EFFECT OF TILLAGE SYSTEMS ON EARLY GROWTH OF WINTER WHEAT (*TRITICUM AESTIVUM* L.)

By

DALE ALAN WEISHAAR

Bachelor of Science in Agriculture

Kansas State University

Manhattan, Kansas

1982

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 1984

EFFECT OF TILLAGE SYSTEMS ON EARLY

GROWTH OF WINTER WHEAT

(TRITICUM AESTIVUM

L.)

Thesis Approved:

Eugene Krenzer Jr.
Thesis Adviser

Lavoy I. Croy

Jewell Crabtree

Norman N. Durham
Dean of Graduate College

ACKNOWLEDGMENTS

The author wishes to express sincere gratitude to his major adviser, Dr. Eugene Krenzer, for his guidance, encouragement and friendship throughout the course of this study.

Appreciation is also extended to the other members of my committee, Dr. Lavoy Croy and Dr. Jewell Crabtree, for their valuable comments in the preparation of this thesis. I also want to thank the Agronomy Department for the use of their facilities and financial support.

Special appreciation is expressed to Rick Matheson, Bill Heer, Steve Smith, and Chris Winterkamp for their assistance in the plot work and data collecting. The author also wishes to thank Sheryl Gray for her typing of the tables.

A very special thanks to my parents, Lloyd and Lee Weishaar, for their encouragement and support throughout this study.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

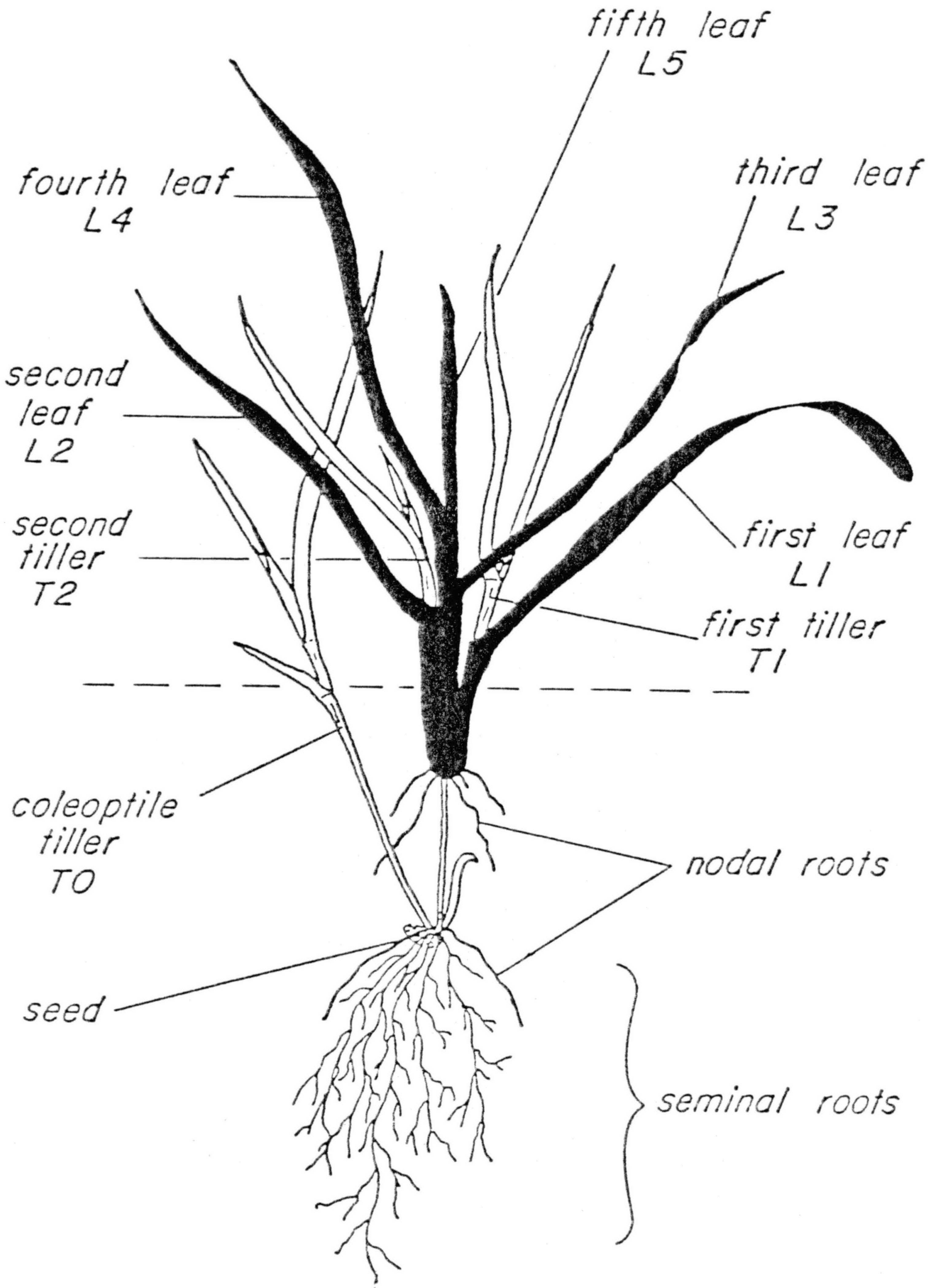
INTRODUCTION AND LITERATURE REVIEW

In the last few years, there has been increased interest in reduced tillage for wheat production. The effects of tillage on early growth and development of winter wheat in Oklahoma needs to be examined. Early growth of wheat is important as many Oklahoma farmers grow wheat not only for grain but also utilize wheat for grazing. Getting an early start allows time for as much forage as possible to be produced. When tiller emergence is delayed, there is a corresponding decrease in forage production. Likewise, anything that inhibits development of a tiller bud and consequently its subtillers reduces forage production available for potential grazing and/or potential grain yield.

Tillering is the growth stage in which the leaf axillary buds develop into shoots or tillers. Tillers are similar in structure to the parent shoots from which they arise. Primary tillers arise from the main stem leaf buds. Axillary buds also form at the base of tiller leaves forming subtillers and sub-subtillers, secondary and tertiary tillers, respectively.

Two common ways to measure growth are total dry weight or leaf area. However, these measures are destructive and growth on specific plants cannot be observed throughout the season. Tiller emergence can be monitored in a nondestructive manner. A tiller bud has a certain time period during which it can develop (8). Stress may delay the development of the tiller from the axillary bud. Adverse environmental conditions, if severe enough, will delay development of the bud past the developmental time period thus inhibiting the tiller from emerging (7). For example, the first tiller (T1) may be inhibited if severe stress prevents its development at the developmental time when the main stem produces the fourth leaf. When conditions improve, the plant does not go back and develop the inhibited tiller after its developmental period is past, but will produce the succeeding tillers during their own developmental time periods. Therefore, the amount of stress imposed on a wheat plant during the developmental time period of a tiller will determine what percent of the plants develop that particular tiller. Klepper, Rickman, and Peterson (7) noted that early tillers are most affected by the environment.

Klepper, Rickman, and Peterson (7) described a tiller naming system (Figure 1). Their tiller nomenclature is based upon the leaves on the main stem which are numbered sequentially beginning with the coleoptile as L0 and the first true leaf as L1, etc. The primary coleoptile tiller and the first tiller are designated respectively as T0 and T1. The leaves of the first tiller (T1) are likewise numbered sequentially. The tiller sheath (prophyll)



Source: Klepper, B. L., R. W. Rickman, and R. K. Belford (6).

Figure 1. Young Wheat Plant with Identified Leaves and Tillers. The Main Culm is Colored Black.

corresponds to the coleoptile. Thus, it is labeled as T10. The first leaf on T1 (L11) produced the secondary tiller labeled T11. Thus in like manner, the prophyll tertiary tiller from T11 is named T110.

Since early tillers are most affected by environmental conditions, Wilkins, Klepper, and Rickman (9) used the plant parameter of presence or absence of the T0 and T1 to evaluate different tillage systems. Different tillage treatments did affect the percent of plants having T0 and T1. Stress imposed on wheat plants during the developmental time period of a tiller is related to the percent of T0 and T1 that develop. Tillage treatments of sweep, no tillage, chemical fallow, and rodweed fallow inhibited Stephens soft winter wheat's T1 by 47, 34, 12, and 12 percent, respectively. In this study the tillage methods that utilized minimal tillage methods had fewer plants with T1 and thus more stress than did the tillage methods that utilized plowing.

Rickman, Klepper, and Peterson (8) used accumulation of degree days as a means to compare growth chamber and field treatments rather than calendar time. Growing degree days (GDD) relates heat units with plant growth and development. This allows for direct comparisons between tillage treatments, locations, and years. If more stress is present in one treatment compared to another, then an increase in GDD required for tiller emergence will be observed due to the longer time period needed for tiller emergence. The equation for GDD is as follows:

$$GDD = \sum_{i=1}^{n}\left(\frac{\left[Tmax_i + Tmin_i\right]}{2} - \left[\text{Base Temperature}\right]\right)$$

> Where $Tmax_i$ was the maximum air temperature in °C for the ith day, $Tmin_i$ was the minimum air temperature in °C for the ith day and the Base Temperature was 3 °C (9, pp. 5-6).

The base temperature which should be used has been debated (5). We chose to use 0 °C on the basis that it is the temperature at which growth is halted for wheat (2, 4, 5). Hay and Wilson found that

> since soil temperatures are strongly correlated with air temperatures, there were also close linear relationships between [wheat] leaf appearances and accumulated air temperatures above 0 °C at 5 cm (3, p. 405).

Rickman, Klepper, and Peterson stated that

> Since mean air temperature and mean soil temperature at seeding depth [also at the crown depth] are correlated and air temperature is so widely available, air temperature was used for degree-day calculation (8, p. 554).

The GDD calculated for 50 percent appearance of T1 and T2 of Stephens soft white winter wheat in Rickman, Klepper, and Peterson's study (8) used the base temperature of 3 °C. Treatment one was conducted in a growth chamber in which the plants required 274 GDD for T1 and 336 GDD for T2. Treatment two involving a wet seedbed condition needed 250 GDD for T1 and 305 GDD for T2. Under a dry seedbed condition, treatment three required 350 and 392 GDD for the 50 percent appearance of T1 and T2, respectively. Fewer GDD were required when the soil moisture was favorable as in treatment two than when soil moisture was less than favorable as in treatment three. Rickman, Klepper, and Peterson stated that when GDD

> for T1 exceeded about 250 in field plots, some problem existed (dry soil, crusted soil, heavy residue cover, or other management problem) which measurably interfered with the development of T1. Once a stressful condition such as dry soil in treatment 3 was relieved subsequent tillers appeared after the accumulation of approximately the same amount of heat as required by an unstressed plant (8, pp. 554-555).

The objectives of this study are to determine if method of tillage, conventional or no-till, and planting date influences early vegetative growth of winter wheat and to evaluate the effects of tillage systems on the rate of tillering at different planting dates. To accomplish these objectives, a comparison of the plant parameters of plant population, number of GDD required for tiller emergence, and percent of plants having T1 and T2 will be utilized to detect if different stress occurred between the treatments. We are not attempting to identify factors causing the stress, only whether there was an effect on the amount of stress.

CHAPTER II

MATERIAL AND METHODS

A split plot experiment with four replications was conducted in 1982 and 1983. The main plot treatments were tillage systems consisting either of conventional methods or no-till in a randomized complete block design. Conventional tillage practices were based on the practices used by the local farmers. At Stillwater the conventional utilized the moldboard plow, tandem disk, and spring tooth while at Lahoma the offset disk and 50.8 cm sweep plow were utilized. Non-residual (in the soil) herbicides were used in the no-till. All herbicides are expressed as active ingredient in kg ha^{-1}. Weed control after harvest was achieved by applying glyphosate (N-phosphonomethyl)glycine) at the rate of 1 kg ha^{-1} and 1.7 kg ha^{-1} at Stillwater and Lahoma, respectively in 1982. Just preceding planting, glyphosate was applied at the rate of 0.5 kg ha^{-1} when needed for weed and volunteer wheat control. MCPA ([(4-chloro-o-tolyl)oxy]-acetic acid) was applied at Stillwater in mid-December 1982 at the rate of 0.5 kg ha^{-1} of active ingredient to control broadleaves in both tillage systems. Chlorsulfuron (2-chloro-N-[[(4- methoxy-6-methyl-1,3,5-triazin-2-yl)-aminol] carbonyl] benzenesulfonamide) at the rate of 0.04

kg ha^{-1} for broadleaf control at both locations in the early spring in 1983 in both tillage systems. Mid-month planting dates of August, September, October, and November were subplot treatments. TAM W-101, a hard red winter wheat (*Triticum aestivum* L.) was grown on Pulaski fine sandy loam, a member of the coarse-loamy, mixed, nonacid, thermic family of Typic Ustifluvents at Stillwater and on Grant silt loam, a member of the fine silty, mixed thermic family of Udic Argiustolls at Lahoma. Previously, both locations had been in wheat production. The treatments were repeated on the same locations the second year. The plot sizes were 7.6 by 22.9 m and 7.6 by 30.5 m at Stillwater and Lahoma, respectively. Planting in 1982 was performed by a John Deere hoe drill while in 1983 a CrustBuster disk opener drill was utilized. Both drills had a 25.4 cm row spacing. The seeding rate was 60 kg ha^{-1} and 65 kg ha^{-1} in 1982 and 1983, respectively.

Fertilizer was applied according to recommendations of the Oklahoma State University soil testing laboratory. The fertilizer rates at Stillwater in 1982 were 110 kg ha^{-1} of N as NH_4NO_3 and 18-46-0, 65 kg ha^{-1} of P as 18-46-0, and 70 kg ha^{-1} of K as 0-0-62. At Lahoma, 115 kg ha^{-1} of N as NH_4NO_3 and 18-46-0, and 65 kg ha^{-1} of P as 18-46-0 were applied. Fertilizer rates at Stillwater in 1983 were 100 kg ha^{-1} of N as NH_4NO_3, 10 kg ha^{-1} of N as 10-34-0, 44 kg ha^{-1} of P as 10-34-0, and 65 kg ha^{-1} of K as 0-0-62. At Lahoma in 1983 the fertilzer rates applied were 100 kg ha^{-1} of N as NH_4NO_3, 10 kg ha^{-1} of N as 10-34-0, and 45 kg ha^{-1} of P as 10-34-0. The NH_4NO_3 and 0-0-62 were applied by broadcasting while 10-34-0 and 18-46-0 were applied with the drill at planting.

Emergence dates were obtained in order to have a basis from which to calculate the time required from plant emergence to emergence of specific tillers. Within each subplot, three plants were randomly selected from each of six 1m rows. Thus, data were collected from 18 plants per plot or 72 plants per planting date in one of the two tillage systems. The tiller identification system used by Klepper, Rickman, and Peterson (7) was utilized. Early vegetative growth was measured by the time of emergence of the tiller beyond its prophyll and/or the ligule of the subtending leaf. The date of tiller emergence was recorded and later converted into the number of GDD required from plant emergence to the emergence of the specific tiller. Air temperatures used for GDD calculations were recorded at the closest weather stations of the Agronomy Research Station at Stillwater and the North Central Research Station at Lahoma (Tables VIII, IX, X, XI). At the time of tiller emergence a color coded wire ring was slipped around the tiller. This ring helped in identification of other main culm tillers and the subtillers of the ringed tiller. Because of time and labor, data on the first five tillers to emerge were recorded but later emerging tillers were not monitored.

Standard split plot analyses of variance were conducted on the mean stand established, mean GDD required for T1 and

T2 emergence, and on mean percent of plants with T1 and T2. Mean stand established was based on the average plant stand of the six rows one meter in length per plot. The mean GDD and percent of plants with T1 and T2 were calculated on a plot basis of 18 plants per plot. Each plot mean per planting date of a tillage method was a replication. An analysis of variance was conducted separately for each location and year. Interactions between year, location, tillage method and planting date were tested to see if they were significant. F tests were used to determine if significant differences between tillage methods existed within a planting date. Duncan's Multiple Range tests were used to determine significant differences in means between planting dates within a tillage method.

CHAPTER III

RESULTS AND DISCUSSION

Several planting dates were eliminated due to problems encountered with weather conditions and/or difficulties with tillage methods. In 1982, the Stillwater August treatments were eliminated due to the severe volunteer wheat situation. Since there had been no rain following harvest, none of the volunteer wheat had germinated prior to the August planting. Also the wheat in the 1982 August treatments at Stillwater did not germinate until the September planting date due to lack of rain or soil moisture. In 1983, the Stillwater August conventional tillage treatment was eliminated due to the lack of emergence. Poor emergence may have been due to the crusting of the soil surface or planting slightly too deep for the soil temperature-cultivar combination (1) which prevented the emergence of the majority of the wheat. The August no-till treatment had good emergence. Therefore, plants were marked and tiller emergence monitored. Later statistical analysis was performed on the no-till separately to utilize the information for all four planting dates. Stillwater 1983 conventional tillage had the three planting dates of September, October, and November. Due to severe cold, plant emergence was slowed and taking emergence data was severely hampered at Lahoma for the November 1983 planting date and this planting date also had to be eliminated.

Stand Establishment

Even though significant tillage effects on stand establishment were observed for a few dates and locations, equal plant populations were generally obtained (Table I, all tables are located in the Appendix). The most important exceptions were at Stillwater in the September 1982 and November 1983 planting dates where the conventional tillage had significantly more plants per meter row than did the no-till. The reverse was true at Lahoma in the 1982 planting dates of August, September, and October where the no-till plots contained more plants per meter row. Within a tillage system, differences between planting dates were not consistent. This was probably due to the difficulty of obtaining exactly the same seeding rate each time. Except for the early planting date where soil temperatures may have been critical, there was no consistent difference between tillage systems in reference to stand establishment.

Differences in stand establishment measures stress in the seedbed but differences in growing degree days (GDD) and percent of plants with the first and second main culm tillers (T1 and T2) measures stress on early growth. The most sensitive measure of stress in early growth is GDD which is based on heat units required for growth. If a difference in GDD for tiller emergence exists between conventional tillage and no-till then it indicates a stress in the system with the higher GDD. If stress is severe enough then the axillary tiller bud is inhibited from development. Percent of tillers present should approach 100 percent; otherwise, stress is indicated. Lack of coleoptilers (T0) is an indicator of stress (9). However, T0 were seldom present in this study, and therefore not reported. Consistency of the same first five tillers developing in all planting dates did not exist. Therefore, only the first and second main culm tillers (T1 and T2) were analyzed as they were present in high enough numbers to give meaningful data. If they were absent, their absence could be explained by stress inhibiting the expression of the first and second main culm axillary buds from which T1 and T2 develop. Since many of the three and four way interactions were significant (Tables IV, V, VI), the data will be presented by individual location and year for GDD required for emergence of tillers and percent of plants with T1 and T2.

Stillwater Growing Degree Days

Plants in the September 1982 no-till at Stillwater needed 144 more GDD for T1 emergence than did the plants in the conventional tillage (Figure 2). This delay in GDD implies that stress was greater for the September no-till than for the September conventional tillage system for T1. There was no difference between the mean GDD for the three conventional planting dates. In contrast, the no-till mean GDD

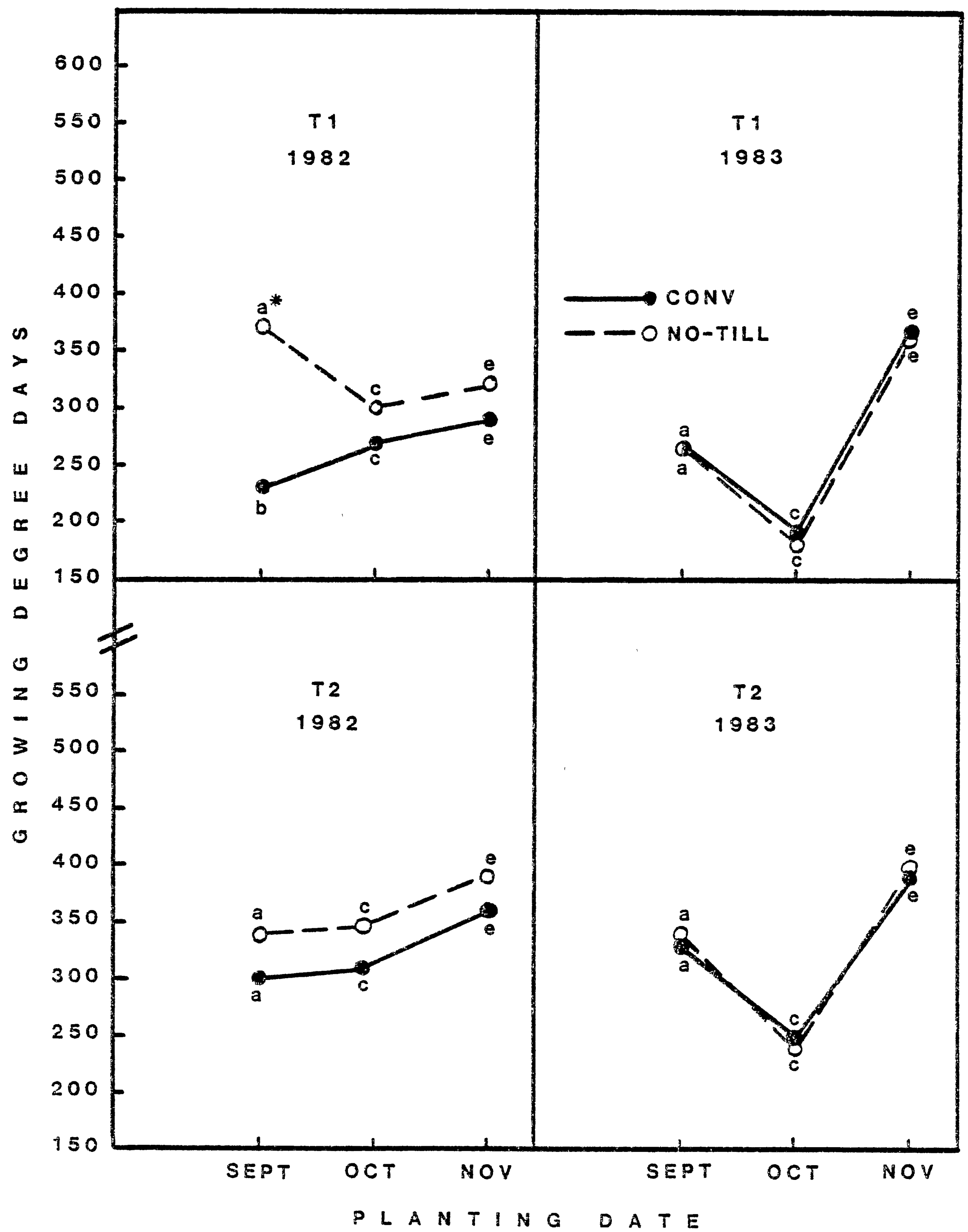


Figure 2. Effect of Planting Date and Tillage Method on Mean Growing Degree Days to Emergence of T1 and T2 at Stillwater. * Tillage Means Followed by the Same Letter in the Same Planting Date Are Not Significant at the 0.05 Level.

was significantly lower for the October than for the September planting. However, the GDD for November planting was not different from either September or the October planting. The tillage by planting date interaction was significant and was due to the GDD difference between tillage treatments in September which was not present in October and November.

There was no tillage difference in GDD required for T2 in 1982 (Figure 2). Therefore, GDD for T2 in September, October, and November plantings were averaged over tillage methods. The September and October plantings had a significantly lower number of GDD than did the November planting. Meaning an increase of 48 GDD occurred in the November planting when compared to the average GDD for September and October plantings average across tillage methods.

In 1983, the tillage treatments required the same GDD for T1 emergence (Figure 3), but a significant difference in GDD between each planting date was present. The October planting date required the least number of GDD for emergence of T1 than did any other planting date at either location or year (Table II). September planting GDD for T1 was significantly greater than October planting's but significantly less than the GDD needed for the November planting date (Figure 3). Speculation is that in October planting T1 was uninhibited at Stillwater in 1983. Thus for the conditions at that time, optimum conditions persisted while a delay may be expressed in the November planting. Between the November and September plantings there existed a 96 GDD delay of T1

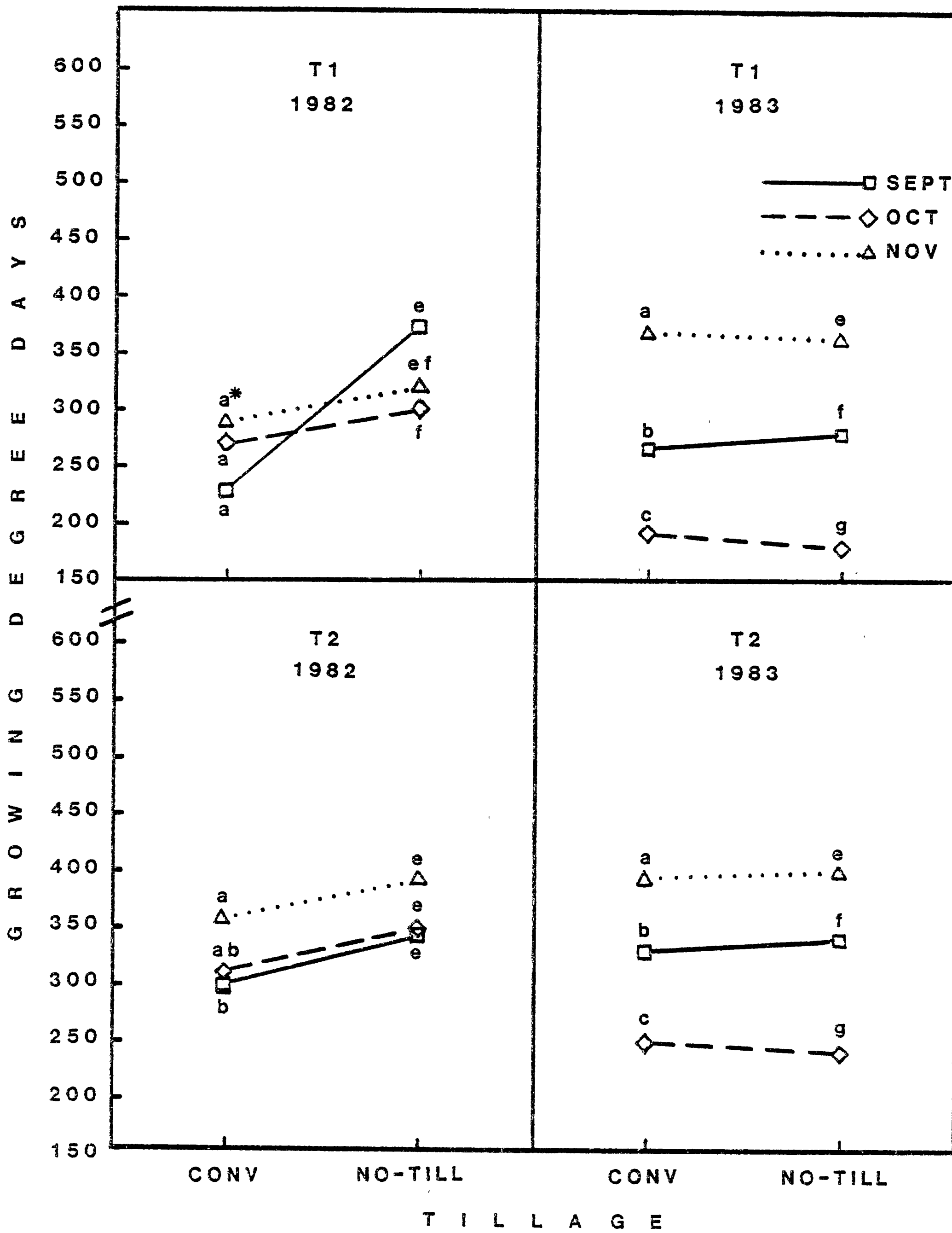


Figure 3. Effect of Tillage Method and Planting Date on Mean Growing Degree Days for Emergence of T1 and T2 at Stillwater. * Planting Date Means Followed by the Same Letter in the Same Tillage Are Not Significant at the 0.05 Level.

emergence which may express a stress occurring in the November planting that was not evident in the earlier planting dates. The different responses of the planting dates in the number of GDD over both years account for the two way interactions, year by tillage and year by planting date.

The pattern for 1983's T2 (Figure 2, Table II) essentially paralleled with the pattern made by the mean GDD of T1. Likewise, no tillage difference in GDD for T2 occurred. September had a significantly greater number of GDD for T2 emergence than did the October planting but significantly fewer than did the November planting. As observed for T1, T2 in the 1983 October planting date required the least number of GDD for the emergence of T2 compared to any planting date any year at either location. A two way interaction of year by planting date was caused by the two October planting dates (Figure 2). For T2, the mean GDD in the 1982 October planting was similar to the 1982 September planting but 1983 October's GDD was significantly lower than the GDD for the 1983 September or November planting. This difference in response of the planting dates in number of GDD over both years accounts for the two way interactions of year by tillage and year by planting date.

In considering only the four no-till planting dates at Stillwater 1983, the number of GDD required for T1 and T2 emergence was greatest in the August planting date and least in the October planting date (Table III). Therefore, more stress was present in the 1983 August planting date than in the other planting dates. A significant difference occurred between all planting dates for T1. But for T2, no difference occurred between September and November plantings (Figure 4, Table III). Looking at T1 there was a delay of 144 GDD that existed between August and November, the two planting dates requiring a greater number of GDD for tiller emergence. Similar trends occurred for both T1 and T2 (Figure 4).

Lahoma Growing Degree Days

In considering the Lahoma study, no difference in GDD was present for either T1 or T2 emergence between tillage treatments in 1982 (Figure 5, Table II). On the other hand, planting date differences existed (Figure 6). August planting date required significantly greater number of GDD for T1 emergence than required for the other three months. By taking the average GDD of the last three months and comparing this average with that of August, there was found a T1 delay of 165 GDD in the August planting. This indicates a stress.

Similarly, in 1982, August planting date required the greatest number of GDD for T2 emergence (Figure 6), while the November planting date had the fewest GDD for T2 emergence. No difference in GDD occurred between November and September planting or between September and October planting. Similar patterns of GDD required for T1 and T2 emergence were observed when comparing the different planting dates for both tillers (Figure 5).

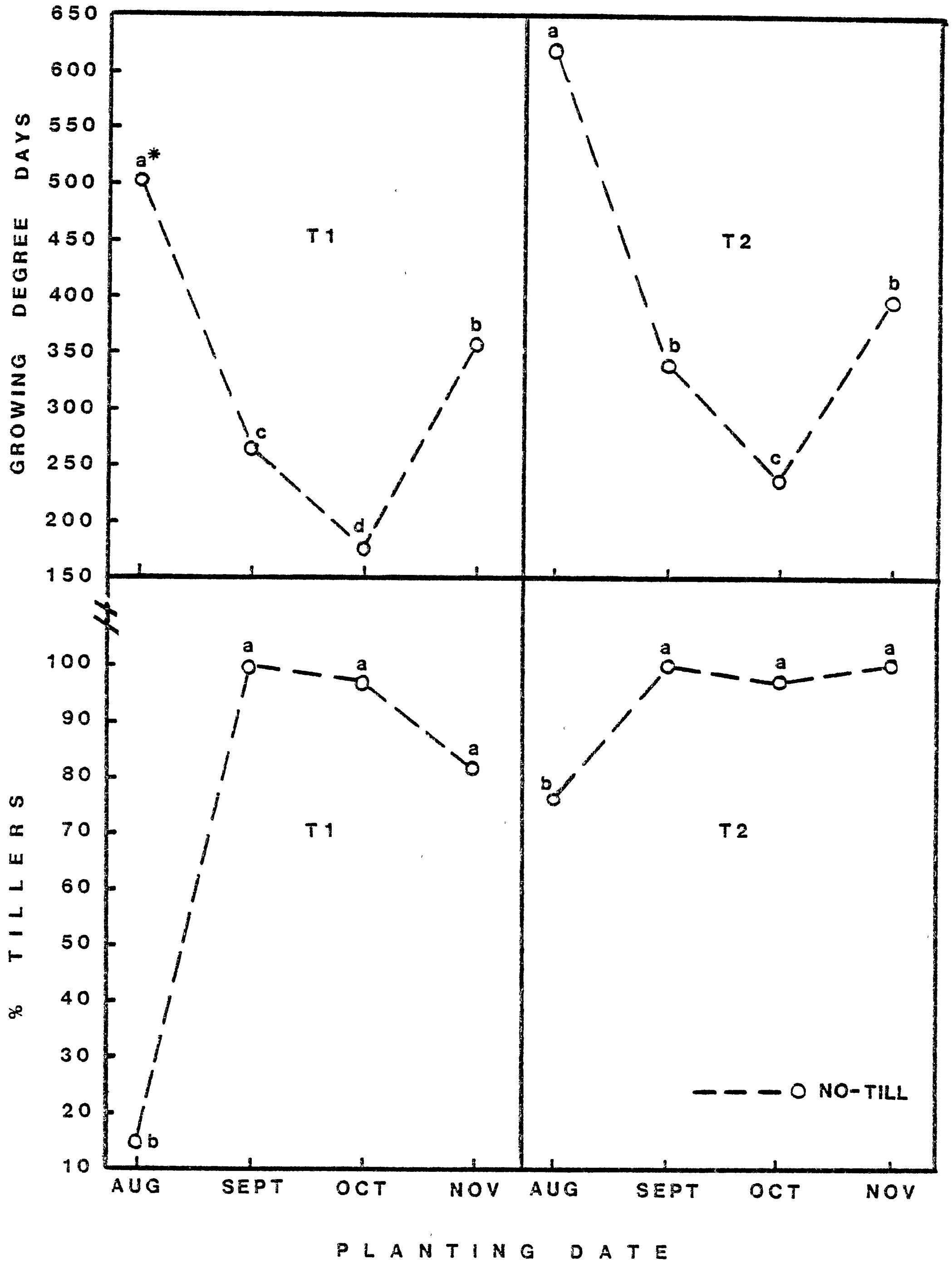


Figure 4. Effect of Planting Date and No-till on Mean Growing Degree Days for Emergence of T1 and T2 and Mean Percent of Plants with T1 and T2 at Stillwater 1983. * Planting Date Means Followed by the Same Letter in the No-till Are Not Significant at the 0.01 Level.

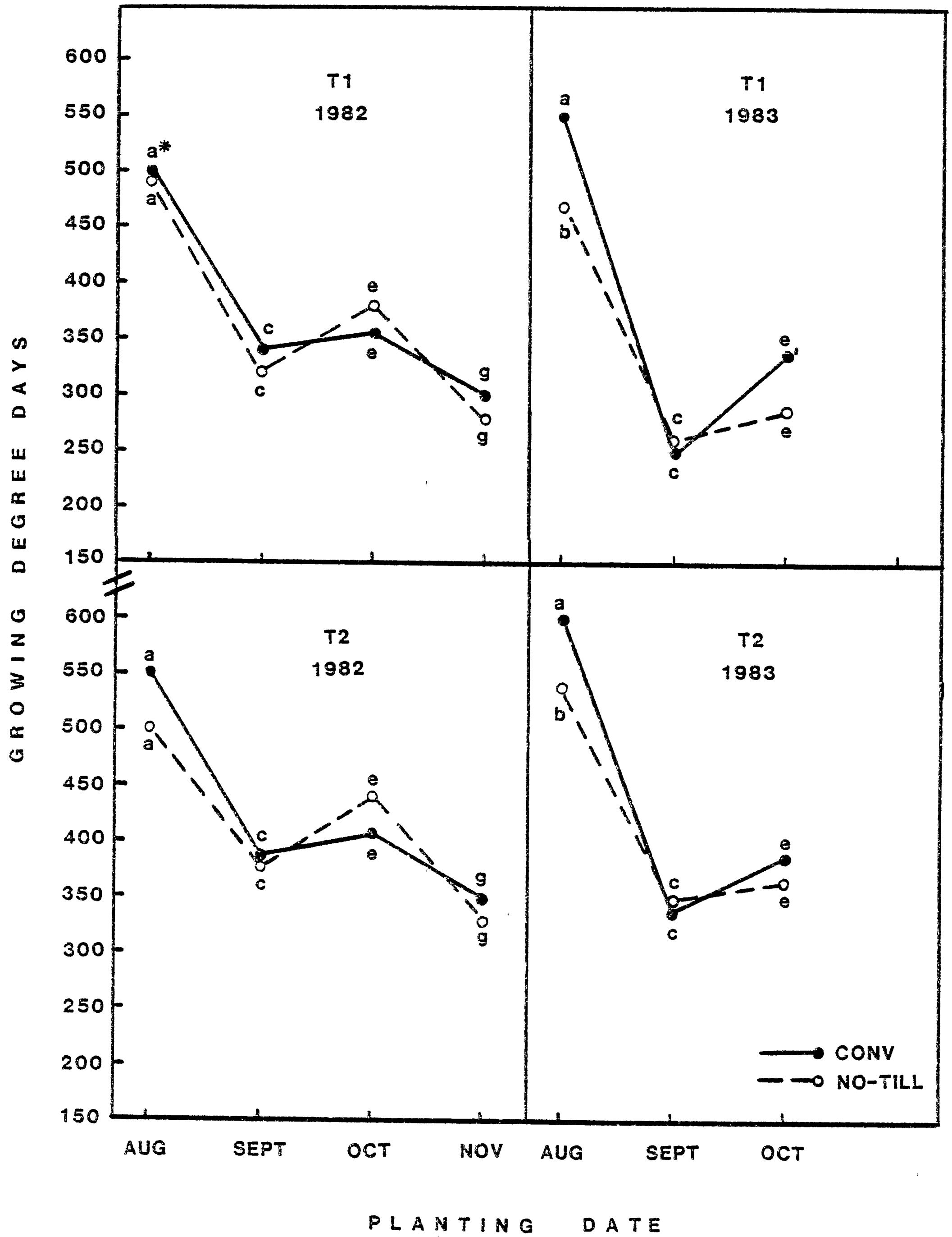


Figure 5. Effect of Planting Date and Tillage Methods on Mean Growing Degree Days to Emergence of T1 and T2 at Lahoma. * Tillage Means Followed by the Same Letter in the Same Planting Date Are Not Significant at the 0.05 Level.

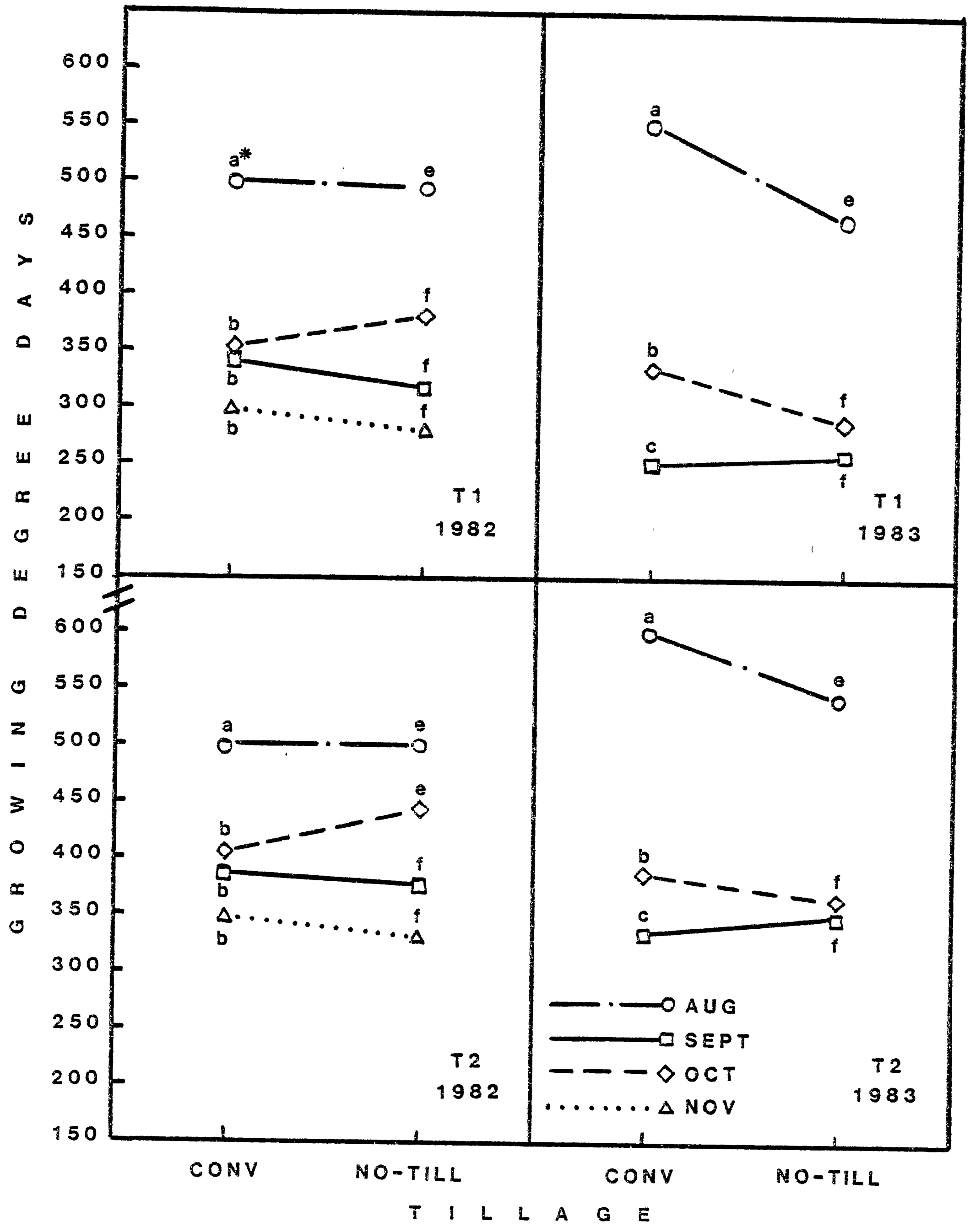


Figure 6. Effect of Tillage Method and Planting Date on Mean Growing Degree Days for Emergence of T1 and T2 at Lahoma. * Planting Date Means Followed by the Same Letter in the Same Tillage Are Not Significant at the 0.05 Level.

No difference between tillage systems existed in the number of GDD required for T1 and T2 emergence at Lahoma 1983 except in the August planting date at the one percent level of significance (Figure 5, Table II). The August conventional tillage experienced a delay of 83 and 59 GDD, respectively for T1 and T2 compared to the August no-till. In the conventional system there was a significant difference between all three planting dates in the number of GDD (Figure 6). Whereby in the no-till, the GDD required for T1 emergence in the October and November plantings were the same but GDD were significantly higher in the August planting date. The trend (Figure 5) in differences between planting dates for T2 GDD for both tillage methods were similar to the trends observed in both tillage methods for T1 GDD. When comparing the T2 for both years (Figure 5), a similar general trend was also seen. There was a deviation in the August planting where 1982 GDD required for T2 emergence was less than observed in 1983, whereas the converse was observed in the planting dates of September and October.

Stillwater Tiller Percentages

A highly significant difference in percent of plants with T1 existed between tillage systems at Stillwater in the 1982 September planting (Figure 7). Stress influences the percentage of T1 produced according to Wilkins, Klepper, and Rickman (9). Evidence of severe stress was prevalent particularly in the no-till demonstrated by the repressed

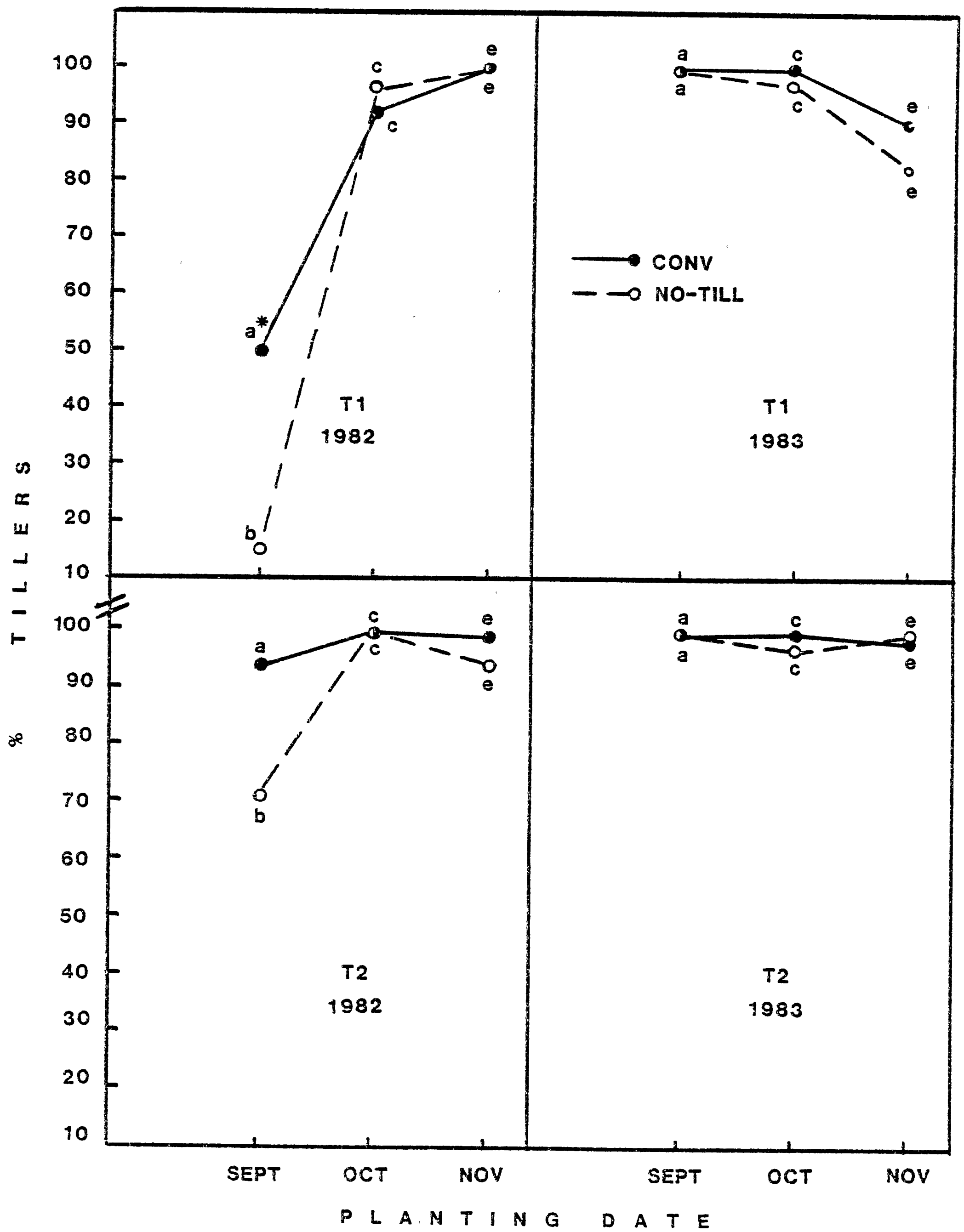


Figure 7. Effect of Planting Date and Tillage Method on Mean Percent of Plants with T1 and T2 at Stillwater. * Tillage Means Followed by the Same Letter in the Same Planting Date Are Not Significant at the 0.05 Level.

percentage of T1 (Figures 7 and 8) and by visual observations. In the September conventional, 50 percent of the plants failed to develop T1 due to stress (Figure 8). A greater stress was indicated in the no-till as 85 percent of the T1's axillary buds were inhibited from developing. This stress was alleviated later in the season as nearly 100 percent of the plants had T1 and there were no differences between tillages for the October and November planting dates.

As for the difference between planting dates in 1982 for T1, September planting date had significantly lower percent of plants developing T1 than either October or November plantings in both tillage systems (Figure 8). This difference confirms that stress did occur in the September planting date. An association existed between the greatest inhibition of T1 (85 percent) in the September no-till and a significant delay of 73 GDD for T1 compared to the October no-till. However, the 50 percent inhibition in the September conventional treatment had no delay in GDD indicated when compared to the other conventional planting dates (Figure 3).

The percent of T2 at Stillwater 1982 (Figure 7) showed the similar trend as seen for T1. Likewise, there was a significant difference between tillages in the September planting date. Although minimum stress existed in the September conventional tillage, a greater stress was present in the September no-till causing a 23 percent inhibition of T2 compared to the conventional tillage. Again there was no

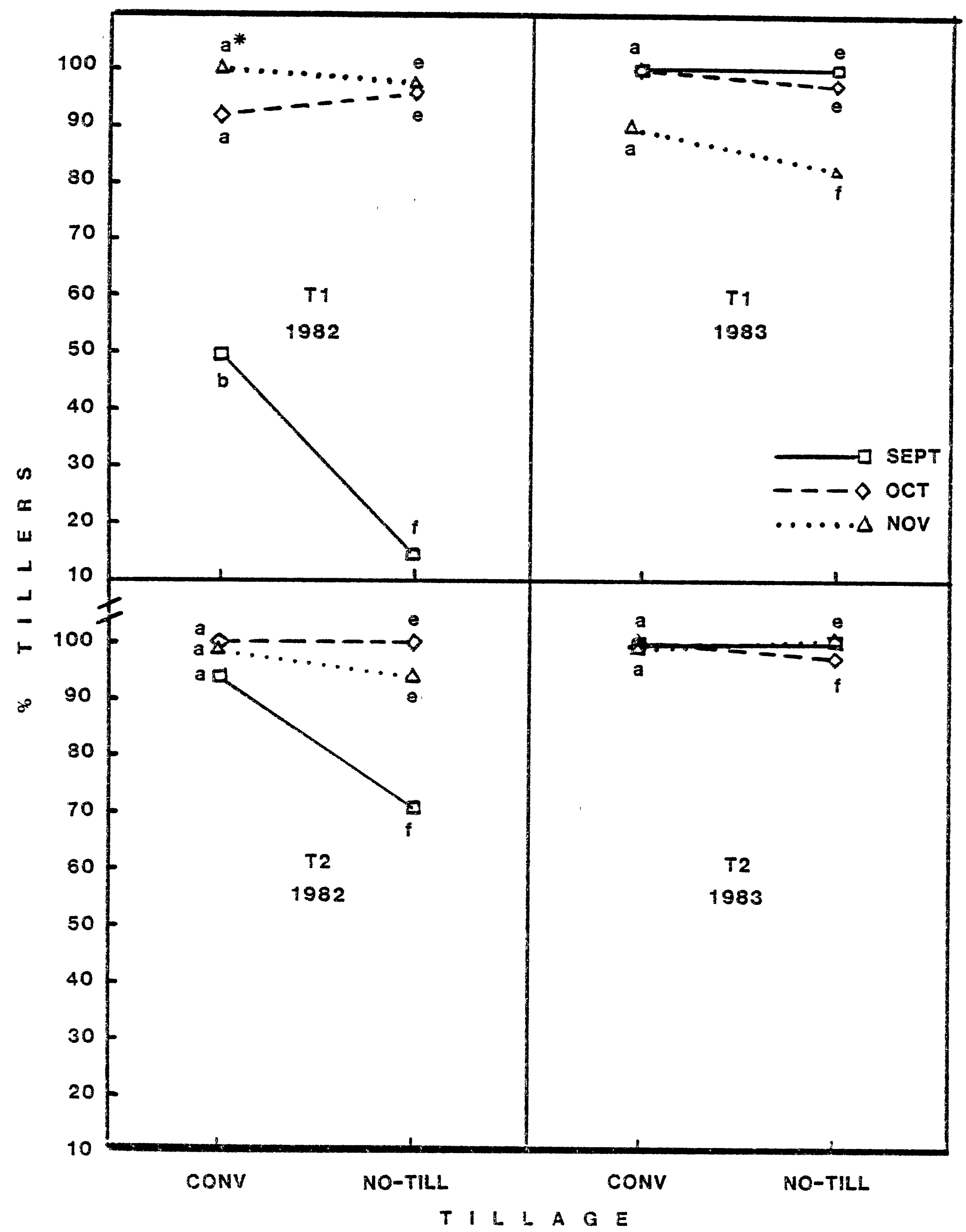


Figure 8. Effect of Tillage Method and Planting Date on Mean Percent of Plants with T1 and T2 at Stillwater. * Planting Date Means Followed by the Same Letter in the Same Tillage Are Not Significant at the 0.05 Level.

tillage difference for percent of T2 in the October and November plantings. The only planting date difference in percent of T2 was between the September no-till and the no-till planting dates of October and November. No significant percentage difference occurred between the conventional planting dates. The stress causing a delay in GDD for T2 emergence in the November conventional planting date compared to the September conventional was not severe enough to cause a reduction of percentage of T2.

There was no T1 percentage difference between the tillage treatments for any planting date in 1983 (Figure 7, Table II). In summary only one planting date, September, showed a significant tillage effect in 1982. This tillage effect for September planting date was strong enough that the three way interaction of year by tillage by planting date was also significant when data were analyzed for both years (Table IV). Between the 1983 planting dates (Figure 8), the November planting had a 15 percent inhibition of T1 in the no-till compared to the October no-till, whereas plants in September and October no-till planting dates developed nearly 100 percent of the T1s. Then the year by planting date interaction for percent of the T1 was explained by the 1982 September planting date responding differently from the other planting dates which were at 100 percent, contrasting to the 1983 September and October plants that developed 100 percent of the T1s.

A significant difference in percent of T2 in the 1983 October planting date between the conventional and no-till did occur at the five percent significance level (Figure 7, Table II). However, practically speaking the 97 percent of the no-till plants with T2 is in the proximity of having 100 percent. Thus, no meaningful difference for percent of plants with T2 occurred between either tillage systems or planting dates. A delay in GDD was evident by the difference in GDD required for tiller emergence between September, October, and November in both tillages indicating some stress (Figure 3); but it was not severe enough to cause an inhibition of T2 in 1983 (Figure 8). The T2 interaction between year and planting date was due to the 1982 September no-till planting date being different than the other two planting dates which contrasts with the percent of T2 being nonsignificantly different from each other in 1983. Consequently, the interaction of year by tillage by planting date for the percent of plants with T1 and T2 (Table IV) has been explained by the previously detailed description of the interaction between tillage and planting dates that were significantly different from year to year.

In considering only the four no-till planting dates at Stillwater 1983, the percentage of plants with T1 and T2 was significantly lower in August than when compared to the succeeding planting dates (Figure 4, Table III). Stress was severe as 85 and 24 percent of T1s and T2s were inhibited. This stress no longer existed later in the season as no inhibition occurred in the September or October plantings. Consequently, the stress noted by the delayed emergence by a higher number of GDD required for both T1 and T2 was sufficient enough to cause inhibition of these tillers in the August no-till planting date.

Lahoma Tiller Percentages

At Lahoma in 1982, no difference in the percentage of T1 existed between tillage systems for any planting date (Figure 9, Table II). The planting dates of August, September, and October had stress indicated by 36, 23, and 40 percent of the plants without T1; however, the November plants had essentially no stress as only six percent of the plants were without T1 (Figure 11, Table II). The August planting date had a significant delay in GDD (Figure 5) corresponding with the considerable inhibition of T1 in this planting date (Figure 10). But the stress that was indicated by percentage of T1 in the October and September planting was not detected by a delay in GDD compared to the November's GDD. In comparing the GDD between Stillwater and Lahoma, Lahoma generally had a much higher number of GDD required for tiller emergence than did Stillwater. Stress may have been significant for all planting dates and tillages because the GDD needed for tiller emergence may have exceeded the optimum range at Lahoma or in some instances at Stillwater.

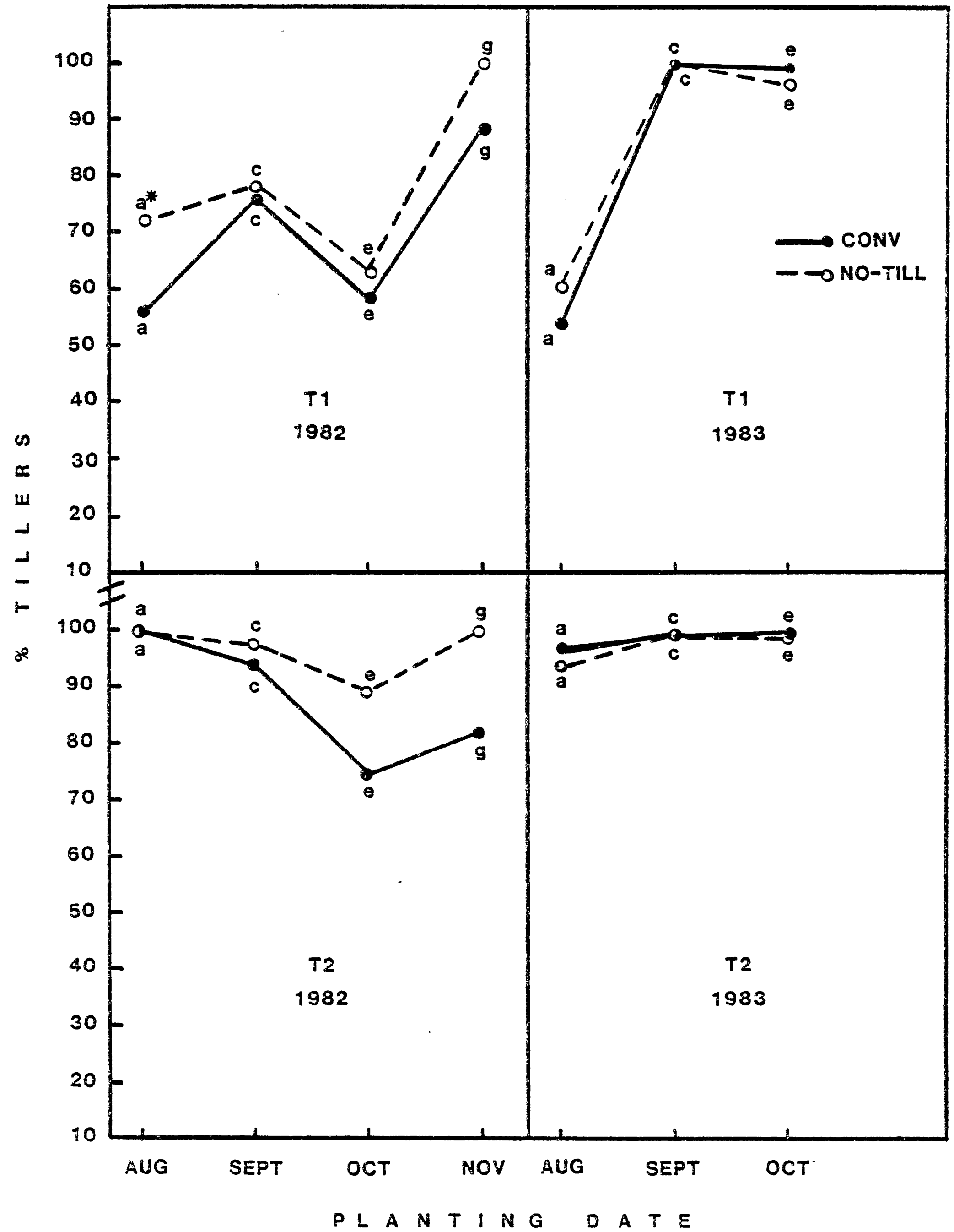


Figure 9. Effect of Planting Date and Tillage Method on Mean Percent of Plants with T1 and T2 at Lahoma. * Tillage Means Followed by the Same Letter in the Same Planting Date Are Not Significant at the 0.05 Level.

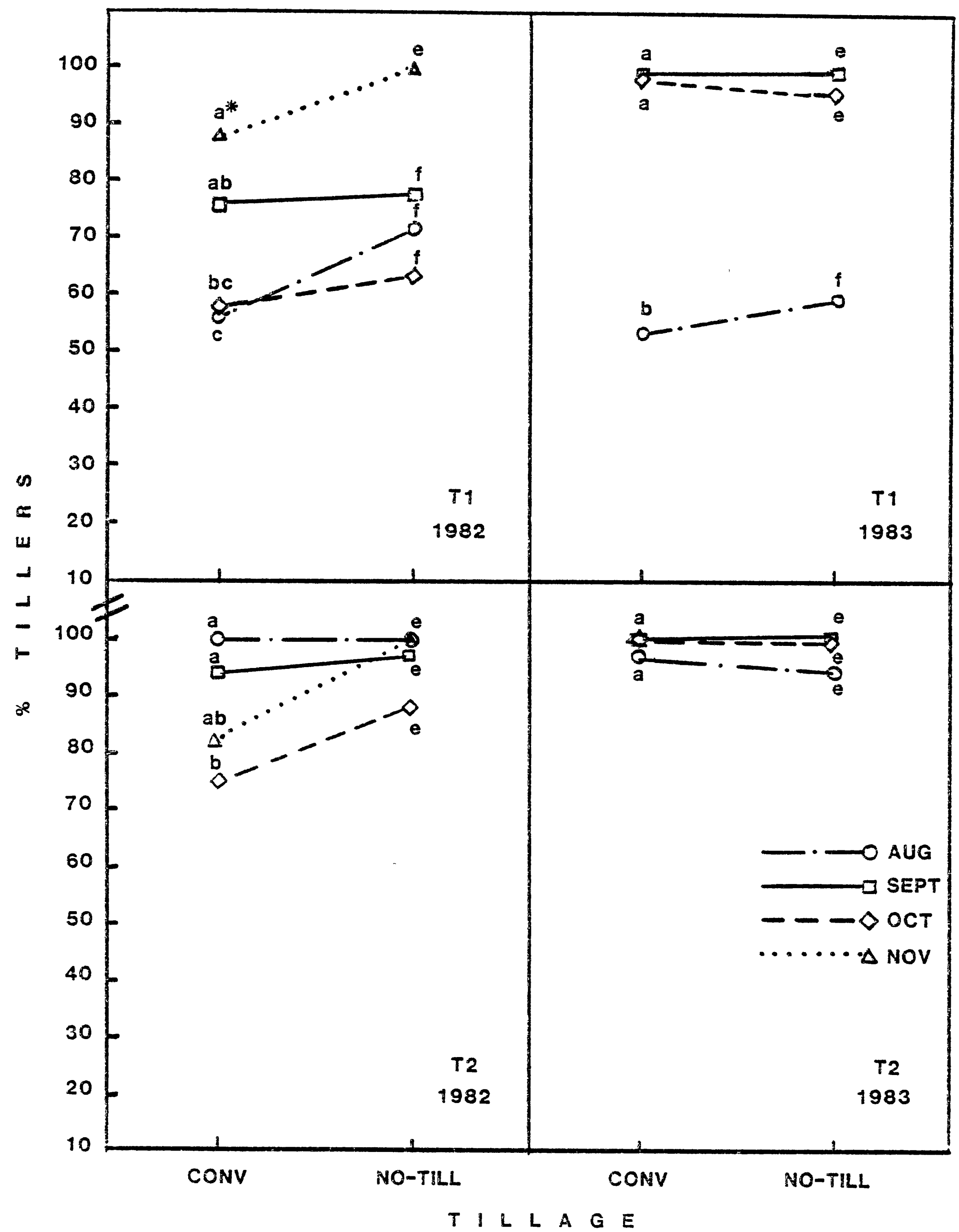


Figure 10. Effect of Tillage Method and Planting Date on Mean Percent of Plants with T1 and T2 at Lahoma. * Planting Date Means Followed by the Same Letter in the Same Tillage Are Not Significant at the 0.05 Level.

No significant effect of tillage on percent of T2 was observed in 1982 at Lahoma (Figure 9, Table II). Therefore, the percentages of T2 in the four planting dates were averaged over the tillage methods. A stress was indicated in the October planting by only 81 percent of the plants having T2. The November planting had 91 percent with T2 which was not significantly different from the August and September planting dates which had 100 and 96 percent T2s developed, respectively. In relating GDD with the percent of plants with T2 there was a significant delay in GDD in the August planting date but 100 percent of the T2s developed. The 19 percent inhibition of T2s in the October planting corresponds to the higher GDD required for T2 emergence. When comparing the trend of T1 with that of T2, there was a similar trend except for the August planting date where T1 was inhibited but T2 was not (Figure 9).

In like manner, at Lahoma in 1983 no significant effect of tillage on percent of T1 and T2 occurred as in 1982 (Figure 9). Averaged across tillages, 43 percent of the plants were without T1 in the August planting date but in September and October nearly 100 percent of the plants had developed T1. Plants in the August, September, and October planting dates developed nearly 100 percent of the T2s (Figure 10). There was a greater percent of plants with T2s than T1s both years in the August planting dates.

CHAPTER IV

CONCLUSIONS

Generally there was no difference in early growth between the conventional tillage and no-till, indicating that any stress which occurred was the same across tillage treatments. At Stillwater in the 1982 September planting date, greater stress was observed in the no-till which was determined by using GDD and the percentage of plants possessing T1 and T2. This was similar to Wilkins, Klepper and Rickman's (9) results where more stress was observed in minimum tillage compared to situations where more tillage was used. However, in Lahoma in the 1983 August planting date greater stress occurred in the conventional tillage.

The August planting date had the greater stress in comparison to the other planting dates. This stress was indicated by a higher number of GDD required for T1 and T2 emergence and the percent inhibition of T1. The August conventional tillage had more stress than the no-till at both Stillwater and Lahoma in 1983. At Stillwater, the wheat in the 1983 August conventional tillage treatment had essentially no emergence which may have been due to crusting of the soil surface or planting too deep for the soil temperature-cultivar combination. Only in the specific plantings mentioned above were there any differences in early growth. All other dates and year combinations resulted in plants having similar growth in no-till and conventional tillage.

Generally there was no difference between the seedbed conditions of the conventional tillage or no-till as measured by stand establishment. When difference in stress did occur, there was no consistent difference between the tillage systems in reference to stand establishment as Stillwater's September 1982 and November 1983 favored the conventional tillage whereas Lahoma 1982 favored the no-till.

In this study the least GDD required for T1 was 178 GDD and 242 for T2 at Stillwater in 1983. In comparing the two locations, there was a trend at Lahoma requiring more GDD for tiller emergence than at Stillwater. We did not have enough information of TAM W-101 to arrive at an ideal range of GDD for emergence of T1 and T2. This range is needed to determine when stress occurs or when it does not. We could only detect a difference in GDD between treatments. Once the ideal is determined, we could accomplish what Rickman, Klepper, and Peterson (8) did when they showed that stress occurred when GDD (at base 3 °C) exceeded 250 for T1 in Stephens wheat.

We conclude that in general the seedbed and early growth conditions are similar for conventional tillage and no-till planted wheat in Oklahoma. Sometimes there were differences in early growth of wheat planted into no-till conditions compared to conventionally tilled conditions. The differences were both year and site specific. Further work is needed to try to identify these differences. The fact that there were differences both year and site specific suggests that a number of factors may be involved.

LITERATURE CITED

1. Burleigh, J. R., R. E. Allan, and O. A. Vogel. 1965. Varietal differences in seeding emergence of winter wheat as influenced by temperature and depth of plants. Agron. J. 57:195-198.

2. Friend, D. J. C. 1966. The effects of light and temperature on growth of cereals. p. 181-199. In The Growth of Cereals and Grasses. London: Butterworth.

3. Hay, R. K. M., and G. Tunnicliffe Wilson. 1982. Leaf appearance and extension in field-grown winter wheat plants: the importance of soil temperature during vegetative growth. J. Agric. Sci. 99:403-410.

4. Johnson, R. C., and E. T. Kanemasu. 1983. Yield and development of winter wheat at elevated temperatures. Agron. J. 75:561-565.

5. Klepper, Betty L. Personal Interview. Stillwater, Oklahoma, October 25, 1983.

6. Klepper, B. L., R. W. Rickman, and R. K. Belford. 1983. Leaf and tiller identification on wheat plants. Crop Sci. 23:1002-1004.

7. Klepper, B. L., R. W. Rickman, and C. M. Peterson. 1982. Quantitative characterization of seedling development in small cereal grains. Agron. J. 74: 789-792.

8. Rickman, R. W., B. L. Klepper, and C. M. Peterson. 1983. Time distributions for describing appearance of specific culms of winter wheat. Agron. J. 75: 551-556.

9. Wilkins, D. E., B. L. Klepper, and R. W. Rickman. 1982. Effect of tillage on wheat tillering. Paper no. 82-1512. Am. Soc. Agric. Eng. St. Joseph, Mich.

APPENDIXES

TABLE I

MEAN NUMBER OF PLANTS PER METER OF ROW UNDER CONVENTIONAL TILLAGE OR NO-TILL AT STILLWATER AND LAHOMA IN 1982 AND 1983

	STILLWATER					
	1982			1983		
	CONV.	NO-TILL		CONV.	NO-TILL	
AUGUST	--	--		--	16yz	
SEPTEMBER	35a+	20y	1%	25a	27x	N.S.
OCTOBER	28a	31x	N.S.	16b	19y	N.S.
NOVEMBER	31a	33x	N.S.	23a	11z	1%

	LAHOMA					
	1982			1983		
	CONV.	NO-TILL		CONV.	NO-TILL	
AUGUST	19a	34x	1%	24b	20z	N.S.
SEPTEMBER	17a	30x	1%	25b	33xy	N.S.
OCTOBER	13a	29x	1%	35a	34x	N.S.
NOVEMBER	16a	20y	N.S.	23b	24yz	N.S.

+ Within column values for a tillage system between planting dates followed by the same letter were not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

* Significant difference at the 0.05 and 0.01 levels, between tillage systems within a planting date.

TABLE II

GROWING DEGREE DAYS (GDD) REQUIRED FOR T1 AND T2 EMERGENCE AND PERCENT OF PLANTS WITH T1 AND T2 UNDER DIFFERENT TILLAGE SYSTEMS AND PLANTING DATES

	STILLWATER						LAHOMA					
	1982			1983			1982			1983		
	CONV.	NO-TILL		CONV.	NO-TILL		CONV.	NO-TILL		CONV.	NO-TILL	
	T1 (GDD)			T1 (GDD)			T1 (GDD)			T1 (GDD)		
AUG.	--	--		--	--		499a	494x	N.S.	551a	468x	1%
SEPT.	230a[+]	374x	1%*	265b	267y	N.S.	343b	322y	N.S.	252c	262y	N.S.
OCT.	273a	301y	N.S.	191c	178z	N.S.	356b	380y	N.S.	337b	287y	N.S.
NOV.	291a	320xy	N.S.	367a	360x	N.S.	304b	283y	N.S.	--	--	
	T2 (GDD)			T2 (GDD)			T2 (GDD)			T2 (GDD)		
AUG.	--	--		--	--		549a	501x	N.S.	603a	544x	1%
SEPT.	303b	344x	N.S.	333b	342y	N.S.	387b	378y	N.S.	337c	350y	N.S.
OCT.	311ab	347x	N.S.	252c	242z	N.S.	407b	444x	N.S.	388b	366y	N.S.
NOV.	358a	392x	N.S.	394a	397x	N.S.	348b	333y	N.S.	--	--	
	T1 %			T1 %			T1 %			T1 %		
AUG.	--	--		--	--		56c	72y	N.S.	54b	60y	N.S.
SEPT.	50b	15y	1%*.	100a	100x	N.S.	76ab	78y	N.S.	100a	100x	N.S.
OCT.	92a	96x	N.S.	100a	97x	N.S.	58bc	63y	N.S.	99a	96x	N.S.
NOV.	100a	99x	N.S.	90a	82y	N.S.	88a	100x	N.S.	--	--	
	T2 %			T2 %			T2 %			T2 %		
AUG.	--	--		--	--		100a	100x	N.S.	97a	94x	N.S.
SEPT.	94a	71y	5%	100a	100x	N.S.	94a	97x	N.S.	100a	100x	N.S.
OCT.	100a	100x	N.S.	100a	97y	5%	75b	88x	N.S.	100a	99x	N.S.
NOV.	99a	94x	N.S.	99a	100x	N.S.	82ab	100x	N.S.	--	--	

[+] Within column values for a tillage system between planting dates followed by the same letter were not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

* Significant difference at the 0.05 and 0.01 levels, between tillage systems within a planting date.

TABLE III

GROWING DEGREE DAYS (GDD) REQUIRED FOR T1 AND T2 EMERGENCE AND PERCENT OF PLANTS WITH T1 AND T2 UNDER NO-TILL AND PLANTING DATES AT STILLWATER 1983

	T1 (GDD)	T2 (GDD)
AUG.	504a*	622a
SEPT.	267c	342b
OCT.	178d	242c
NOV.	360b	397b
	T1 %	**T2 %**
AUG.	15b	76b
SEPT.	100a	100a
OCT.	97a	97a
NOV.	82a	100a

* Within column values between planting dates followed by the same letter were not significantly different at the 1% probability level according to Duncan's Multiple Range Test.

TABLE IV

MEAN SQUARES FOR PERCENT OF PLANTS WITH T1 AND T2 AND GROWING DEGREE DAYS REQUIRED FOR T1 AND T2 EMERGENCE AT STILLWATER AND LAHOMA

	df	T1 %	T1 GDD	T2 %	T2 GDD
STILLWATER					
Year (Y)	1	4646**	8528	469	2951*
Error a	6	96	2792	86	302
Tillage (T)	1	618*	11230*	284*	4160
Y x T	1	145	15754*	232*	3780
Error b	6	54	1699	23	884
Planting Date (D)	2	4267**	39137**	291**	37909**
Y x D	2	7148**	25905**	388**	13229**
D x T	2	342*	5315*	145*	152
Y x D x T	2	579**	3701	182*	73
Error c	24	63	1096	34	277
Total	47				
LAHOMA					
Year (Y)	1	3714**	18532	435	2026
Error a	6	157	4732	88	3507
Tillage (T)	1	372	7694	265	3390
Y x T	1	126	4936	126	671
Error b	6	206	1655	78	1773
Planting Date (D)	3	3594**	150531**	211	124999**
Y x D	2	1999**	8722	504**	11289*
D x T	3	109	1287	117	3095
Y x D x T	2	24	3816	41	1688
Error c	30	162	3487	85	3142
Total	55				

* Indicates significance at the 5% level. ** Indicates significance at the 1% level.

TABLE V

MEAN SQUARES FOR PERCENT OF PLANTS WITH T1 AND T2 AND GROWING DEGREE DAYS REQUIRED FOR T1 AND T2 EMERGENCE IN 1982-83 AND 1983-84

	df	T1 %	T1 GDD	T2 %	T2 GDD
			1982-83		
Location (L)	1	42	13205	165	19412
Error a	6	171	7362	165	3476
Tillage (T)	1	0	11427	8	1203
L x T	1	833*	15931*	1245*	3094
Error b	6	112	2316	86	2236
Planting Date (D)	3	4985**	56727**	370	42443**
L x D	2	6214**	8675	1401**	18049**
D x T	3	470*	242	319*	1942
L x D x T	2	332	6925	51	841
Error c	30	1420	3980	101	3197
Total	55				
			1983-84		
Location (L)	1	4	27981**	1	36761**
Error a	6	82	162	8	333
Tillage (T)	1	22	8074*	9	1974
L x T	1	0	444	1	27
Error b	6	148	1038	15	420
Planting Date (D)	3	3408**	124835**	29	10187**
L x D	1	4	37083**	1	30801**
D x T	3	48	2634**	8	1821**
L x D x T	1	0	1047	1	140
Error c	24	88	479	14	208
Total	47				

* Indicates significance at the 5% level.   ** Indicates significance at the 1% level.

TABLE VI

MEAN SQUARES FOR PERCENT OF PLANTS WITH T1 AND T2 AND GROWING DEGREE DAYS REQUIRED FOR T1 AND T2 EMERGENCE

	df	T1 %	T1 GDD	T2 %	T2 GDD
Location (L)	1	1	30063*	79	37094**
Year (Y)	1	4870**	12382	614*	1254
L x Y	1	156	43	39	373
Error a	12	127	3762	87	1907
Tillage (T)	1	8	42	6	121
L x T	1	350	8814*	619**	2033
Y x T	1	7	18410**	8	3428
L x Y x T	1	326	4877	351*	419
Error b	12	130	1677	51	1328
Planting Date(D)	3	3323**	146315**	71	123633**
L x D	2	3298**	23492**	498**	29719**
Y x D	3	4153**	20602**	240*	13858**
L x Y x D	1	5835**	7448	1065**	7462
D x T	3	216	3435	176*	2847
L x D x T	2	169	2090	22	336
Y x D x T	3	293	1439	129	791
L x Y x D x T	1	326	10716*	58	1147
Error c	54	118	2424	62	1869
Total	103				

* Indicates significance at the 5% level.

** Indicates significance at the 1% level.

TABLE VII

MEAN DATE OF EMERGENCE UNDER CONVENTIONAL TILLAGE AND NO-TILL AT STILLWATER AND LAHOMA IN 1982 AND 1983

		STILLWATER				LAHOMA			
		1982		1983		1982		1983	
	REP	CONV.	NO-TILL	CONV.	NO-TILL	CONV.	NO-TILL	CONV.	NO-TILL
AUGUST	1	--	--	--	8-25	9-23	9-23	8-23	8-23
	2	--	--	--	8-26	9-24	9-23	8-23	8-23
	3	--	--	--	8-28	9-23	9-23	8-23	8-24
	4	--	--	--	8-25	9-23	9-23	8-23	8-23
SEPTEMBER	1	10-02	10-02	9-30	9-30	10-14	10-14	9-29	9-28
	2	10-02	10-02	9-30	9-30	10-14	10-14	9-29	9-29
	3	10-02	10-02	9-30	9-30	10-14	10-14	9-29	9-29
	4	10-02	10-02	9-30	9-30	10-14	9-26	9-29	9-29
OCTOBER	1	10-25	10-25	10-24	10-24	11-14	10-25	11-13	11-13
	2	10-25	10-25	10-24	10-24	10-25	10-25	11-13	11-13
	3	10-25	10-25	10-24	10-24	10-23	10-25	11-13	11-13
	4	10-25	10-28	10-24	10-24	10-25	10-25	11-13	11-13
NOVEMBER	1	11-29	11-29	12-12	12-12	12-05	12-05	--	--
	2	11-29	11-29	12-12	12-12	12-05	12-05	--	--
	3	11-29	11-29	12-12	12-12	12-05	12-05	--	--
	4	11-29	11-29	12-12	12-12	12-05	12-05	--	--

TABLE VIII

MINIMUM AND MAXIMUM DAILY TEMPERATURES AND GROWING DEGREE DAYS (GDD) ACCUMULATED PER DAY AT STILLWATER 1982-1983

Day of Month	Aug.			Sept.			Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD
1				24	38	31	18	31	24	21	28	24	10	21	15	-7	6	0	-2	8	3	1	18	9
2				24	38	31	16	30	23	6	7	6	11	22	17	-4	4	0	-2	4	1	3	21	12
3				14	36	25	16	28	22	1	18	9	7	16	11	-4	6	1	-7	-1	0	6	28	17
4				20	32	26	12	28	20	-3	12	4	4	11	8	-4	1	0	-7	-2	0	11	19	15
5				18	32	25	13	33	23	-6	9	2	4	12	8	-2	2	0	-5	-1	0	10	19	15
6				14	31	23	19	31	25	-6	13	4	-2	12	5	-2	9	4	-4	2	0	10	21	15
7				18	33	26	8	26	17	11	21	16	-1	13	6	-2	16	7	-12	-2	0	5	14	9
8				19	32	26	23	30	27	13	22	17	-1	17	8	-3	14	6	-9	6	0	-1	12	5
9				20	32	26	9	32	21	11	23	17	-2	1	0	-1	14	7	0	6	3	-1	11	5
10				19	32	26	9	22	16	12	23	18	-2	4	1	1	14	7	2	7	4	-3	11	4
11				21	34	28	3	19	11	17	22	19	-1	6	2	1	12	6	-2	11	4	-7	7	0
12				22	33	28	6	22	14	5	24	14	-9	-1	0	-6	10	2	1	4	3	-2	12	5
13				20	34	27	4	21	13	-5	8	1	-4	4	0	-5	15	2	-1	12	6	1	19	10
14				34	34	34	2	22	12	-1	8	4	-1	10	4	-1	23	11	1	16	8	6	22	14
15	24	38	31	18	34	26	4	24	14	-8	8	0	-4	12	4	-6	13	4	6	17	11	11	26	18
16	23	39	31	17	21	19	4	27	16	1	10	6	-3	11	4	-8	6	0	-2	10	4	7	24	16
17	22	33	28	17	27	22	6	22	14	0	12	6	-1	16	7	-6	11	3	-1	17	8	2	12	7
18	21	33	27	14	33	24	10	21	15	4	11	8	-1	17	8	-4	7	1	2	16	7	2	8	5
19	19	33	26	15	24	20	13	28	21	9	16	12	0	18	9	-4	1	0	3	18	8	3	7	5
20	18	33	26	12	19	15	1	26	13	10	26	18	-3	11	4	-2	-1	0	5	20	12	-1	5	2
21	19	36	27	6	22	14	1	14	8	3	19	11	-2	16	7	-1	4	1	8	14	11	-3	2	0
22	22	35	28	6	21	13	-2	17	8	7	19	13	0	16	8	-4	2	0	6	11	9	-6	7	0
23	22	37	29	7	24	16	-2	19	9	0	16	8	6	21	13	-8	0	0	6	11	8	-2	7	3
24	23	39	31	13	31	22	0	19	10	-8	0	0	11	22	17	-4	7	1	4	13	9	1	7	4
25	19	40	30	8	29	18	0	21	11	-5	4	0	0	16	8	-1	6	3	-2	8	3	3	10	7
26	20	31	25	8	24	16	1	22	11	-1	7	3	-3	4	1	-1	7	3	-1	10	5	6	12	9
27	23	39	31	11	22	17	8	23	16	0	6	3	-2	3	1	-4	1	0	4	12	8	2	13	8
28	20	38	29	19	29	24	7	24	16	1	3	2	-4	4	0	-3	4	1	-2	12	5	-3	13	5
29	22	33	27	20	31	26	2	18	20	-2	-1	0	-8	-1	0	4	9	7				2	12	7
30	22	34	28	20	30	25	9	22	16	1	17	9	-6	3	0	-3	10	3				5	8	7
31	23	38	31				17	24	21				-6	3	0	-2	10	4				4	12	8

TABLE IX

MINIMUM AND MAXIMUM DAILY TEMERATURES AND GROWING DEGREE DAYS (GDD) ACCUMULATED PER DAY AT STILLWATER 1983-1984

Day of Month	Aug.			Sept.			Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD
1				17	31	24	14	27	21	16	26	21	-7	3	0	-2	6	2	-2	15	7	2	9	6
2				14	36	25	18	30	24	17	21	19	-4	8	2	-3	6	1	8	20	14	1	17	9
3				14	36	25	21	31	26	17	24	20	3	11	7	-5	8	2	-3	11	4	-2	18	8
4				19	34	27	17	28	23	15	26	21	-3	3	0	-1	14	7	0	17	9	4	19	11
5				23	35	29	6	28	17	11	17	14	-2	16	7	4	14	9	-1	10	4	-1	9	4
6				22	36	29	8	29	19	9	18	14	-4	3	0	0	22	11	-5	4	0	-2	8	3
7				24	38	31	14	18	16	9	12	11	-4	8	2	2	21	11	-1	9	4	2	12	5
8				23	36	29	15	18	17	12	9	11	-4	14	5	4	22	13	2	21	11	-3	17	7
9				21	34	28	14	20	17	6	17	11	-2	13	5	7	19	13	5	14	10	-2	4	1
10				21	33	27	15	26	21	0	7	4	-2	7	3	-4	8	2	-1	13	6	-1	11	5
11				22	34	28	16	26	21	-4	8	4	-1	13	6	-8	2	0	2	17	9	-4	9	3
12				18	35	27	6	21	13	1	12	5	-6	3	0	-1	7	3	2	20	11	6	9	8
13				16	34	25	2	15	9	-1	12	6	2	8	5	-9	0	0	0	22	11	6	10	8
14				13	23	18	9	20	14	1	17	9	-5	7	1	-7	-1	0	3	18	11	11	17	14
15	24	38	31	15	28	22	14	25	19	5	18	11	-4	3	0	-8	1	0	13	25	19	20	24	22
16	26	39	32	17	32	24	14	24	19	-1	16	7	-11	3	0	-17	-1	0	7	21	14	4	27	16
17	24	39	32	16	32	24	14	26	20	6	21	13	-12	3	0	-9	2	0	2	14	8	2	7	4
18	22	38	30	22	34	28	15	22	19	4	20	12	-13	-11	0	-13	-8	0	8	19	13	4	14	5
19	24	36	30	21	34	28	14	22	18	13	26	19	-17	-12	0	-24	-11	0	7	11	9	1	12	7
20	22	31	26	9	28	19	16	22	19	2	13	7	-16	-14	0	-12	-3	0	-2	9	4	-2	2	0
21	27	29	28	2	13	8	10	16	13	6	18	12	-17	-9	0	-17	-2	0	-2	11	5	-1	15	7
22	23	36	29	4	19	12	11	14	13	13	23	18	-20	-15	0	-8	0	0	3	17	7	6	16	11
23	23	38	30	6	23	15	9	18	14	-1	23	11	-17	-13	0	1	2	1	4	21	13	5	16	10
24	22	37	29	6	24	15	6	18	12	-3	5	1	-19	-13	0	-6	6	0	0	13	6	4	16	10
25	22	36	29	16	27	21	8	21	14	2	12	7	-19	-11	0	-4	11	4	-2	13	6	4	8	6
26	24	37	30	14	25	20	3	17	10	5	18	12	-18	-8	0	4	13	9	2	18	8	12	15	13
27	25	37	31	16	32	24	3	23	13	-2	12	5	-8	-3	0	-4	1	0	0	10	5	6	17	12
28	22	37	29	17	31	24	6	25	15	-4	0	0	-8	-4	0	-1	6	2	-2	4	1	2	12	7
29	22	38	30	17	30	23	10	26	18	-6	2	0	-14	-7	0	-1	16	8	-5	4	0	2	9	6
30	13	35	24	6	31	18	12	21	17	1	11	6	-23	-8	0	-1	18	9				4	10	7
31	24	41	33				11	19	15				2	2	2	-1	8	3				2	12	7

TABLE X

MINIMUM AND MAXIMUM DAILY TEMPERATURES AND GROWING DEGREE DAYS (GDD) ACCUMULATED PER DAY AT LAHOMA 1982-1983

Day of Month	Aug.			Sept.			Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD
1				21	41	31	15	31	23	5	28	17	4	18	7	-6	5	0	-6	5	0	1	17	9
2				21	41	31	17	32	24	6	22	14	8	19	14	-6	5	0	-6	-3	0	2	20	11
3				13	36	25	11	27	19	-2	17	8	3	14	8	-6	7	0	-9	0	0	6	26	16
4				14	36	25	11	29	20	-3	12	4	3	9	6	-7	-1	0	-9	-2	0	13	22	17
5				16	36	26	11	33	22	-3	11	4	3	8	6	-2	-1	0	-6	-1	0	7	17	12
6				19	34	26	18	32	25	0	15	8	-1	12	6	-2	8	3	-6	2	0	8	17	13
7				13	36	24	6	25	16	9	21	15	-1	12	6	-2	16	7	-12	0	0	4	13	9
8				17	34	26	7	30	18	5	22	14	-3	14	6	-3	9	3	-10	2	0	0	14	7
9				17	35	26	8	29	18	7	21	14	-4	-1	0	0	13	6	-1	6	3	-1	13	6
10				18	35	27	8	22	15	13	23	18	-3	4	1	0	14	7	-1	3	1	-3	11	4
11				21	37	29	4	19	12	11	19	15	-4	6	1	-1	12	6	-1	11	5	-6	7	1
12				21	36	28	4	20	12	4	23	13	-8	-2	0	-6	10	2	-2	3	1	-4	14	5
13				16	32	24	5	22	13	-7	8	1	-4	3	0	-5	18	6	-2	9	4	4	14	5
14				16	37	26	5	21	13	-6	9	2	-3	9	3	-2	22	10	-2	14	6	4	23	9
15	23	41	32	14	32	23	4	24	14	-9	7	0	-2	11	4	-7	12	3	5	15	5	7	25	16
16	23	40	32	14	20	17	8	22	15	-7	10	2	-3	11	4	-7	8	0	-1	10	4	3	21	12
17	21	34	28	16	28	22	6	27	16	-4	13	5	-3	13	5	-4	7	1	0	17	8	1	5	3
18	19	33	26	13	33	23	7	23	15	-2	10	4	-2	18	8	-6	6	0	1	12	6	1	8	4
19	17	34	26	15	23	19	10	32	21	6	14	10	-2	14	6	-5	1	0	1	16	8	-1	7	3
20	16	35	26	9	23	16	-1	21	10	7	25	16	-2	14	6	-4	0	0	7	19	13	-2	3	0
21	18	37	28	4	24	14	-1	14	6	4	21	13	-3	14	6	-4	1	0	6	13	9	-4	2	0
22	21	36	29	4	21	12	-1	16	7	-1	17	8	-4	14	5	-6	0	0	3	7	5	-5	6	1
23	21	39	30	6	27	16	-1	18	8	-4	19	8	-3	16	6	-8	1	0	4	13	9	-2	3	1
24	22	38	30	13	34	24	2	21	11	-10	1	0	2	21	11	-4	7	1	4	14	9	0	4	2
25	18	41	29	9	29	19	2	21	11	-2	6	2	1	12	7	-2	6	2	-1	7	3	3	10	3
26	18	30	24	8	25	17	2	21	12	-7	4	0	1	12	7	-2	5	2	-1	8	4	6	10	2
27	21	41	31	14	29	22	9	23	16	-7	7	0	-1	4	2	-7	-1	0	3	11	7	1	9	4
28	19	36	28	15	31	23	10	24	17	-7	7	0	-6	1	0	-6	3	0	-1	13	6	-3	7	2
29	18	36	27	20	33	27	1	19	10	-6	9	1	-9	-2	0	2	7	4				-1	11	5
30	21	38	29	21	31	26	6	23	14	-1	15	7	-8	2	0	-1	10	4				4	8	2
31	18	40	29				5	26	15				-7	0	0	2	7	4				3	14	5

TABLE XI

MINIMUM AND MAXIMUM DAILY TEMPERATURES AND GROWING DEGREE DAYS (GDD) ACCUMULATED PER DAY AT LAHOMA 1983-1984

Day of Month	Aug.			Sept.			Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD	Min	Max	GDD
1				18	33	25	14	29	22	13	24	19	- 7	2	0	- 7	4	0	- 4	16	6	- 7	8	2
2				16	35	25	14	32	23	13	21	17	- 6	6	0	- 3	5	1	- 2	20	9	- 2	18	8
3				29	33	31	16	33	24	15	24	19	- 1	9	4	- 6	9	2	- 3	13	5	- 1	18	9
4				19	34	27	14	28	21	14	27	20	- 6	18	6	- 2	14	6	- 2	16	7	0	16	8
5				22	38	30	8	26	17	8	18	13	- 7	17	5	- 2	14	6	- 2	11	5	- 4	8	2
6				21	36	28	9	29	19	9	16	12	- 6	4	0	- 1	21	10	- 9	2	0	- 7	8	1
7				20	39	30	12	27	19	11	15	13	- 7	9	1	0	14	7	- 8	17	4	- 4	13	4
8				20	38	29	14	18	16	11	18	14	- 5	13	4	- 2	19	8	- 2	20	9	- 6	18	6
9				20	36	28	16	22	19	3	19	11	- 5	8	2	2	19	11	- 2	11	4	- 7	4	0
10				20	35	28	13	23	18	- 1	7	3	- 4	6	1	- 5	6	0	- 1	13	6	- 4	13	4
11				21	36	28	14	25	20	- 4	9	3	- 2	13	5	- 8	2	0	0	17	9	- 4	10	3
12				19	30	24	6	21	13	- 1	10	4	- 4	10	3	- 7	7	0	1	18	9	4	7	6
13				14	29	22	4	14	9	1	17	9	- 4	7	1	-12	0	0	- 1	14	7	- 1	8	4
14				14	19	17	4	21	13	5	16	10	- 7	7	0	-11	- 2	0	- 1	18	9	3	20	12
15	23	41	32	14	26	20	9	24	17	2	17	10	- 6	6	0	- 9	- 2	0	0	22	11	8	27	18
16	23	41	32	16	32	24	11	26	18	- 1	16	7	- 9	2	0	-14	- 2	0	4	18	11	2	23	13
17	24	42	33	17	34	25	13	23	18	2	21	11	- 8	4	0	-12	1	0	- 4	14	5	- 1	6	2
18	22	41	31	18	35	27	13	18	16	2	18	8	-16	3	0	-15	- 1	0	- 2	19	8	2	14	8
19	20	38	29	19	34	27	13	19	16	4	24	14	-18	-13	0	-22	- 6	0	- 4	13	4	- 4	7	2
20	21	31	26	9	29	19	12	20	16	- 1	18	8	-18	-14	0	-22	- 7	0	- 6	10	2	- 4	2	0
21	21	33	27	3	14	9	9	13	11	3	18	11	-18	-13	0	-18	- 9	0	- 6	11	3	2	15	9
22	21	38	29	3	19	11	9	13	11	6	23	14	-19	-15	0	-13	1	0	- 3	17	7	2	15	9
23	22	37	29	6	23	14	9	17	13	- 1	17	8	-21	-15	0	- 7	3	0	- 1	20	9	3	11	7
24	22	38	29	5	24	15	6	18	12	- 2	17	8	-19	-14	0	- 7	7	0	- 4	18	7	1	7	4
25	22	38	29	12	29	21	7	18	13	- 3	17	7			0	- 5	11	3	- 2	16	7	- 3	7	2
26	21	38	30	13	24	18	4	16	10	8	18	5	-15	- 8	0	- 3	14	6	2	18	8	8	14	11
27	31	38	35	13	31	22	4	23	14	1	10	6	-13	- 8	0	- 2	13	6	- 3	3	0	4	16	10
28	22	38	29	15	32	24	7	23	15	- 6	1	0	-12	- 4	0	- 2	8	3	- 4	6	1	3	9	6
29	22	38	29	16	32	24	11	22	16	- 6	2	0	-21	- 7	0	- 2	17	7	- 8	4	0	- 1	11	5
30	21	38	29	14	30	22	8	18	13	- 4	11	3	-21	- 6	0	- 3	18	7				- 1	11	5
31	24	41	32				8	17	13							- 5	9	2				- 1	12	6

VITA

Dale Alan Weishaar

Canidate for the Degree of

Master of Science

Thesis: EFFECT OF TILLAGE SYSTEMS ON EARLY GROWTH OF WINTER WHEAT (<u>TRITICUM</u> <u>AESTIVUM</u> L.)

Major Field: Agronomy

Biographical:

Personal Data: Born in Wellington, Kansas, March 9, 1960, the son of Mr. and Mrs. Lloyd Weishaar.

Education: Graduated from Argonia High school, Argonia, Kansas, in May 1978; attended Mid-America Nazarene College, Olathe, Kansas, 1978-1980; received Bachelor of Science degree in Agriculture from Kansas State University, Manhattan, Kansas, in May 1982; completed requirements for Master of Science degree at Oklahoma State University, Stillwater, Oklahoma, in July 1984.

Professional Experience: Graduate research assistant, Department of Agronomy, Oklahoma State University from June 1982 to June 1984.