooth et al. (1989).

The highest yield levels were obtained from PD 2 (Figures 6). The results of this study indicated the following index of H.U. accumulation for favorable and unfavorable conditions for optimum growth and development, 5 and 10 days after planting.

		Low	optimum	high
H.U. accumulation	5 days after planting	75	100	>120
H.U. accumulation	10 days after planting	125	200	>200

FIGURE 5. H.U. ACCUMULATION (30/12.7 C) 5 AND 10 DAYS AFTER PLANTING FOR DPL 20, DPL 90, AND PIMA S-6

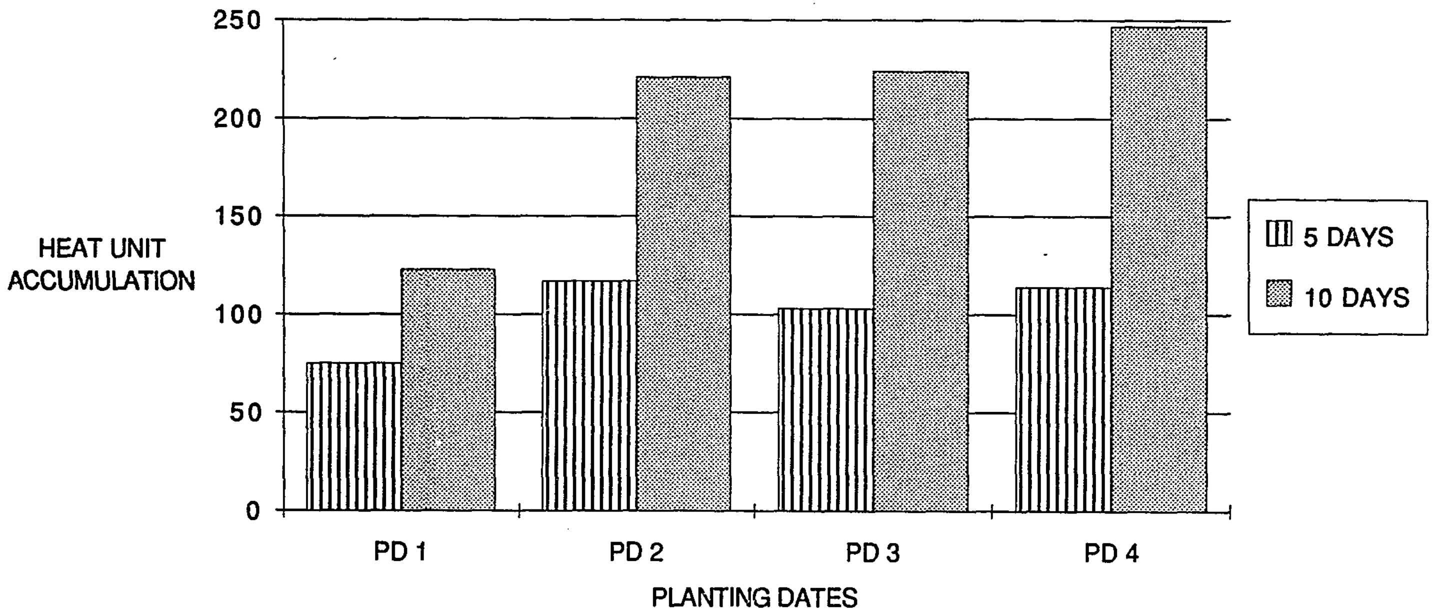


FIGURE 6. COTTON LINT YIELD FROM FOUR DATES OF PLANTING FOR DPL 20, 90, AND PIMA S 6

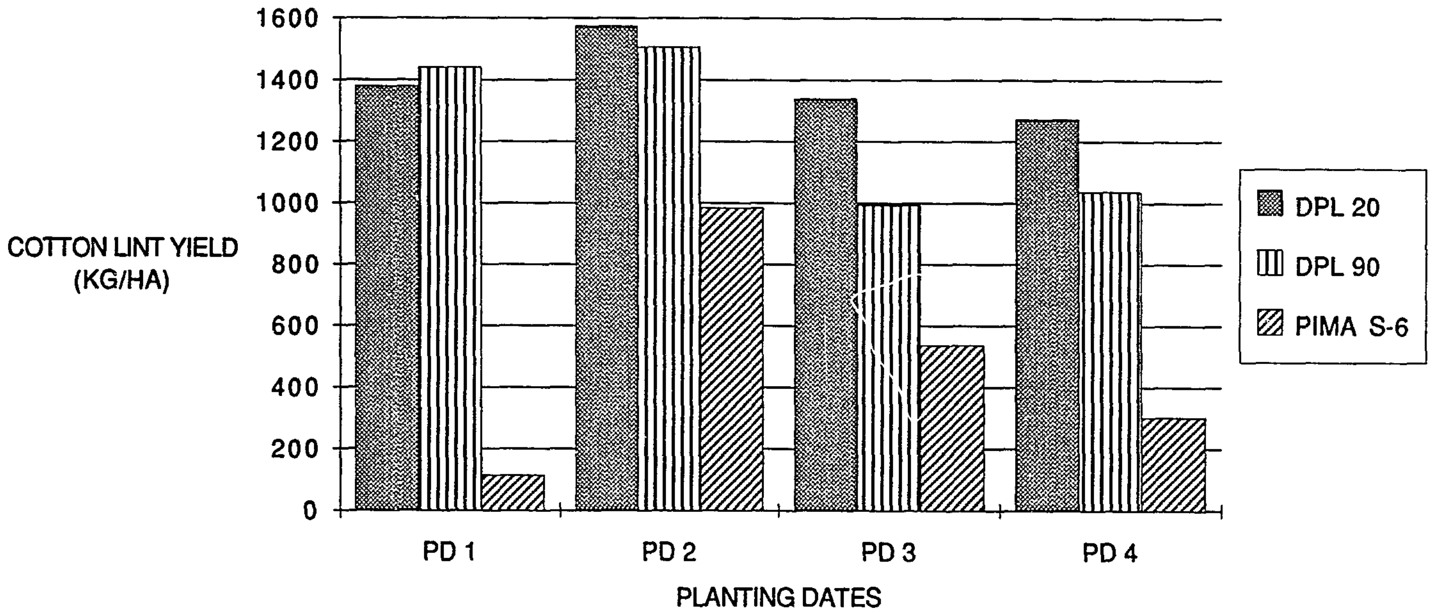


Table 13. Means for lint yields taken from date of planting by variety test at Marana Agricultural Center, 1988.

VARIETY	DATE OF PLANTING			
	PD §1	PD 2	PD 3	PD 4
DPL 20	1243AB*	1417AB	1206A	1147A
DPL 90	1298AB	1356ABC	896C	933ABC
PIMA S-6	103B	887F	484D	273E
$LSD_{.05}$	239	212	176	264
CV (%)	13	12	12	21
OSL**	.33	.00	.00	.00

*Means followed by the same letter within a column are not significantly different at the observed significance level according to a Fisher's LSD.
**Observed significance level (probability of a greater P value).
§ PD = Planting date.

SUMMARY AND CONCLUSIONS

The results of this study indicate that a cold period at Marana in the early spring of 1988 created unfavorable conditions for all cotton varieties on the early planting date (27 April). The H.U. accumulation, especially during early germination 5 and 10 days after planting, had an important impact on growth and development of plant heights, mainstem nodes, flowers, and final yield for all varieties.

In general, plant height and mainstem nodes were uniform by the end of the season for some varieties at all four planting dates. However, the greater H.U. accumulation per unit of plant height and per mainstem node during early sampling dates had an important role in the formation of plant height and mainstem nodes, but further research is needed to evaluate more exact ranges of optimum H.U. accumulation per unit plant height and mainstem node development.

The flowering pattern appeared to be altered by early cold conditions and lower H.U. accumulation during the 5 and 10 days after planting for PD 1. Flower pattern as a result of higher H.U. accumulation were favorable for PD 2 in producing the highest yield of the experiment in 1988.

Studies by Kittock and Hofmann (1987) and Silvertooth et al. (1989) showed that full season Upland varieties and Pima cotton reached greatest yield potential when planted early with sufficient warm conditions. As a result of cold conditions early in the season our experiment showed more vegetative growth with less yield for the earliest planting (27 April). DPL

20, an early maturity type of cotton, produced the highest yield for PD 2 compared to others. DPL 90 and Pima S-6 also had the highest yield on on PD 2, but the yield of these two varieties decreased rapidly after PD 2 compared to DPL 20.

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