A PHENOLOGICAL STUDY OF FIVE MATURITY CLASSES OF CORN AT TWO DATES OF PLANTING

A Thesis

by

ROBERT A. LANE

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Approved as to style and content by:

(Chairman of Committee)

(Head of Department)

(Member)

(Member)

(Member)

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ABSTRACT

A Phenological Study of Five Maturity Classes
of Corn at Two Dates of Planting. (May 1980)
Robert A. Lane, B.S., Sam Houston
State University
Chairman of Advisory Committee: Dr. A.J. Bockholt

A study was conducted on the Texas A&M University Farm during the summer of 1979 to determine what possible effects temperature and photoperiod had on the growth and development of five different maturity classes of corn. These hybrids were planted at two different dates, 25 days apart, in a random block design. An attempt was also made to determine whether accumulated heat units (AHU) were more accurate in predicting the maturity for these corn hybrids than the calendar day method.

The data from the study indicated that accumulated heat units were no more valuable in predicting the maturity of these hybrids than the calendar day method. Generally it was seen that the delayed planting resulted in fewer days to silk, blister, and maturity, but a greater accumulation of heat units. This was attributed to the higher temperatures prevalent during the growing period of the second planting. The period of emergence to blister was the best indicator of maturity short of maturity itself.

These five hybrids were found to be photoperiod insensitive due to the fact that their developmental rate was actually speeded up

under an increasing daylength rather than a delay, as would have been expected had they been photoperiod sensitive.

Using date of planting as a measure of temperature, it was seen that temperature had little or no effect on leaf area, leaf number, plant height, or percent grain. Temperature did seem to have an effect on total grain weight thus having a complimentary effect on the accumulation of total dry matter.

This indicates that temperature was the major controlling environmental factor in the developmental rate of these hybrids but a genetic x environment (mostly temperature) interaction probably controlled the growth characteristics. This interaction varied from one genotype to the next.

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CHAPTER I

INTRODUCTION

The most important factors in obtaining maximum production from maize are the use of adapted varieties and planting at the optimum time. Corn hybrids or varieties are classified into several different maturity classes, each depending on which latitudinal area in which it is grown. Of course, the area in which each hybrid is grown is supposedly the zone to which that particular hybrid is best adapted. The corn crop as a whole, is grown under a wide range of environmental conditions ranging from 58°N in Canada to 35° to 40°S in the Southern Hemisphere (19).

For many years, the maturity rating of individual hybrids has been based on the number of days that occurred between time of planting or emergence to the time of maturity. For instance, a variety grown in the northern U.S. might be classified as a 90 or 110-day type, while those grown in the South may be 170 or 190-day types. This method of classification is still used to a large extent, but under different environmental conditions, the number of days required to reach maturity may vary considerably. This variation is likely due to either differences in temperature or photoperiod, although moisture, fertility and intensity of radiation can also have an effect.

Recently, much interest has been shown in the area of heat unit accumulation in respect to predicting the number of days to certain

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The citations on the following pages will follow the style of Crop Science.

stages of development of the corn plant. Since temperature is the only factor involved in these calculations, one could assume that temperature plays the major role in the growth and development of maize.

Corn is commonly classified as a short day plant, but one of the objectives of modern crop improvement programs is the elimination of photoperiod sensitivity. If the short day character were present, northern varieties grown in the South, where the days are shorter, would mature quickly with less vegetative growth and southern adapted varieties moved northward would take longer to mature with more vegetative growth under the longer days. It is obvious how photoperiod sensitivity would limit widespread use and north-south adaptation of any given line. With this in mind, the growth duration of corn lines or hybrids is controlled by temperature and photoperiod in those that are photoperiod sensitive and almost strictly by temperature in insensitive lines.

Varieties which have a longer duration of growth generally are the highest yielders when grown under the same conditions as those with a short season requirement, provided of course that the long season types have adequate time to reach maturity. The later maturing types generally are larger plants, having a greater leaf area (due to an increased number of leaves, as well as increased leaf size), thus possessing more photosynthetic area. According to Van Dobben (22), "The final yield of a crop is largely determined by its longevity. Longevity is influenced by climatic factors. Consequently, temperature and light conditions have both an indirect and direct impact on yield." But it should be noted that genetics plays the most important role in the longevity of any particular hybrid or line.

Nearly all reports on the subject conclude that corn planted as early after the last killing frost as possible will yield higher than those plantings made later in the season. But this has usually been attributed to the fact that drought is more common later in the season and is more likely to occur when the later plantings are silking, thus lowering the yield. Under irrigation this problem should not be so prevalent.

This study was designed to see what effect temperature, and photoperiod to some extent had on the development and growth of these maturity classes.

The correlations noted between leaf number, days to anthesis, silking, blister, and maturity; and dry matter accumulation, leaf area, plant height and grain yield will be helpful in developing simulation models for crop growth, which in turn might be used someday to choose a variety for a particular environment and specify its planting date.

The objectives of this research problem were:

1. To observe with different maturity classes of maize the effect of planting date on the number of days from emergence to anthesis, silking, blister and maturity.

2. To evaluate leaf area, leaf number, plant height, total dry matter and grain yield as affected by planting date and maturity class.

3. To determine whether accumulated heat units were a more accurate index of predicting the occurrence of the developmental stages of maize than the calendar day method.

CHAPTER II

REVIEW OF LITERATURE

Many years ago, Hanna (12) concluded from his experiments that out of the several environmental factors that affect growth, the air temperature was the most important. A study conducted by Duncan and Hesketh (6) involving 22 races of maize at eight different temperatures, showed a decrease in leaf numbers with a decrease in temperature. They also concluded that since there are no leaves formed after initiation of the tassel, the lower temperatures induced earlier flowering in terms of physiological age.

Van Dobben (22) concluded that at higher temperatures, the plants grew larger. This, he attributed to the growth rate being relatively more accelerated than development at higher temperatures. The larger plant would either have to possess more leaves, thus a greater number of nodes, or there would have to be an increase in the distance between the nodes. Hesketh, Chase and Nanda (14) showed that an increase in temperature resulted in an increase of leaf numbers.

Photoperiod also seems to play a role in the number of leaves formed. The same study by Hesketh, et al., (14) which showed an increase in leaf numbers at higher temperatures also revealed that by decreasing the daylength, the number of leaves could be reduced. Work done by Chase and Nanda (3) indicates this is true even with day neutral hybrids. Using 21 double crosses, they determined that all of the hybrids probably would have come into flower under continuous illumination and in that sense were day neutral. They state, "It is evident that photoperiod has a marked effect on the number of leaves formed."

Evidently there is a strong interaction involving daylength and temperature as they affect the number of leaves formed.

In the early 1930's, Kuleshov (15, 16) classified maize strains from various parts of the world using the average number of leaves on the main stalk as an index of maturity group. He found that the average number of leaves per line varied from 8 in the earliest to 48 in the latest maturity group.

In a study conducted at several locations in Italy, Nozzolini (20) reported highly significant positive correlations between number of leaves on the main stalk and length of the vegetative period of maize. He states, "leaf number is a rather constant character, little influenced by environmental conditions." This is in contrast to what was stated earlier.

The hybrids planted by Chase and Nanda (3) represented the full range of kinds and maturities grown in the U.S. and Canada. They were planted at three locations and at three different dates; one each in May, September, and November. It was reported that highly significant positive correlations were obtained between mean total leaf number per hybrid and mean days from planting to anthesis in all three plantings. Earlier maturity hybrids had fewer leaves and required fewer days to reach anthesis than later maturity hybrids in all cases. It was also noticed that fewer leaves were developed per hybrid in the winter plantings than in the summer. Fewer days were required for anthesis in the September planting than in the other two.

In an experiment involving 18 maize hybrids representing a wide range of genotypes, Hesketh, et al., (14) concluded, "Days to tassel emergence, leaf area, dry weight and plant height were for the most part significantly correlated with leaf number".

While it is possible to say that one hybrid will mature more quickly than another on the basis of leaf numbers, it is generally agreed that it is not possible to accurately describe varieties as 100- day, 120- day, or 150- day types because the number of days to maturity will vary greatly with different dates of planting. Grogan, Zuber, and Brown (9) found the number of days from planting to tasseling was greatly affected by dates of planting. Using hybrids representing four different maturity classes planted in April, May, and June, it was seen that the June 20 planting required three weeks less than the April 20 planting to reach the tassel stage. On the average, the 90- day hybrids (earliest maturity group) were 7 days earlier in tasseling than the 140- day hybrids (latest maturity group). There was little difference between the 90- and 115- day hybrids and between the 125- and 140- day hybrids. There was an approximate decrease of 10 days to tasseling for each 20 days delay in planting until the June 1 date. It is also interesting to note that 8 days separated the 90- day hybrids from the 140- day hybrids planted on April 1, but only 5 days on June 20. Mangelsdorf (17) also reported a delay of approximately 1/2 day in silking for each day's delay in planting. A similar relationship was seen by Zuber (23) and Genter and Jones (7).

Genter and Jones (7) noticed that the days from planting to silking decreased significantly at each successive planting date. Daynard (5) found that in general, delayed planting resulted in a shorter time period from planting to mid-silking and a longer period from mid-silking to maturity.

Different dates of planting can also have a great effect on yield. Grogan, et al., (9) revealed, "All hybrids decreased in yield as the dates of planting were delayed." The yields of the hybrids they used were according to the lateness or duration of the growth period, with the 90- day hybrids yielding lowest for all planting dates and the 140- day hybrids yielding the best. In the same light, Mangelsdorf (17) saw that all varieties tested showed a reduced yield as the result of late planting, and "the reduction in yield from late planting is undoubtedly partly due to the accompanying delay in time of blooming and maturity."

In contrast, Genter and Jones (7) concluded over the 8-year period their experiment was conducted, "no significant and very little actual difference was found between planting dates for yield."

Another point of controversy involves the amount of time from silking to physiological maturity. Shaw and Thom (21) deduced this period to be very constant (50 to 52 days). Hanway (13) agreed that the period of time was relatively constant for different hybrids and different conditions. However, he indicated that corn reaches physiological maturity at about 60 days after silking. A later study by Hallauer and Russell (11) agreed with the conclusions of Hanway.

Other reports are contradictory to these results. Gunn and Christensen (10) report that earlier hybrids reach physiological maturity in fewer days after mid-silk than later hybrids. The interval from mid-silk to physiological maturity ranged from 45 days for early hybrids to 70 days for later hybrids. Mederski, Miller, and Weaver (19) indicate the same was true.

The application of the accumulated heat units (AHU) or growing-degree-days (GDD) concept to maturity classification of dent corn hybrids is gaining interest. However, published data are very limited and with the methods now used, it has not been shown that these concepts are superior to the calendar day method. The report by Aspiazu and Shaw (1) does not indicate a significant difference in variance between the calendar-day method and several of the commonly used growing-degree-unit methods. It was seen that Brown's (2) Ontario method was less variable than calendar days, but the difference was small. The study by Cross and Zuber (4) also failed to show that the best of 22 thermal unit calculations was less variable than the calendar day method.

However, Mederski, et al., (19) claim growing-degree-day methods of classifying corn hybrids are superior to calendar days. Gilmore and Rogers (8) concluded that effective degrees appears adequate for classifying genetic materials accurately enough so that classification may be applied in different areas and in different years. Gunn and Christensen (10) state, "Effective degree days gave a relatively accurate determination of the period from planting to mid-silk in varying locations and years." This statement may be true, but if the period from mid-silk to maturity of corn cannot be classified using AHU's from planting to silking as others have tried to do.

The amount of contradiction between these reports indicates that the effect of planting date on corn is not clear cut. It is generally agreed that temperature is the main factor controlling the growth and development of corn but photoperiod still plays a role even in insensitive lines.

CHAPTER III

MATERIALS AND METHODS

Five hybrids of different maturity classes were used in this study. Their classification was based on which latitudinal area in which they were normally grown. Their normal range of adaptation varies from Wisconsin (maturity class #1) to South Texas (maturity class #5). The genotypes used included:

Maturity Class	Pedigree
1	W64A x W117
2	Mo17 x A634
3	B73 x Mo17
4	Tx6252 x B73
5	Tx601 x Tx303/Tx441

The original design of the experiment included each of the hybrids being planted in a random block design at four different dates. Two replications of each maturity class were to be used at each planting date.

A breakdown in the irrigation system was not corrected in time to prevent severe drought stress in the third planting. The fourth planting encountered a heavy infestation of the Southern Corn Stalk Borer which caused a drastic reduction in plant growth. For these reasons, data collected from these two plantings were omitted from this thesis. Thus, only the first two plantings were used for data collection.

The first planting was made on March 30, 1979 with a tractor mounted cone type planter. The second planting followed on April 24, 1979 and was hand planted. The study was conducted on the Texas A&M University Farm in Burleson County, Texas.

Each hybrid was planted in three row plots 6.7 meters in length with a distance of 1 meter between rows. Plots were overplanted and thinned to approximately 47,000 plants per hectare. When the plants reached the 4th leaf stage, ten plants were randomly selected and tagged from the middle plot of each three row plot. These plants were used throughout the study for measurement purposes and data collection.

At each planting date the following information was recorded for each maturity class:

1. Date of planting - date when seed was planted.

2. Date of emergence - date of 75% coleoptile protrusion from the soil.

3. Date of anthesis - date when at least 50% of the plants were shedding pollen.

4. Date of silking - date when silks were seen to emerge from at least 50% of the plants.

5. Date of blister - date when the silks had turned brown, just prior to rapid grain filling, on at least 50% of the plants.

6. Date of maturity - date when kernels from the middle of the ear showed black layer formation on at least half of the plants checked. Six ears were checked daily when approaching this stage to insure accuracy.

7. Leaf area - computed by measuring the length, and width at its widest point, of each leaf upon ligule appearance and multiplying by a factor of 0.75.

8. Leaf number - total number of leaves possessed by the plant. Leaf numbers were marked on every 4th leaf with a black felt pen to avoid losing count due to senescence of lower leaves.

9. Plant height - measured from the crown to the collar of the flag leaf.

10. Total dry matter - individual plants were cut off at the crown and dried in burlap sacks at 75°C until no further weight loss was noted.

11. Total ear weight - ears were removed from the plants after total dry matter was measured, and weighed without the husk or peduncle attached.

12. Total grain weight - the grain was shelled from the dried ear at about 4-5% moisture and weighed.

For measurements 1 and 2, the complete three row plot of each hybrid was used. To determine 3,4,5, and 6, all plants in the center row of each three row plot was used. Measurements 7,8,9,10,11, and 12 were taken only from those plants which were randomly selected at the 4th leaf stage from the middle plot of each three row plot.

Climatic data was obtained from the Environmental Service Center in the Soil & Crop Sciences Department, Texas A&M University, and from Dr. Alva Niles, cotton geneticist with Texas A&M University. These included:

1. Maximum daily temperature
2. Minimum daily temperature

This data was used to calculate accumulated heat units to the various stages of development listed before. Calculations were made using the formula suggested by Gilmore and Rogers (9).

The formula used was:

$$AHU = \frac{Tmax + Tmin}{2} - 50$$

where if Tmax > 86, Tmax = 86.

The entire section of land used for the study was fertilized with 600 lbs of 12-12-12 preplant. The first planting was sidedressed with 250 lbs of 30-0-0 on May 10, 1979. The second planting was sidedressed with an equivalent amount on June 3, 1979. Furadan^{tm} granules were broadcast over the section as needed to prevent damage by the corn earworm. Weeds were controlled by hand pulling and hand hoeing.

Analysis of variance (ANOVA) and Duncan's multiple range test, along with the general linear model (GLM) were used to statistically analyze the data.

CHAPTER IV

RESULTS AND DISCUSSION

Data were collected from five separate maturity classes of corn planted on two different dates in an attempt to determine how each maturity class would react to the different dates of planting in regards to developmental rate and growth and yield characteristics. In general, the later date of planting tended to cause a significant increase in the developmental rate of these maturity classes while having varied effects on their yield and other agronomic characters. The results of each characteristic are presented and followed by a discussion of that characteristic.

Days from emergence to silk. Data from Table 1 indicate that a greater number of days was required to reach the silk stage in each succeeding maturity class. Due to lack of repetition, Duncan's Multiple Range Test could not be run on the individual maturity classes at each planting date. Using an average of the two planting dates, it can be seen that the difference between maturity classes 1 and 2 were non-significant as well as the differences between 2, 3, and 4 and 3, 4, and 5. These results are similar to those seen by Grogan, Zuber and Brown (9).

The data is also in agreement with conclusions made by Genter and Jones (7) in that the days from planting to silking decreased significantly at successive planting dates. The second planting required a mean of eight fewer days to reach silking from planting and five fewer days from emergence. This figures to be a delay of

Table 1. Days from emergence to silk for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	52	51	51.5 a
2	62	53	57.5 ab
3	61	57	59.0 bc
4	62	58	60.0 bc
5	69	61	65.0 c
mean	61.2 a	56.0 b	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

1/3 day for each day's delay in planting rather than 1/2 as seen by Mangelsdorf (17), Zuber (23), and Genter and Jones (7).

Days from emergence to blister. The data in Table 2 show a better separation of maturity classes than days from emergence to silk. Therefore days from emergence to blister may be a better index of determining the ranking of maturity classes rather than days to silk. Here again, little difference was seen between classes 2 and 3.

This stage is very hard to determine without close examination of the ears and is greatly affected by the amount of pollen present. If the silks are rapidly pollinated, blister will occur more quickly than it would if they were not. It was seen here also that the number of days to reach blister was significantly lower in the second planting as was days to silk, although the difference noted here was only about three days.

Days from emergence to maturity. The later planting date did result in a decrease in the number of days to reach maturity (Table 3), but separation of maturity classes was not as great as might have been expected. Maturity class 1 was not significantly different from 2 as was seen in Table 1. Classes 2 and 3 were not significantly different from each other as was the case with 4 and 5.

Comparing dates of planting, the second planting date required approximately 4 fewer days to reach maturity than the first. This relationship was not seen with maturity class 3. It actually required one more day in the second planting. The second planting of maturity class 3 required about the number of days expected of it when compared to the other hybrids while the first planting fell short a few days.

Table 2. Days from emergence to blister for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	62	58	60.0 a
2	68	65	66.5 b
3	68	67	67.5 b
4	74	71	72.5 c
5	79	74	76.5 d
mean	70.2a	67.0 b	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Table 3. Days from emergence to maturity for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	98	93	95.5 a
2	104	99	101.5 ab
3	100	101	100.5 b
4	110	106	108.0 c
5	115	110	112.5 c
mean	105.4 a	101.8 b	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

The first planting of class 3 should have taken 105 to 106 days to mature to show a uniform comparison.

The difference between classes 1 and 2 was six days for both planting dates. This same close relationship was seen between 4 and 5. A similar relationship would have been seen between classes 3 and 4 had maturity class 3 been closer to the expected.

It should be obvious from these results that these hybrids were not sensitive to photoperiod. If the short day character had been present, there should not have been an increase in the rate of development under the increasing daylength of the second planting.

It seems evident that temperature was the major controlling factor influencing the number of days required to reach the different stages of development. The higher temperatures of the second planting evidently caused an acceleration in the developmental rate.

Days from silk to maturity. The data in Table 4 does not totally support the findings by Daynard (5). Daynard was of the opinion that delayed planting resulted in a shorter time period from planting to mid-silk and a longer period from mid-silk to maturity.

Maturity class 1 required fewer days from both planting to mid-silk and mid-silk to maturity in the later planting while class 4 required the same number of days from silk to maturity in both plantings. The data from the other maturity classes are in agreement with Daynard's findings.

This data is in disagreement with that of either Shaw and Thom (21), Hanway (13), and Hallauer and Russell (11). Shaw and Thom deduced the period from silk to maturity to be very constant at

Table 4. Days from silk to maturity for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	Coefficient of Variance
1	46	42	5.73
2	42	46	
3	39	44	
4	48	48	
5	46	49	

Table 5. Days from blister to maturity for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	Coefficient of Variance
1	36	35	3.06
2	36	34	
3	32	34	
4	36	35	
5	36	36	

about 50 to 52 days. These figures indicate that the period was neither constant nor did they require the number of days that were specified.

Hanway (13) and Hallauer and Russell (11) agreed with Shaw and Thom (21) in that the period was relatively constant but that physiological maturity was reached at about 60 days following silking. The range found with these hybrids was from 39 to 49 days. A 10 day difference is certainly not constant. Furthermore, each hybrid varied considerably from one date of planting to the next.

These data also did not agree with those of Gunn and Christensen (10) or Mederski, Miller and Weaver (19). They reported that the earlier hybrids reach physiological maturity in fewer days after mid-silk than later ones. In the first planting, class 1 matured in the same number of days following silking as class 5, with the others falling either lower or higher than these. Planting number two shows a slightly better arrangement as far as what was expected, however the range is not but seven days from the first maturity class to the fifth one.

Days from blister to maturity. The data in Table 5 shows that the period from blister to maturity was relatively constant among maturity classes and between planting dates. This indicates that the period from planting or emergence to blister would give a much better estimate of maturity classification than that of planting or emergence to silk. The coefficient of variation for days from silk to maturity was 5.73 (Table 4) while that of blister to maturity was 3.06 (Table 5) indicating a much closer relationship between days to blister and the actual maturity of these hybrids. The correlation between days to blister and days to maturity is much more significant than that between days to silk and days to maturity.

Accumulated heat units to silk. There was no significant difference between the two dates of planting for the number of heat units required to reach the silking stage (Table 6). There was an actual increase in heat units required in the second planting for all maturity classes except class 2.

Even though there was an actual increase in the number of heat units required from one maturity class to the next at both planting dates, classes 2, 3, and 4 were not statistically different, nor was 5 significantly different from 4. Maturity class 1 required significantly fewer heat units to reach silking than all the others.

Accumulated heat units to blister. The means of the accumulated heat units to blister showed a much better separation than those of heat units to silk. Only class 2 was not different from class 3 statistically (Table 7), as was also the case in Table 2 - Days from emergence to blister. In fact, the same separation of means was seen in both tables. This again indicates that the period from emergence to blister would be more accurate than the period from emergence to silk classifying hybrids into maturity classes, but this method would be much more difficult. This similar separation of means also indicates a very close relationship between the number of days required and the number of heat units required.

In Table 2, it was seen that fewer days were required to reach the blister stage at the second date of planting, while it was seen

Table 6. Accumulated heat units to silk for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	1022	1170	1096.0 a
2	1303	1232	1267.5 b
3	1272	1351	1311.5 b
4	1303	1380	1341.5 bc
5	1474	1497	1485.5 c
mean	1274.8 a	1326.0 a	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Table 7. Accumulated heat units to blister for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	1303	1408	1355.5 a
2	1449	1590	1519.5 b
3	1449	1651	1550.0 b
4	1623	1773	1698.0 c
5	1772	1885	1828.5 d
mean	1519.2 a	1661.4 b	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

in Table 7 that a significantly greater number of heat units were accumulated during this same period. This inverse relationship was seen in all comparisons between heat units and days. Naturally, the days under which the plants at the second date of planting were growing possessed higher temperatures, thus a greater accumulation of heat units occurred at the second planting in all cases.

If it was true that heat units was a better indicator of maturity than days, the heat units of the second planting should have more closely approached those of the first planting which would have resulted in an even fewer number of days to reach the different stages of development. This indicates that the temperature can only affect the plants developmental rate to a certain extent, beyond which the genetics of the plant takes control over development.

Accumulated heat units to maturity. Data from Table 8 show a very poor separation of means by maturity class when using accumulated heat units. Though an actual increase in heat units was seen from one maturity class to the next, 1, 2, and 3 were not significantly different from each other and 4 and 5 were not either.

Again, it was seen that the second date of planting required significantly more heat units to reach maturity than the first. If heat units were more accurate than days for predicting maturity of a hybrid, there should have been no separation of means between planting dates.

It seems highly unlikely that maturity classes 1, 2, and 3 should fall into the same category of maturity as was seen here. The same is true with 4 and 5. This was due to the inverse relationship

Table 8. Accumulated heat units to maturity for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2	mean
1	2337	2514	2425.5 a
2	2520	2611	2540.0 a
3	2402	2678	2565.5 a
4	2699	2838	2768.5 b
5	2839	2951	2895.0 b
mean	2559.4 a	2718.4 b	

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

between 2 and 3 at planting date 1. This indicates that heat units at least in this case, were no more accurate than days for maturity classification. In fact, data from Table 3 (days to maturity), showed a slightly better separation of means.

Leaf area. The mean leaf areas of maturity classes 2 and 3 were not statistically different at either planting date (Table 9). Classes 3 and 4 were not significantly different only in the second planting. There was an actual increase in leaf area from one maturity class to the next; class 1 being the lowest and class 5 the highest. Maturity class 5 has a significantly greater leaf area than all others at each planting and class 1 was significantly lower. Maturity class 4 was significantly higher than 1, 2 and 3 in the first planting but not statistically different from 3 in the second. These actual differences between maturity classes was expected due to each hybrids adaptation to length of growing season.

Date of planting had little effect on leaf area. Maturity classes 2, 3, and 5 did not differ statistically from one date to the next, although there was an actual increase in the second planting. Classes 1 and 4 did show a significant difference between planting dates, but the difference was an increase in the second planting for class 1 while class 4 decreased.

Leaf number. In the first planting there was an actual increase in leaf numbers from maturity class 1 to 5 respectively, but the difference between 3 and 4 was not significant (Table 10). In the second planting, maturity class 3 showed a marked decrease in leaf numbers. This was not expected and cannot be explained.

If the conclusions drawn by Hesketh, Chase and Nanda (14), that

Table 9. Comparison of mean leaf areas (cm^2) of each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting	
	1	2
1	3624.3 g	4493.7 f
2	5187.7 e	5568.3 de
3	5581.8 de	5834.0 cd
4	6930.5 b	6279.7 c
5	8741.0 a	9393.8 a

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Table 10. Comparison of mean leaf numbers of each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2
1	15.0 e	16.8 d
2	18.6 c	19.5 b
3	19.4 b	18.3 c
4	19.8 b	19.9 b
5	21.5 a	22.1 a

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

an increase in temperature would result in an increase in leaf number, were totally correct, then an increase should have been evident in all hybrids for the second planting. But maturity class 3 showed a significant decrease, while the increase in classes 4 and 5 were not significant. A significant increase in leaf numbers at the second planting was seen only in classes 1 and 2.

Plant height. The height of these hybrids was not as closely related to their maturity classification as leaf area and leaf number (Table 11). Nor did the date of planting have definite consistent effects on plant height.

Maturity class 1 was significantly shorter than all others at each planting date. From this point, nothing definite was seen. In the first planting, 2 and 5, and 3 and 4 were not different statistically. In the second planting, the same was seen between 2 and 4 and 3 and 4.

Significantly taller plants in the second planting over the first were seen in classes 1 and 5, but the plants were shorter in classes 2 and 3. No significant difference was seen in class 4.

Internode length. Even though internode length measurements were not taken, it can be calculated from this data by dividing plant height by leaf number. It can be seen in Table 12 that plants of the second planting were shorter in internode length in classes 1, 2, 3, and 4. The internodes of maturity class 5 were estimated to be longer in the second planting. No definite statement can be made concerning internode length but the data is interesting and does raise some questions as to what effect temperature might have on this

Table 11. Comparison of mean plant heights (cm) for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2
1	125.2 g	147.8 f
2	197.1 bc	181.9 d
3	182.6 d	167.9 e
4	186.4 cd	178.3 de
5	209.6 b	244.6 a

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Table 12. Estimated internode lengths (cm) for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting	
	1	2
1	8.4	7.9
2	10.7	9.4
3	9.4	9.1
4	9.4	8.9
5	9.7	11.2

character.

Total dry matter. Although an actual decrease in total dry matter was seen in all maturity classes except 5 for the second planting, only significant differences were seen in 3 and 4 (Table 13). The increase in the second planting for 5 as well as the decrease in 1 and 2 were not determined to be statistically different.

Differences between maturity classes were not highly notable. Class 1 accumulated significantly less dry matter compared to all the others in the first planting, but was not different statistically from 3 in the second. Classes 2 and 3 were not significantly different from each other in either planting. Class 4 was significantly greater than all others in the first planting but actually less than 5 in the second, though not significantly.

Total grain weight. In most all research cited, it was noted that a delay in planting from the optimum date resulted in a decrease in grain yield. Only class 4 showed a significant decrease in grain yield at the second date of planting. But all maturity classes, except 5, did show an actual decrease in grain weight in the second planting (Table 14).

Since these means were computed from only ten plants each, it is obvious that a very large sample would have shown significant decreases in yield on a per ha basis. The increase in the second planting for class 5 might be explained by its greater adaptation to high temperatures. The very low yield of the first planting for class 5 could have been due to a slightly dry soil condition at silking, although attempts were made to prevent this from happening.

Table 13. Comparison of means of total dry matter (g) for each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting	
	1	2
1	218.7 f	212.2 f
2	309.4 de	291.2 de
3	340.6 cd	257.7 ef
4	531.1 a	411.2 b
5	393.5 bc	426.8 b

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Table 14. Comparison of means of total grain weight (g) of each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting 1	Planting 2
1	108.1 e	107.8 e
2	153.9 c	134.7 cde
3	144.9 cd	116.2 de
4	277.9 a	190.8 b
5	139.0 cde	166.8 bc

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

The low grain yield of class 5 in the first planting no doubt contributed to its relatively low total dry matter production at the same time.

Percent grain. About the only point of interest seen here was the significantly lower grain yield of maturity class 5 (Table 15). It is generally expected that the larger the plant and the greater the duration of growth (e.g. maturity class 5), the greater the yield. This is especially true when the size of the plant is due to its inheritance and not excess fertilization rates, as was the case here.

It is possible that this particular hybrid was planted at above optimum density resulting in very large plants being crowded too close together causing a shading effect upon one another. This shading might not have allowed the leaves to absorb as much sunlight for the photosynthetic purpose of grain formation.

Surprisingly, maturity class 1 produced the largest percentage of grain compared to its total dry matter. Perhaps it should not be a surprise, for these plants were small enough that at the plant population used, the entire plant was exposed to sunlight, thus in a better position for assimilation of photosynthetic products.

It seems possible that in a yield trial comparing these hybrids, planting rate and row width should be a major consideration for maximum grain production.

The data in Table 15 show that the date of planting probably had no effect on the percentage of grain produced.

Table 15. Comparison of means of percent grain of each maturity class at two planting dates, College Station, 1979.

Maturity Class	Planting	
	1	2
1	50.9 a	50.9 a
2	49.7 ab	46.5 abc
3	43.0 cd	45.0 bc
4	49.8 ab	46.0 abc
5	35.3 e	39.8 de

Duncan's multiple range test. Means with a common letter are not significantly different. Alpha = .05.

Correlation between heat units and days. Days to blister, silk, and maturity all showed highly significant correlations to accumulated heat units to blister, silk, and maturity respectively (Table 16).

Since heat units are a measure of temperature only, it can be deduced that the temperature is the major controlling environmental factor involved in the longevity of these hybrids coupled with their genetic make-up and that photoperiod had little effect.

Morphological characters associated with heat units and days. Leaf area, leaf number, and plant height were all found to be highly correlated with days to blister, more so than either days to silk or days to maturity. On the other hand, these characters were most significantly correlated with heat units to silk rather than blister or maturity (Table 16).

The importance of this fact is probably small. None of these characters were consistent with regards to planting date, so it is evident that their use in predicting maturity would be limited, if any.

Correlation between leaf area and leaf number. The figures in Table 17 were calculated by dividing the mean leaf areas by mean leaf numbers. Significance values could not be placed on these due to lack of repetition. But it is evident that leaf area per leaf increased from maturity class 1 to 5 respectively and there was also an increase in the second planting. The only exception to this was maturity class 4 in the second planting. Generally, this shows that higher temperatures do cause an increased expansion of the leaves, thus higher growth rate. This increased growth rate is

Table 16. Correlation Coefficients of Growth and Development Measurements Taken on 5 Maturity Classes of Corn at Two Planting Dates at College Station, Texas, 1979.

	DTB	DTM	STB	STM	BTM	HUS	HUB	HUM	HSM	HSB	HBM	LA	LN	PH	TDM	TGW	TEW	PE	PG
DTS [z]	.909**	.880**	.023	.099	.195	.755**	.531	.497	-.069	-.087	.006	.730**	.754**	.750**	.691*	.375	.438	-.573	-.707*
DTB		.982**	.438	.472	.283	.827**	.769**	.731**	.291	.325	.081	.847**	.846**	.793**	.843**	.526	.583	-.616*	-.727**
DTM			.457	.561	.461	.789**	.751**	.747**	.374	.347	.283	.832**	.799**	.770**	.831**	.536	.591	-.545	-.670*
STB				.915**	.258	.356	.699*	.680*	.846**	.966**	.182	.456	.404	.283	.532	.453	.452	-.240	-.219
STM					.626*	.337	.647*	.697*	.902**	.877**	.488	.469	.360	.305	.537	.468	.475	-.143	-.171
BTM						.119	.198	.355	.525	.231	.814**	.242	.082	.185	.258	.245	.262	.123	.014
HUS							.909**	.881**	.360	.361	.163	.915**	.879**	.893**	.646*	.323	.354	-.716**	-.723**
HUB								.979**	.677*	.717**	.245	.891**	.824**	.778**	.661*	.375	.396	-.670*	-.651*
HUM									.759**	.716**	.439	.865**	.789**	.747**	.648*	.394	.413	-.584	-.575
HSM										.913**	.644*	.439	.343	.241	.388	.338	.331	-.155	-.123
HSB											.276	.455	.371	.244	.397	.306	.300	-.288	-.229
HBM												.180	.104	.098	.168	.218	.214	.171	.132
LA													.860**	.909**	.636*	.233	.284	-.822**	-.847**
LN														.890**	.749**	.447	.489	-.651*	-.684*
PH															.645*	.324	.362	-.654*	-.678*
TDM																.879**	.910**	-.233	-.340
TGW																	.996**	.251	.144
TEW																		.193	.075
PE																			.974**

**Indicates significance at the .01 level

*Indicates significance at the .05 level

[z] Explanation of terms on following page

Explanation of Terms for Table 16

DTS - Days from emergence to silk

DTB - Days from emergence to blister

DTM - Days from emergence to maturity

STB - Days from silk to blister

STM - Days from silk to maturity

BTM - Days from blister to maturity

HUS - Accumulated heat units (AHU) from emergence to silk

HUB - AHU from emergence to blister

HUM - AHU from emergence to maturity

HSM - AHU from silk to maturity

HSB - AHU from silk to blister

HBM - AHU from blister to maturity

LA - Leaf area

LN - Leaf number

PH - Plant height

TDM - Total dry matter

TGW - Total grain weight

TEW - Total ear weight

PE - Percent ear

PG - Percent grain

Table 17. Calculated area per leaf (cm^2) for each maturity class at two planting dates.

Maturity Class	Planting 1	Planting 2
1	241.62	267.48
2	278.90	285.54
3	287.67	318.76
4	350.17	315.53
5	406.54	425.06

also reflected in the number of leaves formed (Table 10).

The higher temperatures of the second planting were expected to cause an increase in leaf number with a corresponding increase in leaf area. As the data in Table 17 shows, the increase in leaf area was not only due to an increase in leaf number, but also due to an increase in the size of the leaves present. The data in Figure 1 shows that for classes 1, 2 and 5 there was an increase in leaf area along with an increase in leaf number. But in classes 3 and 4, there was an actual decrease in leaf number with an increase in leaf area. The difficulty in explaining this lies in the fact that 3 had fewer leaves in the second planting with a greater leaf area, while 4 had fewer leaves in the first planting with a greater leaf area. Perhaps this was due to a temperature x photoperiod interaction with this interaction having different effects on different genotypes. In any case, class 4 is difficult to explain.

Nevertheless, the correlation between leaf area and leaf number was positive and highly significant (Table 16) as was expected.

<u>Correlation between plant height and leaf number</u>. The correlation between plant height and leaf number was positive and highly significant (Table 16). Although no general statement can be made concerning date of planting effect on plant height or leaf number, the data in Figure 2 shows that as a general rule, the taller the plant, the greater number of leaves it will possess. This characteristic was expected.

<u>Correlations of leaf number, leaf area, and plant height with total dry matter</u>. Total dry matter was found to be highly correlated

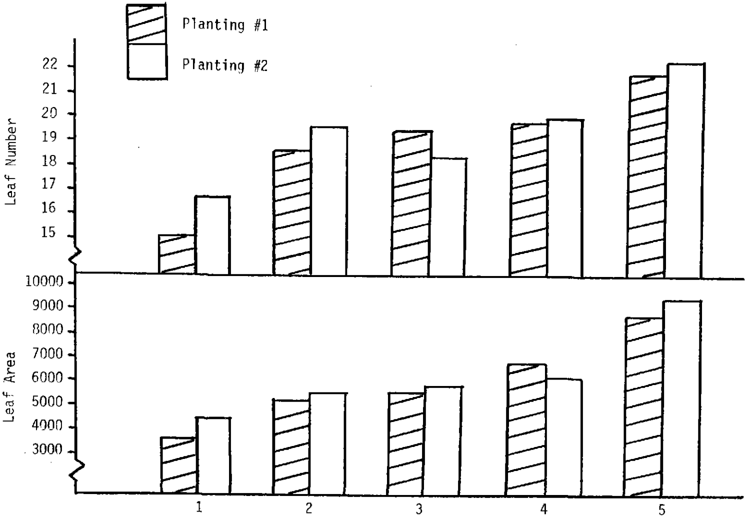

Figure 1. Relationship between leaf area (cm^2) and leaf number of 5 maturity classes of corn at two planting dates, College Station, 1979.

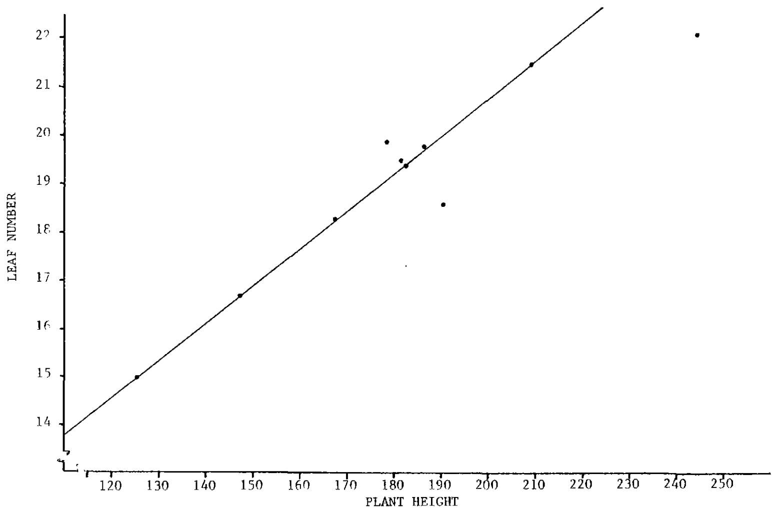

Figure 2. Regression of mean leaf number and mean plant height for 5 maturity classes at two planting dates, College Station, 1979.

with leaf number, much more so than with either leaf area or plant height (Table 16, Figures 3, 4, and 5). This occurance may be a coincidence. It was expected that the height of a corn plant would be more closely related to total dry matter than leaf number or leaf area, simply because the leaves contribute very little to the actual dry weight of the plant while the stalk makes up the major portion along with the ear. The height of the plant determines, to a large extent, the amount of stalk present, thus it should have had a higher correlation with total dry matter.

Correlation between total grain weight and total dry matter. As expected, the correlation between total grain weight and total dry matter was positive and highly significant (Table 16). This indicates that the grain contributes greatly to the total weight of the plant (Figure 6).

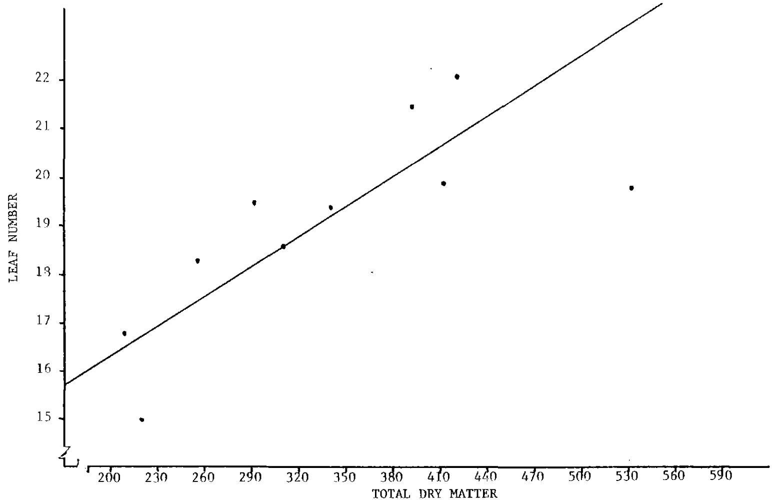

Figure 3. Regression of leaf number and total dry matter (g) for 5 maturity classes of corn at two planting dates, College Station, 1979.

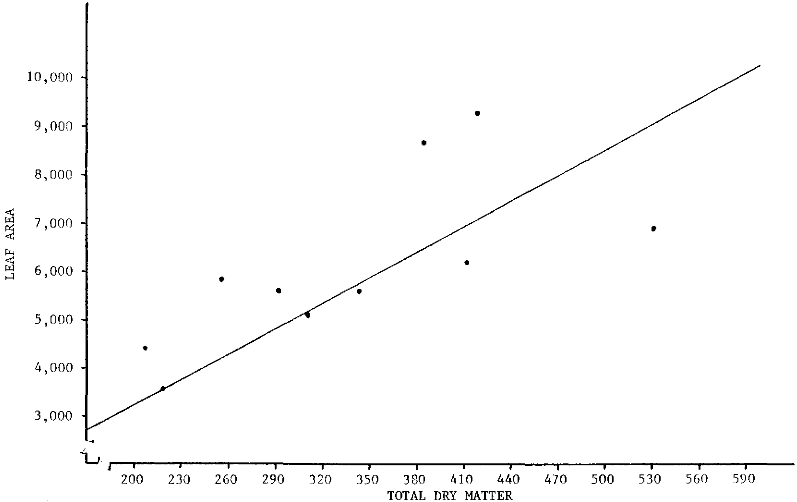

Figure 4. Regression of leaf area and total dry matter (g) for 5 maturity classes of corn at two planting dates, College Station, 1979.

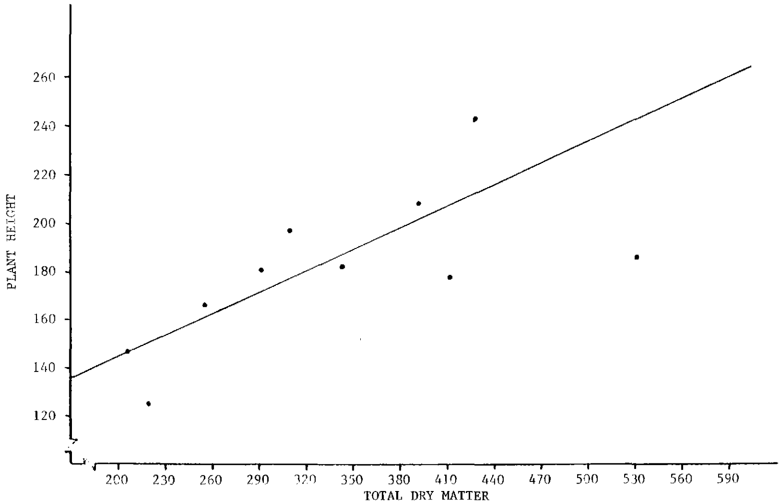

Figure 5. Regression of plant height (cm) and total dry matter (g) for 5 maturity classes of corn at two planting dates, College Station, 1979.

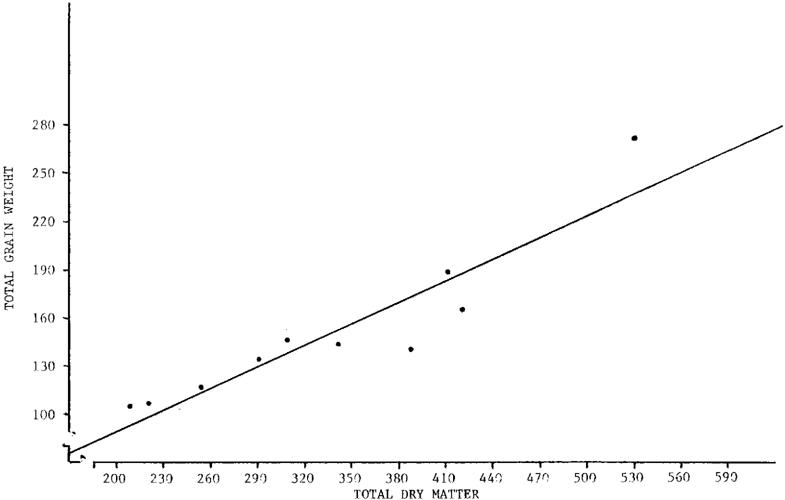

Figure 6. Relationship between total grain weight (g) and total dry matter (g) for 5 maturity classes of corn at two planting dates, College Station, 1979.

CHAPTER V

SUMMARY AND CONCLUSIONS

A study was conducted on the Texas A&M University Farm at College Station during the summer of 1979. Five hybrids of separate maturity classifications were planted at two different dates, 25 days apart, in an attempt to evaluate what effect this treatment would have on the developmental rate and growth characteristics of these hybrids. An attempt was also made at determining the usefulness of accumulated heat units over the calendar day method for predicting maturity of these hybrids.

The data from this study indicated that photoperiod played a minor role in the growth and development of these hybrids and that temperature was the major environmental factor in control.

It was seen that the delayed planting resulted in an increase of the developmental rate. The delay had little or no effect on leaf area, leaf number, or plant height, while it did seem to have some effect on total dry matter accumulation, mostly in the form of a decrease in grain yield.

It was also found that by using the calendar day method of maturity classification, a better separation of means at maturity could be obtained for these hybrids over the accumulated heat unit method. This data indicates that neither of these methods shows a broad separation between the maturity classes in regards to the length of time required to reach maturity.

Generally, it was seen that leaf area, plant height, and plant yield (dry matter and grain) increased from maturity class 1 to 5, respectively. This indicates that, at least for this region, choice of hybrid should be based more on these characteristics rather than number of days required to reach maturity.

APPENDIX

Table 18. Analysis of variance of days to silk, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	51.4 *
MC	4	47.4 *
DOP	1	67.6 *
Error	4	5.4

Table 19. Analysis of variance of days to blister, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	68.0 **
MC	4	78.6 **
DOP	1	25.6 **
Error	4	1.1

** .01 level of significance
* .05 level of significance

Table 20. Analysis of variance of days to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	77.8 **
MC	4	89.1 **
DOP	1	32.4 *
Error	4	13.6

Table 21. Analysis of variance of accumulated heat units (AHU) to silk, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	32885.2 *
MC	4	39468.1 **
DOP	1	6553.6
Error	4	3317.1

** .01 level of significance
* .05 level of significance

Table 22. Analysis of variance of AHU to blister, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	62152.9 **
MC	4	65053.2 **
DOP	1	50552.1 **
Error	4	734.4

Table 23. Analysis of variance of AHU to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	69877.2 **
MC	4	71545.9 **
DOP	1	63202.5 **
Error	4	2655.8

** .01 level of significance
* .05 level of significance

Table 24. Analysis of variance of days from silk to blister, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	7.6
MC	4	7.0
DOP	1	10.0
Error	4	5.5

Table 25. Analysis of variance of days from silk to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	13.1
MC	4	14.8
DOP	1	6.4
Error	4	6.7

** .01 level of significance
* .05 level of significance

Table 26. Analysis of variance of days from blister to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	2.3
MC	4	2.8
DOP	1	.4
Error	4	1.2

Table 27. Analysis of variance of AHU from silk to blister, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	9147.9
MC	4	5982.7
DOP	1	21808.9
Error	4	3937.7

** .01 level of significance
 * .05 level of significance

Table 28. Analysis of variance of AHU from silk to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	16482.9 *
MC	4	13013.6 *
DOP	1	30360.1 *
Error	4	2285.6

Table 29. Analysis of variance of AHU from blister to maturity, College Station, 1979.

Source of Variation	Degrees of Freedom	Mean Square
Total	9	
Model	5	2218.7
MC	4	2561.8
DOP	1	846.4
Error	4	1464.2

** .01 level of significance
 * .05 level of significance

Table 30. General linear model (GLM) analysis of leaf area of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	65	
Model	9	442474.46 **
Date of Planting	1	175974.03 **
Maturity Class	4	926767.37 **
DOP x MC	4	24806.65 **
Error	56	6958.38

Table 31. GLM analysis of leaf number of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	88	
Model	9	36.27 **
Date of Planting	1	13.43 **
Maturity Class	4	72.99 **
DOP x MC	4	5.25 **
Error	79	.34

** .01 level of significance
 * .05 level of significance

Table 32. GLM analysis of plant height of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	81	
Model	9	1209.78 **
Date of Planting	1	15.80
Maturity Class	4	2417.19 **
DOP x MC	4	300.86 **
Error	72	21.60

Table 33. GLM analysis of total dry matter of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	81	
Model	9	83502.95 **
Date of Planting	1	44489.02 **
Maturity Class	4	163958.18 **
DOP x MC	4	12801.21 *
Error	72	4113.91

** .01 level of significance
* .05 level of significance

Table 34. GLM analysis of total grain weight of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	81	
Model	9	21065.21 **
Date of Planting	1	15379.62 **
Maturity Class	4	37820.18 **
DOP x MC	4	5731.64 **
Error	72	1154.53

Table 35. GLM analysis ofpercent grain of maturity classes and planting dates, College Station, 1979.

Source of Variance	Degrees of Freedom	Mean Square
Total	81	
Model	9	156.42 **
Date of Planting	1	5.90
Maturity Class	4	307.53 **
DOP x MC	4	42.95
Error	72	20.31

** .01 level of significance
 * .05 level of significance

Table 36. Specific dates of stages of development of 5 maturity classes of corn at two planting dates, College Station, 1979.

	Maturity Class	Planting 1	Planting 2
Date of Planting:		March, 30	April, 24
Date of Emergence:		April, 8	April, 30
Date of Silk:	1	May, 29	June, 19
	2	June, 8	June, 21
	3	June, 7	June, 25
	4	June, 8	June, 26
	5	June, 15	June, 30
Date of Blister:	1	June, 8	June, 27
	2	June, 14	July, 3
	3	June, 14	July, 5
	4	June, 20	July, 9
	5	June, 25	July, 12
Date of Maturity:	1	July, 14	August, 3
	2	July, 20	August, 6
	3	July, 16	August, 8
	4	July, 26	August, 13
	5	July, 31	August, 17

Table 37. Maximum and minimum daily temperatures from March 30 to August 17, 1979, College Station, Texas.

Day Number	Maximum Temperature	Minimum Temperature
1*	74	66
2	72	62
3	78	62
4	76	66
5	54	50
6	60	52
7	62	48
8	76	36
9	80	42
10	72	56
11	86	68
12	74	62
13	72	60
14	82	68
15	82	68
16	86	54
17	80	46
18	88	52
19	82	66
20	70	64
21	70	62
22	76	62
23	82	62
24	70	62
25	68	62
26	80	62
27	86	54
28	86	58
29	86	58
30	80	48
31	80	52
32	68	56
33	80	62
34	76	60
35	82	68
36	58	52
37	72	52
38	80	55
39	86	72
40	88	66

* Day number 1 begins with March 30, 1979.

Table 37. (cont.)

Day Number	Maximum Temperature	Minimum Temperature
41	82	62
42	86	74
43	76	52
44	76	48
45	60	45
46	86	68
47	86	56
48	86	58
49	86	58
50	88	55
51	82	62
52	88	62
53	78	62
54	80	62
55	80	60
56	78	68
57	82	60
58	86	62
59	82	63
60	88	62
61	84	62
62	90	68
63	88	64
64	84	72
65	82	70
66	88	70
67	86	72
68	82	72
69	86	72
70	92	76
71	92	76
72	94	74
73	82	72
74	82	64
75	86	54
76	90	58
77	90	62
78	90	64
79	90	66
80	92	66
81	96	80
82	96	78
83	96	78
84	96	74
85	96	72

Table 37. (cont.)

Day Number	Maximum Temperature	Minimum Temperature
86	94	72
87	96	72
88	96	78
89	92	72
90	94	70
91	98	72
92	100	74
93	98	74
94	98	74
95	98	80
96	96	74
97	86	74
98	86	76
99	88	76
100	98	76
101	98	72
102	96	76
103	94	72
104	94	61
105	94	72
106	94	76
107	90	76
108	90	78
109	96	80
110	100	76
111	90	72
112	90	72
113	90	72
114	92	72
115	90	70
116	96	80
117	92	74
118	84	76
119	86	72
120	84	72
121	94	76
122	96	72
123	80	71
124	89	69
125	85	79
126	85	78
127	88	80
128	86	79
129	88	78
130	93	80

Table 37. (cont.)

Day Number	Maximum Temperature	Minimum Temperature
131	94	82
132	97	80
133	99	80
134	90	78
135	90	80
136	98	78
137	96	74
138	94	72
139	94	72
140	92	68
141	94	70

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VITA

Name of Author: Robert Alan Lane

Place of Birth: Mobile, Alabama

Date of Birth: May 9, 1955

Parents: Mr. and Mrs. G.M. Lane, Jr.
3003 Avenue J
Nederland, Texas

Educational Background: Nederland High School-1973
Sam Houston State University
B.S. Agricultural Education-1977
Texas A&M University
Entered graduate school-1977

The typist of this thesis was Ms. Gina Harvell.