# SOIL WATER AVAILABILITY FOR SPRING GROWTH of WINTER WHEAT (Triticum aestivum L.) as INFLUENCED BY PLANTING DATE AND TILLAGE

BY

WILLIAM FREDERICK HEER

Bachelor of Science
Central Missouri State University
Warrensburg, Missouri
1972

Master of Science
Central Missouri State University
Warrensburg, Missouri
1974

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
DECEMBER 1985

# SOIL WATER AVAILABILITY FOR SPRING GROWTH OF WINTER WHEAT (*Triticum aestivum* L.) AS INFLUENCED BY PLANTING DATE AND TILLAGE

Thesis Approved:

Eugene G. Krenzer, Jr.
Thesis Adviser

Richard C Johnson

John B Solie

John F Stone

James H. Stiegler

Norman N. Durham
Dean of the Graduate College

TO MY FATHER

A TRUE AGRICULTURALIST

# PREFACE

The author is deeply indebted to his associates as well as to others who have assisted in the preparation of the manuscript of this thesis. He wishes to thank his thesis adviser, Dr. Eugene G. Krenzer, the project Senior Agriculturists, Mr. Rick Matheson and Mr. Mark Hodges, for their assistance and guidance throughout the time of the study. The time and assistance rendered by Dr. John F. Stone (my commettee chairman) and the other members of my committee, Dr. Jim Stiegler, Dr. Richard Johnson, and Dr. John Solie, is greatly appreciated. Special thanks are also extended to Dr. Claypool, Mr. Joe Williams, Mr. Harold Gray, Ms. Sheryl Gray, Mrs. Penny Lyons, and Mrs. Stacey Welch for their assistance and understanding during the time this study was conducted.

The author also appreciated the assistance given by the numerous individuals employed by the Lo-Till Project while he was conducting the research that lead to this thesis.

Deep felt appreciation and thanks go to my family: Barbara, Patrick, and Susan for their constant love, support, encouragement, and understanding in my endeavers to complete the requirements of my continued education. Thanks are also extended to my parents for their support of my educational program.

This research was supported in part by the Oklahoma State University Agronomy Department, the Oklahoma State University University Center for Water Research, and the Oklahoma Wheat Research Foundation.

Chapters IV and V of this thesis are separate manuscripts to be submitted for publication in *Soil Science Society of America Journal*, and *Agronomy Journal*. As a result of this format the tables and figures are numbered by chapter. The literature cited in each chapter is also presented at the end of that chapter.

# TABLE OF CONTENTS

Chapter Page

# LIST OF TABLES

Table Page

CHAPTER III

CHAPTER IV

Table Page

## CHAPTER V

## CHAPTER VI

# LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

Each year producers must decide when to plant their crops. Most producers in the South Central Great Plains delay the planting of winter wheat (Triticum aestivum L.) until sufficient precipitation has been received to bring the soil moisture to a level that will insure germination and establishment of the wheat seedling. Another practice often employed is to seed shallow and hope that the next precipitation event will be enough to insure germination and establishment but not cause sufficient crusting of the soil such that the seedling cannot emerge. In either case, soil moisture is critical to stand establishment and maximum yield. The practice of delaying planting until sufficient soil moisture is present can and often does increase the amount of soil erosion by both wind and water under the conventional tillage systems employed by most producers.

With no-till methods of wheat production gaining acceptance in Oklahoma and other Great Plains States, there is a need to evaluate the effects of this practice on monoculture winter wheat production. There is a need to know if there is a potential to plant earlier with no-till; if so, will this result in an increase in the amount of fall forage avaliable for winter grazing. Another area of concern is the affect this potential increase in forage production under no-till will have on the soil water content for spring regrowth and grain yield.

Therefore, the objectives of this study were:

A. To determine if and to what extent tillage and planting date affect the growth and yield of monoculture winter wheat produced in the South Central Great Plains.

B. To determine if and to what extent tillage and planting date affect the soil water for monoculture winter wheat produced in the South Central Great Plains.

# CHAPTER II

# LITERATURE REVIEW

Reports of research related to soil moisture and wheat production is voluminous. However, those dealing with wheat grown under conventional tillage and reduced tillage (in particular no-till) systems and planting date effects on soil moisture are somewhat limited. The literature review for this study will be presented in two sections. The first dealing with tillage-soil-water-yield relations and the second with planting date-soil-water-yield relationships.

## TILLAGE-SOIL-WATER-YIELD RELATIONSHIPS

In their summary on research experience with stubble-mulch farming Zingg and Whitfield (1957) indicated that as runoff is decreased in areas where cover or residue is present on the soil surface thus more available moisture should be present in that soil for subsequent plant growth. They also presented evidence that deeper penetration of precipitation occurred in mulched (untilled, straw remaining on the surface) versus bare (tilled, no straw on the surface) soil. Their summary showed that this movement depended upon several factors some of which are: climate, soil type, amounts and characteristics of residue, soil temperature and the length of time after a precipitation event.

Mathews and Army (1960) reported a water storage efficiency (change in soil water content during the fallow period) increase of 18 percent in favor of stubble mulch tillage (wheat stubble is maintained on the soil surface) over bare soil.

Davidson and Santelmann (1973) at Oklahoma State University reported that the amount of water in the top 45 cm of the soil profile was significantly influenced by the tillage system used when wheat was produced under monoculture conditions. In this study, the four year average soil water content (cm) in the top 45 cm of soil was 7.0 cm for clean-till and 8.8 cm for no-till with chemical weed control.

Blevins et al. (1971) also presented results which indicate the increase in soil water content ($cm^3$ $cm^{-3}$) in their no-till treatments extended to a depth of 45 cm. But at depths of 60 cm and beyond, the tillage system had very little effect on soil moisture contents. Unger and Jones (1981) at Bushland, Texas, showed similar soil water content data to that of Blevins et al. (1971). Their data showed that most of the changes in soil water content occurred in the top 60 cm of the soil profile, with changes at the 120 and 180 cm depths being negligible in most cases. Thus, depending upon the magnitude of the difference in the top 45 to 60 cm of the soil profile a 120 or 180 cm soil profile may have very little difference in total profile soil water under different tillage systems.

Tanaka (1985) found that a significantly greater soil water content existed in the top 30 cm of the soil in the no-till plots at planting time. This increase in soil water content provided a more favorable seed zone soil water in the no-till over the conventional tilled plots. In a study conducted on the U.S. Central Great Plains Research Station at Akron, Colorado, Smika (1976) showed similar results. He found that soils under no-till conditions maintained a soil water content of 0.14 cm/cm of available water in the first 15 cm of soil longer than those under reduced and conventional tillage. However, it is unclear if this difference is sufficient to carry the seedling through an extended dry period allowing it to yield more than plants which germinate later in the conventional tilled plots.

In a study conducted in south central Nebraska, Fenster and Wicks (1982) reported that no-till plots stored significantly more soil moisture than the treatments with tillage in the study. They also reported that no-till plots had three percent more water in the upper 8 cm of the soil profile than the clean-tilled plots. Greater soil water contents in the top 6 cm of soil where no-till methods were used as compared to adjacent conventional tilled plots were also reported by Wicks and Smika (1973). Fenster and Wicks (1982) also reported fallow efficiency (percent of the precipitation stored in the soil profile during the fallow period) to a depth of 180 cm was significantly increased in the no-till plots over the clean-till plots. This increase in fallow efficiency is consistent with the findings of Mathews and Army (1960) cited earlier.

Smika and Wicks (1968) reported that plow treatments lost water while the no-till treatment gained soil water from harvest to fall freezeup during the fallow period in a three year wheat-sorghum-fallow rotation. Even though this difference was small they felt it was important as over 30 percent of the total fallow precipitation is received during that time period. From fall freezeup to spring thaw, water storage was not found to be significantly different between the treatments. This was also true for the early spring and summer period. They pointed out that the control of weed growth during the fallow period and preservation of residues are the important factors leading to the increased soil water contents observed.

Unger (1978) showed that the precipitation storage efficiency increased as the mulch rate increased from 0 to 12 metric tons $ha^{-1}$. The average precipitation storage for the treatment with 12 metric tons $ha^{-1}$ mulch was reported to be more than twice that of the treatment with no mulch left on the surface. This increase in precipitation storage efficiency was also evident in the available soil water in the treatments at the time of planting. Unger and Jones (1981), showed that most of the changes in soil water content occurred in the first 60 cm of the soil profile. They also showed that increasing mulch rates increased both the amount and depth of soil water as the mulch rate increased. It is not clear however if the water which moves to greater depths under increased mulch rates is available for growth and development of wheat?

In a ten year study conducted in Texas, Johnson and Davis (1980) indicated that growing season precipitation was more important to plant growth and yield than stored soil water at planting time. Tanaka (1985) also reported that the frequency and distribution of precipitation during the growing season may be just as important to plant growth and yield as the amount of water stored in the rooting profile which is influenced by the quantity and position of residue on the soil surface.

The results of Tanaka (1985) and Johnson and Davis (1980) are inconsistent with those of Smika (1983). Smika (1983) reports that straw position had a significant influence on both total fallow period water storage and storage efficiency. His results indicate a straw position of 1/2 flat and 1/2 standing during the fallow period was more efficient than a 3/4 flat and 1/4 standing which was more efficient than an all flat straw mulch. The all flat straw mulch was also reported to be more efficient than a bare soil. He also reported significantly greater evaporation losses in the bare soil over the three mulch conditions. The 1/2 flat and 1/2 standing mulch also had significantly less evaporation than did the other two mulch treatments which were not significantly different from each other.

Unger and Jones (1981) indicated that soil water content at planting generally had a greater effect on yield, grain quality, water use and water use efficiency than does mulch rate. This brings us back to the findings of Tanaka (1985) and Johnson and Davis (1980) that frequency and distribution of precipitation may be more important to plant growth and yield than position and/or rate of residue on the soil surface.

Thus, the amount of residue and its position may influence the amount of soil water with no-till having greater soil water contents than conventionally tilled plots. But, this increase in soil water content may not be reflected in yield increases.

The question raised from the work of Unger and Jones (1981) seems to be answered to some extent by Weatherly and Dane (1979). Their work showed that corn roots absorbed little or no water below the 50 cm depth under conventional tillage treatment while corn under no-till treatments took up more total water with 28 percent of the total water coming from below the 50 cm depth. As with other data [Blevins et al. (1971), Unger and Jones (1981) and Tanaka (1985)] Weatherly and Dane's (1979) data showed that the major zone of influence on soil water is in the upper 45 cm of the soil profile. It should be noted here that water in this zone is influenced mainly by the amount and distribution of precipitation.

As can be seen from the above, there seems to be considerable disagreement regarding the influence of tillage on soil water content. The same is also true when looking at tillage and its effect on yield. Cochran et al. (1982) reported increases in grain yield for no-till wheat planted in spring wheat stubble compared to tilled wheat. However, they found no significant differences in grain yield under different tillage practices for wheat planted in winter wheat stubble. Retarded growth of seedlings in areas of heavy residue was given as a possible yield reducing factor in the no-till plots.

A wheat yield increase in the no-till compared to plow was reported by Fenster and Peterson (1979). This yield increase was reported to be directly related to soil water stored during the fallow period. Others reporting grain yield increases when comparing no-till to conventional are: Peterson and Fenster (1982), Wicks and Smika (1973), Ciha (1982). Those reporting a yield decrease for no-till or no differences in yield caused by tillage are: Davidson and Santelmann

(1973), Smika and Wicks (1968), Johnson and Davis (1980), Cochran et al. (1982).

With these discrepancies in soil water content and grain yield there is a definite need for further research in this area. In addition, all the studies cited above except the Davidson and Santelmann study involved some kind of crop rotation and/or a 14 to 21-month fallow period. Yet in Oklahoma, most of the wheat produced is continious from year to year with only a 3 to 4-month fallow period.

## PLANTING DATE-SOIL-WATER-YIELD RELATIONS

Using five dates of seeding at five locations in Nebraska, Fenster et al. (1972) showed an increase in grain yield as the planting date was delayed from mid-August to late September. However, delaying the planting date from late September to early October decreased grain yield. Data from this study also showed the soil profile under the mid-August and early September planting to have significantly less available soil moisture at fall dormancy than that of the late September and early October plantings. This same pattern existed for soil moisture in early spring. Thus, the lack of soil moisture in the early plantings may have been a factor in reduced yield in these plantings. At the two locations in the study where a tillage factor was introduced the conventional tillage plots had higher grain yields than the no-till plots when planted early. But as the planting date was delayed, this difference was reversed with the no-till having higher yields than the conventionaly tilled plots.

Darwinkel et al. (1977) showed that delaying the sowing of winter wheat past the usual sowing time caused a distinct reduction in yield, but sowing earlier increased yield only slightly. The major contributing factors to the yield decreases were a lower grain weight and fewer grains per ear. The earlier planted wheat had more fall tillers which produced larger ears than the spring tillers of the late planted wheat. Knapp and Knapp (1978) indicate that the decreasing yield with delayed planting may result from a decrease in plant height and grain test weight as planting is delayed. Thus, over time, increases in grain yield with early planting may of winter wheat not be an advantage and the practice of delaying planting until sufficient soil moisture is present may be ill advised.

Russelle and Bolton (1980) point out that early planted cereals often utilize excessive amounts of soil water, are more susceptible to winter killing and are frequently subject to disease. Thus, under limited moisture at planting, early planted wheat which germinates and starts its growth may not yield as well as wheat which is planted later in the planting period due to excessive water use. On the other hand, they point out that later seeding often results in delayed emergence and poor establishment resulting in fewer fall tillers and smaller ears on the plant at maturity. A yield decrease with delayed planting was also reported by Lafever and Campbell (1977). They, as did Fenster et al. (1972) showed that an optimum date of seeding existed for an area based on precipitation and elevation (climate). These optimum times are for maximum grain yield and do not necessarily lend themselves to producers who are interested in both grain production and fall forage production for winter pasture, as is the case in much of Oklahoma.

The effect of planting date and fall growth on soil water content under continious wheat has not been addressed. Fawcett and Carter (1973) in a spring wheat study showed that soil water contents were relatively constant at and below the 150 cm depth for all dates of planting. The rate of depletion of available soil water was also relatively rapid during the growing season for all planting dates.

Therefore, if a mulched soil (no-till) has more available water in the profile than an unmulched soil (clean-till) and water is a yield limiting factor, a yield advantage due to this increased soil water should exist regardless of planting date. As the planting date is moved either earlier or later than the late September early October optimum for Oklahoma, it is not known if these differences in soil water contents have an important influence on winter wheat yields.

# LITERATURE CITED

Blevins, R.L., Doyle Cook, S.H. Phillips, and R.E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

Ciha, A.J. 1982. Yield and yield components of four spring wheat cultivars grown under three tillage systems. Agron. J. 74:317-320.

Cochran, V.L., L.F. Elliott, and R.I. Papendick. 1982. Effect of crop residue management and tillage on water use efficiency and yield of winter wheat. Agron. J. 74:929-932.

Darwinkel, A., B.A. Ten Hag and J. Knizenga. 1977. Effect of sowing date and seeding rate on crop development and grain production of winter wheat. Neth. J. Agric. Sci. 25:83-94.

Davidson, J.M. and P.W. Santelmann. 1973. An evaluation of various tillage systems for wheat. Okla. Agric. Exp. Stn. Bul. B-711.

Fawcett, R.G. and O.G. Carter. 1973. Utility of a simple soil water budget model in agronomic research I. Effects of plant density, time-of-sowing and fallow water on available soil water under spring wheat. Aust. J. of Exp. Agric. and An. Husb. 13:714-717.

Fenster, C.R., M.G. Boosalis, and J.L. Wirhing. 1972. Date of planting studies of winter wheat and winter barley in relation to root and crown rot grain yields and quality. Nebr. Agric. Exp. Stn. Research Bul. 250.

Fenster, C.R. and G.A. Peterson. 1979. Effects of no-tillage fallow as compared to conventional tillage in a wheat-fallow system. Nebr. Agric. Exp. Stn. Research Bul. 289.

Fenster, C.R. and G.A. Wicks. 1982. Fallow systems for winter wheat in western Nebraska. Agron. J. 74:9-13.

Johnson, Wendell C. and Ronald G. Davis. 1980. Yield-water relationships of summer-fallowed winter wheat a precision study in the Texas panhandle. USDA-ARR-S-5/July.

Knapp, W.R. and J.S. Knapp. 1978. Response of winter wheat to date of planting and fall fertilization. Agron. J. 70:1048-1053.

Lafever, H.N. and L.G. Campbell. 1977. Timely winter wheat seeding important for top yields, 56-59. In Ohio Report August. 1977.

Mathews, O.R. and T.J. Army. 1960. Moisture storage on fallow wheatland in the great plains. Soil Sci. Soc. Amer. Proc. 24:414-418.

Peterson, G.A. and C.R. Fenster. 1982. No-till in the Great Plains. Crops and Soils 34:7-9.

Russelle, M.P. and F.E. Bulton. 1980. Soil temperature effects on winter wheat and winter barley emergence in the field. Agron. J. 72:823-827.

Smika, D.E. 1976. Seed zone soil water conditions with reduced tillage in the semiarid central Great Plains. The 7th Conference of the International Soil Tillage Research Organization, Sweden, 1976.

Smika, D.E. 1983. Soil water changes as related to position of wheat straw mulch on the soil surface. Soil Sci. Soc. Am. J. 47:988-991.

Smika, D.E. and G.A. Wicks. 1968. Soil water storage during fallow in the Central Great Plains as influenced by tillage and herbicide treatments. Soil Sci. Soc. Amer. Proc.. 32:591-595.

Steel, Robert G.D. and James H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York.

Tanaka, D.L. 1985. Chemical and stubble-mulch fallow influences on seasonal soil water contents. Soil Sci. Soc. Am. J. 49:728-733.

Unger, Paul W. 1978. Straw-mulch rate effects on soil water storage and sorghum yield. Soil Sci. Soc. Am. J. 42:486-491.

Unger, Paul W. and Ordie R. Jones. 1981. Effect of soil water content and a growing season straw mulch on grain sorghum. Soil Sci. Soc. Am. J. 45:129-134.

Weatherly, A.B. and J.H. Dane. 1979. Effect of tillage on soil water movement during corn growth. Soil Sci. Soc. Am. J. 43:1222-1225.

Wicks, G.A. and D.E. Smika. 1973. Chemical fallow in a winter wheat-fallow rotation. Jour. of The Weed Sci. Soc. of Am. 21(2):97-102.

Zingg, A.W. and C.J. Whitfield. 1957. A summary of research experience with stubble-mulch farming in the western states. Tech. Bul. No. 1166 USDA.

# CHAPTER III

# MATERIALS AND METHODS

The study was conducted on a Pulaski coarse-loamy, mixed, thermic Typic Ustifluvent (fine sandy loam 0-2 percent slope) soil at the Oklahoma State University North Agronomy Research farm, Stillwater, Oklahoma, and on a Grant fine, mixed, thermic Argiustoll (silt loam 3-5 percent slope) soil at the Oklahoma State University North Central Research Station, Lahoma, Oklahoma. Data were collected over three growing seasons, 1982-85 at both locations. Both sites had been in wheat the year prior to the beginning of the study. Precipitation was measured at the Agronomy Farm Main Station for the Stillwater location and at the North Central Research Station for the Lahoma location.

A randomized block design with a split plot arrangement was used in the study. The main plot effect consisted of two tillage systems, conventional tillage (CT) and no tillage (NT). At Stillwater, the CT consisted of moldboard plowing to a depth of 20 cm as soon after harvest as soil conditions allowed. These plots were then disked, as needed, for weed control and seedbed preparation. Final seedbed preparation consisted of running a mulch treader over the plots just prior to planting. At Lahoma, the CT plots were disked with an offset disk immediately after harvest. These plots were then disked or swept with 30.5 cm sweeps spaces 30.5 cm apart as needed, for weed control and residue incorporation. At both locations, the NT consisted of planting directly into the residue of the previous year's crop. Weed control in the NT plots was achieved through the use of various herbicides (Tables 1a and 1b).

The subplot treatment consisted of four planting dates, mid-August, mid-September, mid-October, and mid-November (Table 2). The hard red winter wheat TAM W-101 (Triticum aestivum L.) was used throughout the study. Planting in 1982 was performed with a modified John Deere hoe drill. In 1983 and 1984 a Crustbuster double disk opener No-Till drill was utilized. A row spacing of 25 cm and a seeding rate of 67 kg $ha^{-1}$ was used in all three years of the study at both locations. Planting depth ranged from 2 cm to 4 cm depending on soil moisture conditions at the time of planting. The plot size was 7.6 by 22.9 meters at the Stillwater location and 7.6 by 38 meters at the Lahoma location.

Soil fertility was maintained by using the Oklahoma State University Soil Testing Lab indexes to determine the total amount of nitrogen, phosphorus, and potassium needed. Fertilizer rates by year and location are given in Table 3. These needs were met through broadcast application of nitrogen as ammonium nitrate (34-0-0) and potassium as muriate of potash (0-0-60) prior to planting. Phosphorus was applied in the rows at planting. Diammonium phosphate (18-46-0) was the source in 1982 and 1984. In 1983, liquid 10-34-0 was used as a source of phosphorus.

Excessive fall growth resulted a need to remove some of the foliage from the early planted treatments. In the fall of 1983, the August no-till plots at Stillwater and all the August plots at Lahoma were clipped. In the fall of 1984, the August and September no-till plots at Stillwater were clipped. Clipping was preformed with a Carter harvester at a height of 12 to 15 cm above the soil surface. The amount of dry material removed in the clipping process was calculated and its nitrogen content determined. Additional nitrogen fertilizer was applied to the plots to replace the equivalent amount removed from each plot. Forage production at jointing was taken in 1983-4 and 1984-5 at Stillwater and 1984-5 at Lahoma.

Soil water content in the plots was monitored through the use of a neutron probe depth moisture gauge (Troxler Model 3223). Two, 3.8 cm inside diameter thick wall electrical conduit tubes per plot were used for neutron probe access. Readings were taken at 15 cm intervals from 15 to 180 cm below the surface at Stillwater and from 15 to 120 cm below the surface at Lahoma. Moisture readings were taken at each planting date for those plots which were planted. After all plots were planted, moisture readings were taken on a bi-weekly schedule until mid-December. Winter readings were taken approximately once per month. Once spring regrowth started, readings were again taken on a bi-weekly basis until jointing. From jointing through physiological maturity, neutron moisture readings were taken on a weekly basis. The last reading each crop year at each location was taken on the day of harvest. Readings were not taken during the fallow period as the CT tubes were removed to permit tillage. These tubes were not replaced until the plot was planted the following fall. Soil moisture in the surface 15 cm was determined on a weight basis (gravimetric moisture) at each planting for the plots planted on that date.

Percent ground cover (the percent of the soil surface covered by the previous years crop residue) was determined using the point count system as described by Owensby (1973) immediately after planting for each date of planting and tillage. Plant population, total above ground dry matter, and heads per area data were collected using two, one meter of row subsamples per plot. Spikelets per head and kernels per head were determined using 10 subsamples from the above samples. The meter row samples were collected at or just prior to harvest. Grain yield, and kernel weight data were collected using a Model A Gleaner combine with a 3 meter header at both locations in 1983 and at the Lahoma location in 1984. In 1984, a small plot combine with a 1.5 meter header was used at the Stillwater location and at both locations in 1985. Grain yields were adjusted to a moisture content of 135 g $kg^{-1}$ and a test weight of 772.2 kg $m^{-3}$ each year. The harvest area and date of harvest by year and location is presented in Table 4.

Split plot analysis of variance were performed on the individual reading date soil water content (SWC) data and the 120 and 180 cm profile water content (PWC) data for Lahoma and Stillwater respectively. The split plot analysis of variance procedure was also used to determine the F values for the gravimetric moisture and percent ground cover at planting, plant population, total above ground dry matter, heads per area, spikelets per head, kernels per head, kernel weight and grain yield data. If the calculated F values were significant and no significant interaction existed the F Test was used to determine significance differences between tillage treatments and the Duncan Multiple Range Test was used to determine significant differences in the planting date means. If significant interaction existed the procedure as outlined by Steel and Torrie (1960) was used.

Table 1a. Summary of Herbicide Applied, Rate of Application, and Date of Application. Stillwater, OK.

| Date | Chemical Applied | Rate kg $ha^{-1}$(ai) | Treatments Sprayed[1] |
|---|---|---|---|
| 8-23-82 | Glyphosate | 2.24 | 5,6,7,8 |
| 12-17-82 | MPCA | 0.56 | 1,2,3,5,6,7 |
| 3-11-83 | Chlorproham | 0.034 | ALL |
| 7- 8-83 | Glyphosate | 1.12 | 5,6,7,8 |
| 8-15-84 | Glyphosate | 1.12 | 5,6,7,8 |
| 11-12-84 | Glyphosate | 0.56 | 8 |
| 3-15-85 | Sencor | 0.40 | 1,2,3,5,6,7 |

1. Treatments 1 Aug. CT, 2 Sept. CT, 3 Oct. CT, 4 Nov. CT
5 Aug. NT, 6 Sept. NT, 7 Oct. NT, 8 Nov. NT

Table 1b. Summary of Herbicide Applied, Rate of Application, and Date of Application. Lahoma, OK.

| Date | Chemical Applied | Rate kg $ha^{-1}$(ai) | Treatments Sprayed[1] |
|---|---|---|---|
| 7-13-82 | Paraquat | 1.12 | All |
| 9-15-82 | Paraquat | 0.56 | 6,7,8 |
| 10-21-82 | Glyphosate | 0.56 | 3,4,7,8 |
| 7-21-83 | Glyphosate | 2.24 | 5,6,7,8 |
| 11- 2-83 | Glyphosate | 0.56 | 3,7 |
| 11-15-83 | Glyphosate | 0.56 | 4,8 |
| 7-12-84 | Glyphosate | 1.12 | 5,6,7,8 |
| 11- 9-84 | BAY-SMY 1500 | 1.12 | All |

1. Treatments 1 Aug. CT, 2 Sept. CT, 3 Oct. CT, 4 Nov. CT
5 Aug. NT, 6 Sept. NT, 7 Oct. NT, 8 Nov. NT

Table 2. Subplot Planting Dates for Stillwater (Swtr) and Lahoma (Lhma) for the Crop Years 1982-5.

| | August | | | September | | | October | | | November | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | | | | | | | | | | | |
| Loc | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 |
| Swtr | --[1] | --[2] | 15 | 13 | 24 | 19 | 15 | 14 | 15 | 17 | 16 | 14 |
| Lhma | 24 | 16 | 16 | 14 | 23 | 18 | 19 | N2[3] | 15 | 16 | 15 | 15 |

1. Planted August 27, but did not germinate. Was replanted September 24, 1982.
2. Planted August 17, but CT did not germinate. Replanted the CT plots October 14, 1983.
3. Wet conditions forced the delay from Oct. 15 to Nov 2.

Table 3. Fertilizer Application Rate by Year and Location.

| Year | Location | N | P | K |
|---|---|---|---|---|
| | | ---- kg $ha^{-1}$ --- | | |
| 1982 | Stillwater | 100 | 32 | 60 |
| 1983 | Stillwater | 100 | 32 | -- |
| 1984 | Stillwater | 100 | 32 | 60 |
| 1982 | Lahoma | 100 | 32 | -- |
| 1983 | Lahoma | 100 | 32 | -- |
| 1984 | Lahoma | 100 | 32 | -- |

Table 4. Harvest Plot Size and Date of Harvest by Year and Location.

| YEAR | LOCATION | HARVEST PLOT SIZE | DATE HARVESTED |
|---|---|---|---|
| | | ---- m ---- | |
| 1983 | Stillwater | 3 x 16.5 | June 24 |
| 1984 | Stillwater | 1.5 x 16.8 | July 3 |
| 1985 | Stillwater | 1.5 x 18.3 | June 10 |
| 1983 | Lahoma | 3 x 24.4 | June 30 |
| 1984 | Lahoma | 3 x 22.9 | June 19 |
| 1985 | Lahoma | 1.5 x 22.9 | June 10 |

# LITERATURE CITED

Owensby, C.E. 1973. Modifide step-point system for botanical composition and basal cover estimates. J. Range Manage. 26:302-303.

# CHAPTER IV

# SOIL WATER IN MONOCULTURE WINTER WHEAT AS INFLUENCED BY TILLAGE AND PLANTING DATE

## ABSTRACT

The study was conducted for three crop years (1982-85) at Stillwater, Oklahoma on a Pulaski course-loamy, mixed, thermic, Typic Ustifluvent soil and at Lahoma, Oklahoma on a Grant fine, mixed, Thermic Argiustoll soil. Two tillage treatments [conventional (CT) and no-tillage (NT)] were used as main unit treatments and four dates of planting (mid-August, mid-September, mid-October, and mid-November) were the subunit treatments. The objectives of the study was to determine if and to what extent the above tillage and dates of planting affect soil water for monoculture winter wheat (Triticum aestivum L.) produced in the South Central Great Plains. Soil water was measured through the neutron scattering method during the three crop years.

The effects of tillage and date of planting on soil water were quite different for both locations. At Stillwater neither tillage nor date of planting seemed to have an effect on the soil water. This is most likely the result of the precipitation received exceeding the demands of the crop such that excess soil water was present regardless of tillage or date of planting. At Lahoma where precipitation was more limiting, a significant tillage and date of planting effect developed. During the second year of the study a trend toward higher profile soil water (PSW) in the NT compared to the CT treatments began to emerge. This trend continued into the the third year at which time the PSW in the NT treatments became significantly greater than that of the CT treatments. In all three years of the study the November planting date at Lahoma had significantly higher PSW than the other planting dates. With the September and October planting dates having significantly higher PSW than the August.

It appears that the use of NT methods has a potential to increase soil water for the production of monoculture winter wheat in the South Central Great Plains. However, the potential to deplete this increase by planting early (mid-August) exists and the producer needs to evaluate the benefits of additional forage obtained with earlier planting versus the depletion of the stored soil water and the potential effect upon grain yields.

- - - - - - - - - - - - - - - - - - - - -

Additional index words: No-till, profile soil water, soil water content, _Triticum_ _aestivum_ L.

- - - - - - - - - - - - - - - - - - - - -

## INTRODUCTION

Planting winter wheat (_Triticum_ _aestivum_ L.) using no-till (NT) methods is a production practice gaining acceptance in Oklahoma and other Great Plains states (CTIC 1984). As these NT methods gain acceptance they must be considered in the evaluation of monoculture wheat production. Of particular concern is how soil moisture is affected under different tillage systems at different planting dates. Several researchers have addressed the effect of tillage methods on soil water content and wheat yields under wheat-fallow practices (Fenster and Peterson, 1979; Wicks and Smika, 1973; Ciha, 1982; Johnson and Davis, 1980; and Cochran et al., 1982). However, there seems to be considerable disagreement as to what effect the tillage practice employed has on soil water content. Previous work at Oklahoma State University with monoculture wheat (Davidson and Santelmann, 1973) reported soil water content in the top 45 cm of the soil profile was greater for NT than conventional tillage (CT). This is consistent with Blevins et al. (1971). Their data also showed that most of the changes in soil water content occurred in the first 60 cm of the soil profile, with changes at the 120 and 180 cm depth being negligible in most cases. However Zingg and Whitfield (1957), along with reporting increased soil water under NT when compared to CT, presented evidence of deeper penetration of precipitation in NT when compared to CT. This same increase in penetration was observed by Unger and Jones (1981). In all the above research, the wheat was planted at the usual planting times for the location in which the research was being conducted and an extended fallow period (14 to 18 months) was used. With the reported increase in soil water content and lower soil temperatures under wheat-fallow NT conditions as compared to wheat-fallow CT (Blevins et al., 1971; Tanaka, 1985; Fenster and Wicks, 1982; Unger, 1978; Smika, 1983; Russelle and

Bolton, 1980; Fenster and Peterson, 1979; and Smika and Ellis, 1971) it would be expected that soil water contents in monoculture winter wheat planted NT would be equal to or greater than that in CT planted wheat.

There is limited information concerning the interactions of tillage and planting date on the soil water content for monoculture wheat production. Fenster et al. (1972) reported significantly more soil water in the first 30 cm of soil at fall dormancy for wheat planted in late September when compared to wheat planted in early September or late August. The early and late September plantings also had significantly more soil water to a depth of 60 cm than the late August planting. Early planting also had less soil water than late plantings in the Spring (April 1) as well.

Lafever and Campbell (1977) and Fenster et al. (1972) showed that an optimum seeding date for maximum grain field exist for an area based on precipitation and elevation. The optimum time for Oklahoma is generally considered to be from the last week of September through the first week of October. But, it is unknown how earlier planting of winter wheat affects the soil water under both CT and NT. Russelle and Bolton (1980) showed that earler planted cereals often utilize . excessive amounts of soil water, are more susceptible to winter killing and are frequently subject to disease. The objective of this study was to determine if and to what extent tillage and planting date affect soil water for monoculture winter wheat produced in the South Central Great Plains.

# MATERIALS AND METHODS

The study was conducted on a Pulaski coarse-loamy, mixed, thermic Typic Ustifluvent (fine sandy loam 0-2 percent slope) soil at the Oklahoma State University North Agronomy Research farm, Stillwater, Oklahoma and on a Grant fine, mixed, thermic Argiustoll (silt loam 3-5 percent slope) soil at the Oklahoma State University North Central Research Station, Lahoma, Oklahoma. Data were collected over three growing seasons, 1982-85 at both locations. Both sites had been in wheat the year prior to the beginning of the study. Precipitation was measured at the Agronomy Farm Main Station for the Stillwater location and at the North Central Research Station for the Lahoma location (Table 1).

A randomized block design with a split plot arrangement was used in the study. The main plot effect consisted of two tillage systems, conventional tillage (CT) and no tillage (NT). At Stillwater, the CT consisted of moldboard plowing to a depth of 20 cm as soon after harvest as soil conditions allowed. These plots were then disked, as needed, for weed control and seedbed preparation. Final seedbed preparation consisted of running a mulch treader over the plots just prior to planting. At Lahoma, the CT plots were disked with an offset disk immediately after harvest. These plots were then disked or swept with 30.5 cm sweeps spaces 30.5 cm apart as needed, for weed control and residue incorporation. At both locations the NT treatments consisted of planting directly into the residue of the previous year's crop. Weed control in the NT plots during the fallow period was achieved through the use of various herbicides.

The subplot treatment consisted of four planting dates (Table 2). The hard red winter wheat TAM W-101 (Triticum aestivum L.) was used throughout the study. Planting in 1982 was preformed with a modified John Deere hoe drill. In 1983 and 1984, a Crustbuster double disk opener No-Till drill was utilized. A row spacing of 25 cm and a seeding rate of 67 kg $ha^{-1}$ was used in all three years of the study at both locations. Planting depth ranged from 2 cm to 4 cm depending on soil moisture conditions at the time of planting. The plot size was 7.6 by 22.9 meters at the Stillwater location and 7.6 by 38 meters at the Lahoma location.

Soil fertility was maintained by using the Oklahoma State University Soil Testing Lab indexes to determine the total amount of nitrogen, phosphorus, and potassium needed. These needs were met through broadcast application of nitrogen as ammonium nitrate (34-0-0) and potassium as muriate of potash (0-0-60) prior to planting. Phosphorus was applied in the rows at planting. Diammonium phosphate (18-46-0) was the source in 1982 and 1984. In 1983, liquid 10-34-0 was used as a source of phosphorus.

Excessive fall growth resulted a need to remove some of the foliage from the early planted treatments. In the fall of 1983, the August no-till plots at Stillwater and all the August plots at Lahoma were clipped. In the fall of 1984, the August and September no-till plots at Stillwater were clipped. Clipping was preformed with a Carter harvester at a height of 12 to 15 cm. The amount of dry material removed in the clipping process was calculated and its nitrogen content was determined. Nitrogen fertilizer was then applied to the plots to replace the equivalent amount removed from each plot.

Soil water content in the plots was monitored through the use of a neutron probe depth moisture gauge (Troxler Model 3223). Two, 3.8 cm inside diameter thick wall electrical conduit tubes per plot were used for neutron probe access. Readings were taken at 15 cm intervals from 15 to 180 cm below the surface at Stillwater and from 15 to 120 cm below the surface at Lahoma. Initial moisture readings were taken at each planting date. After all plots were planted, moisture readings were taken on a bi-weekly schedule until mid-December. Winter readings were taken approximately once per month. Once spring regrowth started, readings were again taken on a bi-weekly basis until jointing. From jointing through physiological maturity, neutron moisture readings were taken on a weekly basis. The last reading each crop year at each location was taken on the day of harvest. Readings were not taken during the fallow period as the CT tubes were removed to permit tillage. These tubes were not replaced until the plot was planted the following fall. Soil moisture in the surface 15 cm was determined on a weight basis (gravimetric moisture) at each planting for the plots planted on that date.

Percent ground cover (the percent of the soil surface covered by the previous years crop residue) was determined by the point count system as described by Owensby (1973) immediately after planting for each date of planting and tillage system (Table3). Grain yield (Yield) and kernel weight (KW) data were collected using a Gleaner A combine with a 3 meter header at both locations in 1983, and at the Lahoma location in 1984. In 1984, a small plot combine with a 1.5

meter header was used at the Stillwater location and at both locations in 1985. Grain yields were adjusted to a moisture content of 135 g $kg^{-1}$ and a test weight of 772.2 kg $m^{-3}$ each year.

Split plot analysis of variance were performed on the individual reading date 15 through 120 and 180 cm soil water content (SWC) data and the profile water content of the soil (PSW) to 120 and 180 cm data for Lahoma and Stillwater respectively. The split plot analysis of variance procedure was also used to determine the F values for the gravimetric moisture and grain yield data. If the calculated F values were significant and no significant interaction existed the F Test was used to determine significance differences between tillage treatments and the Duncan Multiple Range Test was used to determine significant differences in the planting date means. If significant tillage by date interactions existed the procedure for split-plot design and analysis as outlined by Steel and Torrie (1960) was used.

## RESULTS AND DISCUSSION

The precipitation at Lahoma was somewhat evenly distributed except for the unusually large amounts of precipitation received in May and October of 1983, March 1984, and Feburary and April of 1985 (Table 1). This rainfall pattern resulted in a definite trend in the soil water contents (SWC) by tillage at Lahoma. This trend becomes obvious with the April 1983 SWC (Figure 1) where the August CT SWC started to become less than those of the other treatments. This trend continued through the rest of the 1982-83 crop year and was observed again in the November 1983 SWC (Figure 2). In Figure 2 it can also be seen that the August NT had lower SWC values in the profile than the other treatments. This decrease in SWC for the August treatments is carried through Feburary of 1984. With the unusually high precepitation in March 1984 the August NT SWC appears to have equalized with the other treatments leaving the August CT with the driest soil profile (Figure 3). This increase in the early planted NT SWC is consistent with the findings of Zingg and Whitfield (1957) and Russelle and Bolton (1980). This same occurance did not exist at the Stillwater location and therefore seems to be site specific. Which points out the fact that increased soil water under NT cropping practices may not be a major benefit in areas of increased precipitation.

The soil water contents at the Lahoma location began to show a separation by tillage in June of 1984. Again, this did not seem to happen at the Stillwater location. The separation could be seen in the fall and spring of 1984 and 1985 (Figures 4 and 5). Statistical analysis of the 1984-85 SWC and profile soil water content (PSW) data showed a significant (P = 0.05) tillage difference at all reading dates. The data shows that most of the changes in SWC occur in the first 60 cm of the soil profile for the CT treatments. This is also true of the NT treatments once the profile seems to have been completely recharged (Figures 4 and 6). However, there were changes in the SWC throughout the profile which is inconsistent with the findings of Blevins et al. (1971). who reported only minimal changes in the soil water content below the 45 cm depth. By the end of the 1984-85 crop year the SWC in the NT treatments had never decreased to the levels of the SWC in the CT treatments. Therefore, it is unlikely that soil water was the limiting factor causing the decreased yields for the NT when compared to the CT as reported in Chapter IV of this thesis.

The differences in PSW in 1982-83 at Lahoma (Figure 7) is likely the result of a lack of weed control in the NT plots during the fallow period just prior to the establishment of the study. This lack of weed control resulted in the CT treatments having more PSW until sufficient precipitation was received to recharge the NT plots. The PSW curves for 1983-84 (Figure 8) show the beginning of a trend toward higher soil water in the NT treatments when compared to the CT treatments. This trend becomes statistically significant in the 1984-85 data (Figure 9) with NT having significantly more water in the profile than CT. The PSW data from Lahoma also showed that a statistically significant planting date affect existed from jointing through harvest in all years of the study (Table 4). There was no definite trend for one planting date to have the lowest PSW values. However, the November planting date consistantly had the highest PSW values.

Precipitation at the Stillwater location was five below the long term average in 1982-83, seven percent below in 1983-84, and 23 percent above in 1984-85 (Table 2). The above average precipitation in May and October 1983, March and December 1984, and Feburary, March and April 1985 made the SWC under both tillage treatments at all planting dates appear equal. There also appears to have been sufficient precipition prior to any dry period such that no definite date or tillage effect in SWC or PSW could be reconized.

For the locations and rainfall conditions experienced, the potential for the growth from the early plantings to severely reduce the PSW to a deficite level appears to be relatively low. Once the tillage differences in SWC and/or PSW at Lahoma were established the NT continued to have the highest values. Therefore, it appears that as precipition becomes more limiting the SWC and thus the PSW for monoculture NT winter wheat production will be greater than those of monoculture CT winter wheat. Therefore, if water is a yield limiting factor, increased soil water under monoculture NT wheat production should allow for yield increases in dryer years or areas of lower annual precipitation when compared to CT wheat production. It can also be seen that a potential to depleat the PSW by planting early exist when CT practices are used.

Table 1. Precipitation: Long-Term Average for Stillwater (STWR) and Lahoma (LAHA) and the 1982 to 1985 Growing Season.

| Month | Long-Term AVE |  | 1982-83 |  | 1983-84 |  | 1984-85 |  |
|---|---|---|---|---|---|---|---|---|
|  | STWR | LAHA | STWR | LAHA | STWR | LAHA | STWR | LAHA |
|  | mm |  |  |  |  |  |  |  |
| July | 90 | 67 | 50 | 82 | 0 | 0 | 16 | 2 |
| August | 82 | 74 | 35 | 2 | 22 | 36 | 26 | 21 |
| September | 86 | 87 | 58 | 18 | 52 | 95 | 30 | 12 |
| October | 71 | 78 | 25 | 4 | 193 | 121 | 123 | 33 |
| November | 47 | 50 | 70 | 39 | 55 | 42 | 56 | 33 |
| December | 34 | 24 | 59 | 38 | 10 | 5 | 101 | 78 |
| January | 30 | 29 | 8 | 21 | 5 | 0 | 77 | 20 |
| February | 34 | 17 | 76 | 41 | 18 | 47 | 116 | 140 |
| March | 47 | 71 | 78 | 87 | 130 | 145 | 127 | 60 |
| April | 73 | 69 | 41 | 85 | 73 | 84 | 136 | 132 |
| May | 117 | 84 | 189 | 109 | 68 | 30 | 43 | 36 |
| June | 108 | 61 | 93 | 145 | 135 | 43 | 162 | 114 |
| Total | 818 | 711 | 782 | 711 | 761 | 648 | 1013 | 681 |

Table 2. Subplot Planting Dates for Stillwater (Swtr) and Lahoma (Lhma) for the Crop Years 1982-5.

| | August | | | September | | | October | | | November | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | | | | | | | | | | | |
| Loc | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 |
| Swtr | --[1] | --[2] | 15 | 13 | 24 | 19 | 15 | 14 | 15 | 17 | 16 | 14 |
| Lhma | 24 | 16 | 16 | 14 | 23 | 18 | 19 | N2[3] | 15 | 16 | 15 | 15 |

1. Planted August 27 but did not germinate. Was replanted September 24, 1982.
2. Planted August 17 but the CT did not germinate. Replanted the CT plots October 14, 1984.
3. Wet conditions forced the delay from Oct. 15 to Nov 2.

Table 3. Percent Ground Cover after Planting as Affected by Tillage and Planting Date.

| | STILLWATER | | | | LAHOMA | | | |
|---|---|---|---|---|---|---|---|---|
| PD | AUG. | SEPT. | OCT. | NOV. | AUG. | SEPT. | OCT. | NOV. |
| Tillage | | | | 1983-84 | | | | |
| | | | | % | | | | |
| CT | 3 | 4 | 4 | 6 | 18 | 19 | 17 | 17 |
| NT | 94 | 92 | 92 | 75 | 96 | 93 | 84 | 92 |
| | | | | 1984-85 | | | | |
| | | | | % | | | | |
| CT | 6 | 9 | 8 | 8 | 31 | 35 | 30 | 28 |
| NT | 97 | 91 | 81 | 82 | 95 | 98 | 84 | 88 |

Table 4. Water Content of the 120 cm Soil Profile (PSW). Lahoma.

| Date[+] | 1982-83 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 200 | 242 | 256 | 261 | 284 | 296 | 309 | 319 |
| | mm | | | | | | | |
| Aug. | 320b | 312c | 275b | 269b | 243b | 223b | 253a | 272a |
| Sept. | 335a | 326b | 285b | 281n | 252ab | 227b | 265a | 288a |
| Oct. | 341a | 341a | 314a | 306b | 266a | 244a | 265a | 282a |
| Nov. | 343a | 345a | 312a | 307a | 263a | 242a | 263a | 278a |

| Day[++] | 1983-84 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 204 | 251 | 265 | 273 | 280 | 287 | 204 | 302 | 322 |
| | mm | | | | | | | | |
| Aug. | 302c | 320b | 299b | 280b | 252b | 241b | 225b | 213b | 222b |
| Sept. | 326b | 328b | 308b | 286b | 253b | 243b | 222b | 213b | 229b |
| Oct. | 341a | 346a | 330a | 317a | 291a | 382a | 258a | 237a | 236a |
| Nov. | 346a | 349a | 334a | 319a | 296a | 288a | 271a | 251a | 260a |

| Day[+++] | 1984-85 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 238 | 251 | 258 | 267 | 274 | 281 | 289 | 296 | 330 |
| | mm | | | | | | | | |
| Aug. | 331c | 302b | 296b | 283b | 300bc | 292b | 258bc | 232b | 283ab |
| Sept. | 344a | 320a | 316a | 308a | 324a | 314a | 386a | 258a | 294a |
| Oct. | 333bc | 302b | 295b | 283b | 296c | 285b | 248c | 222b | 268bc |
| Nov. | 342ab | 322a | 324c | 302a | 319ab | 300ab | 265b | 236b | 265c |

[+] Days from August 15, 1982.
[++] Days from August 10, 1983.
[+++] Days from August 1, 1984.

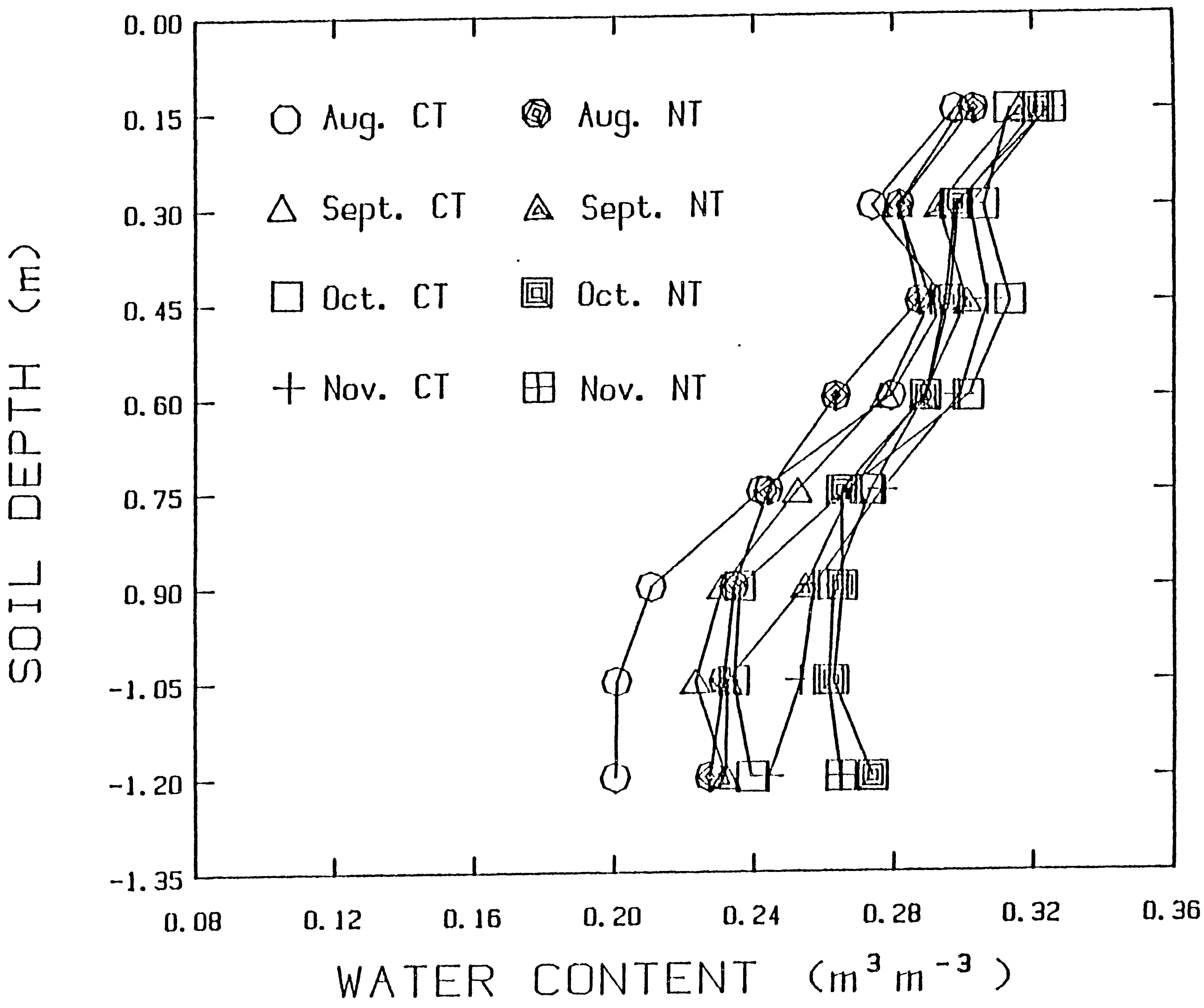

Fig. 1. Soil Water Contents on April 14, 1983. Lahoma.

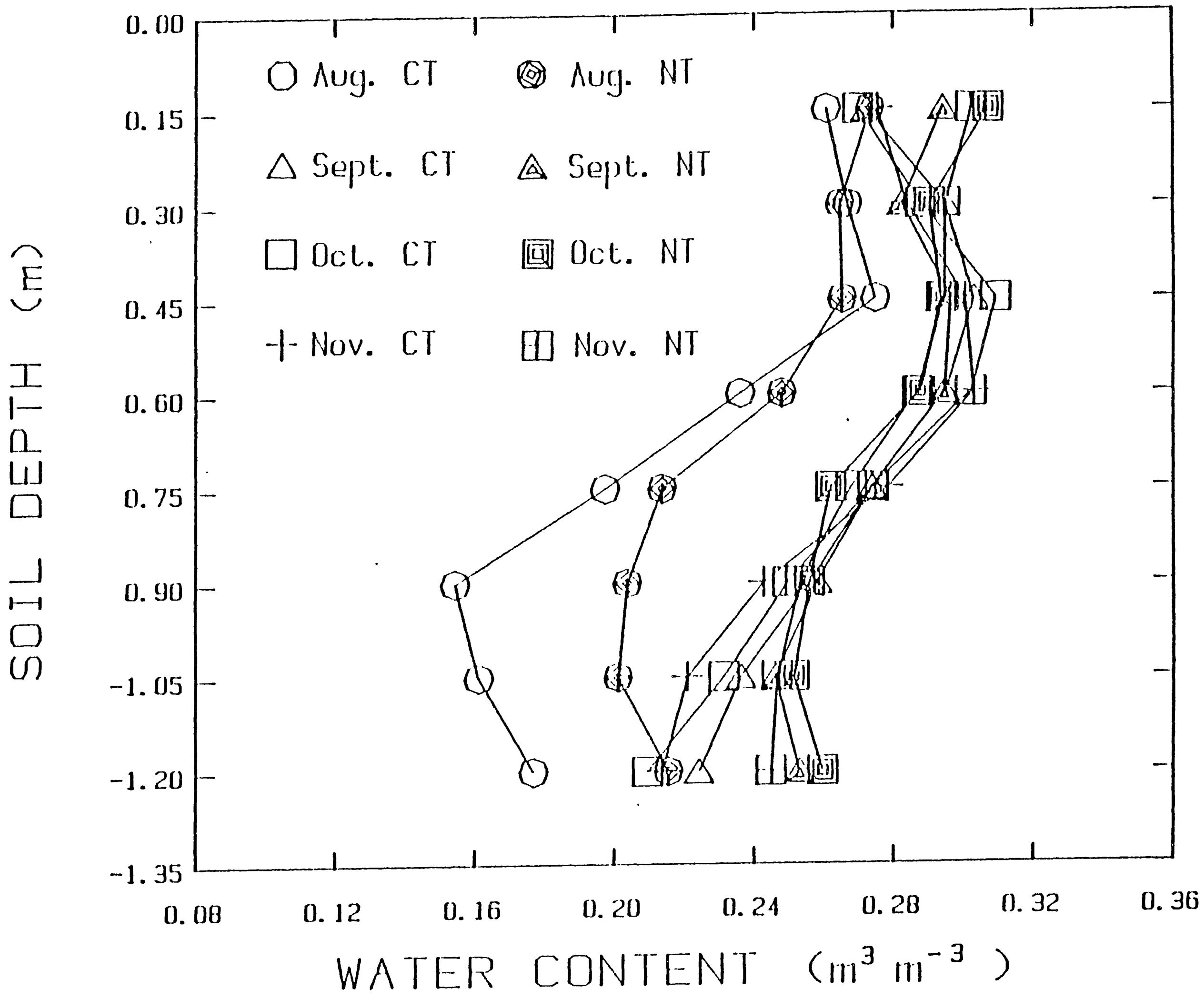

Fig. 2. Soil Water Contents on November 15, 1983. Lahoma.

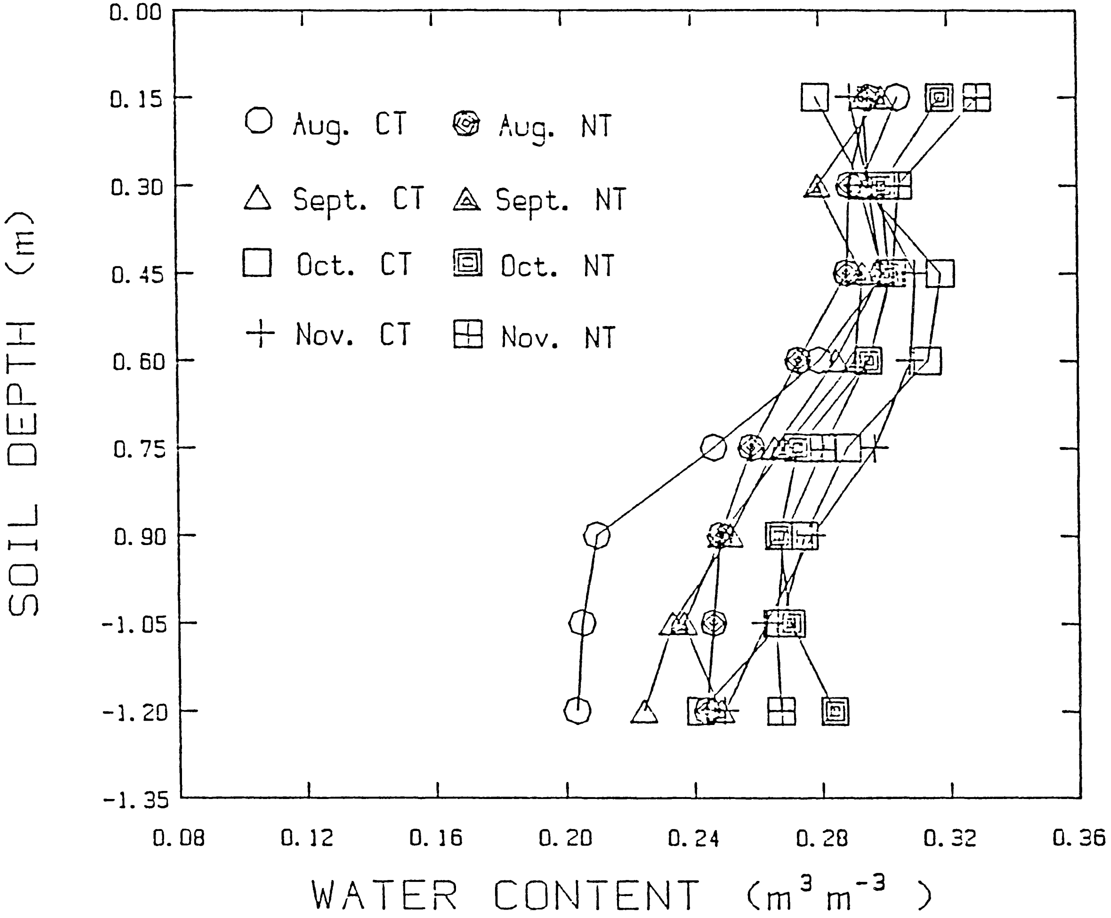

Fig. 3. Soil Water Contents on April 17, 1984. Lahoma.

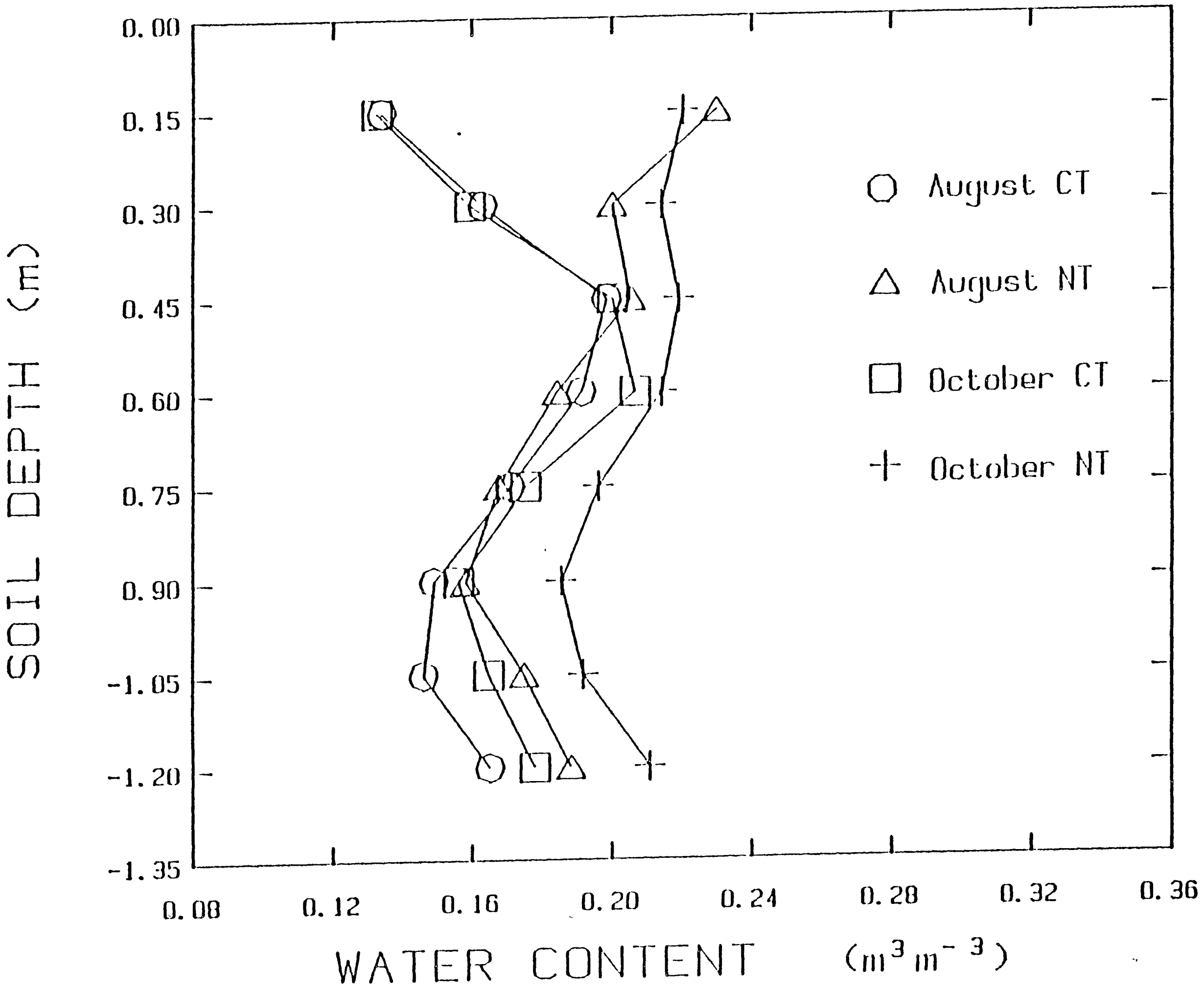

Fig. 4. Soil Water Contents on November 15, 1984. Lahoma.

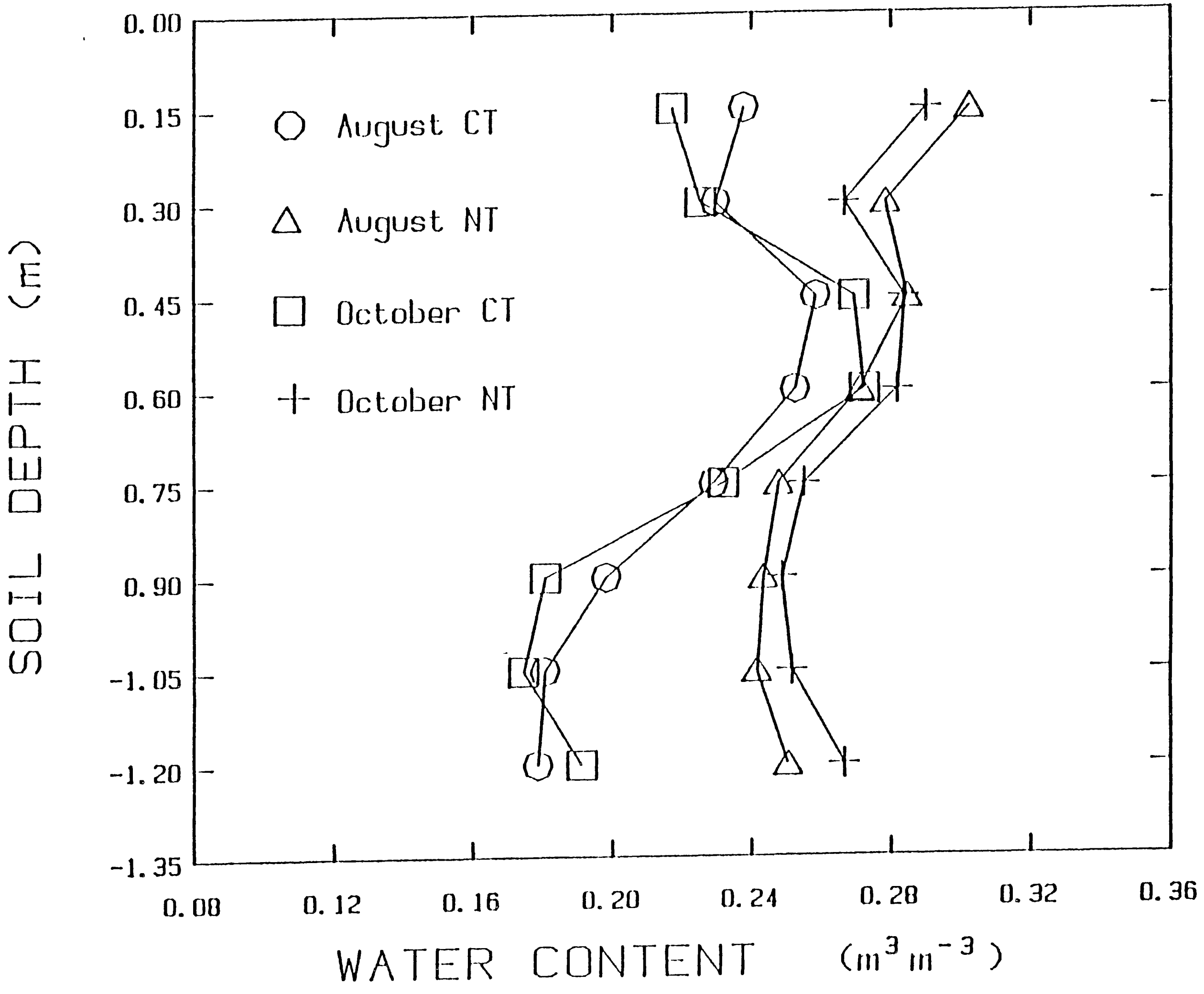

Fig. 5. Soil Water Contents on April 16, 1985. Lahoma.

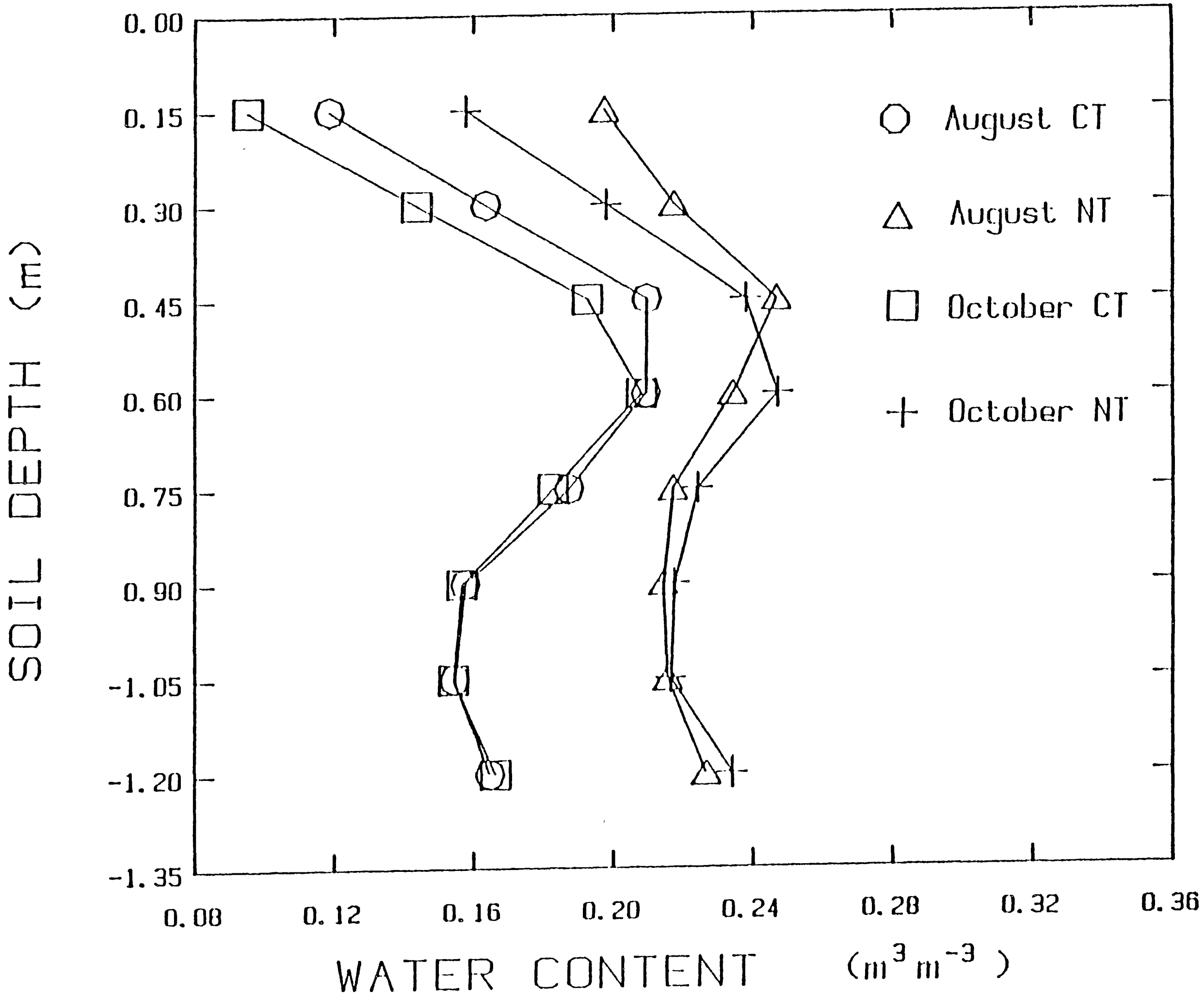

Fig. 6. Soil Water Contents on May 24, 1985. Lahoma.

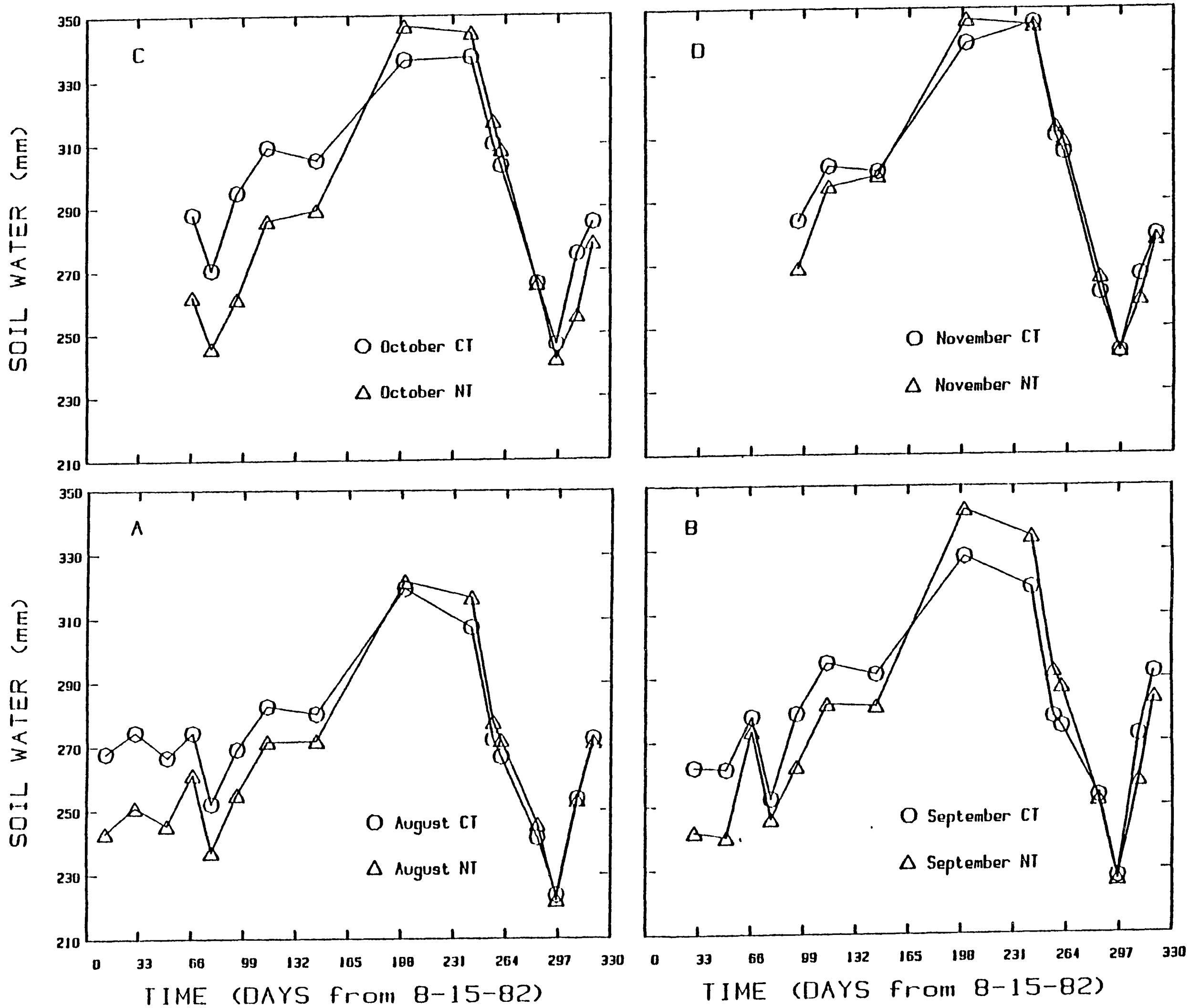

Fig. 7. Water Content of the 120 cm Soil Profile. 1982-83. Lahoma.
(A) August, (B) September, (C) October, and (D) November Planting Dates.

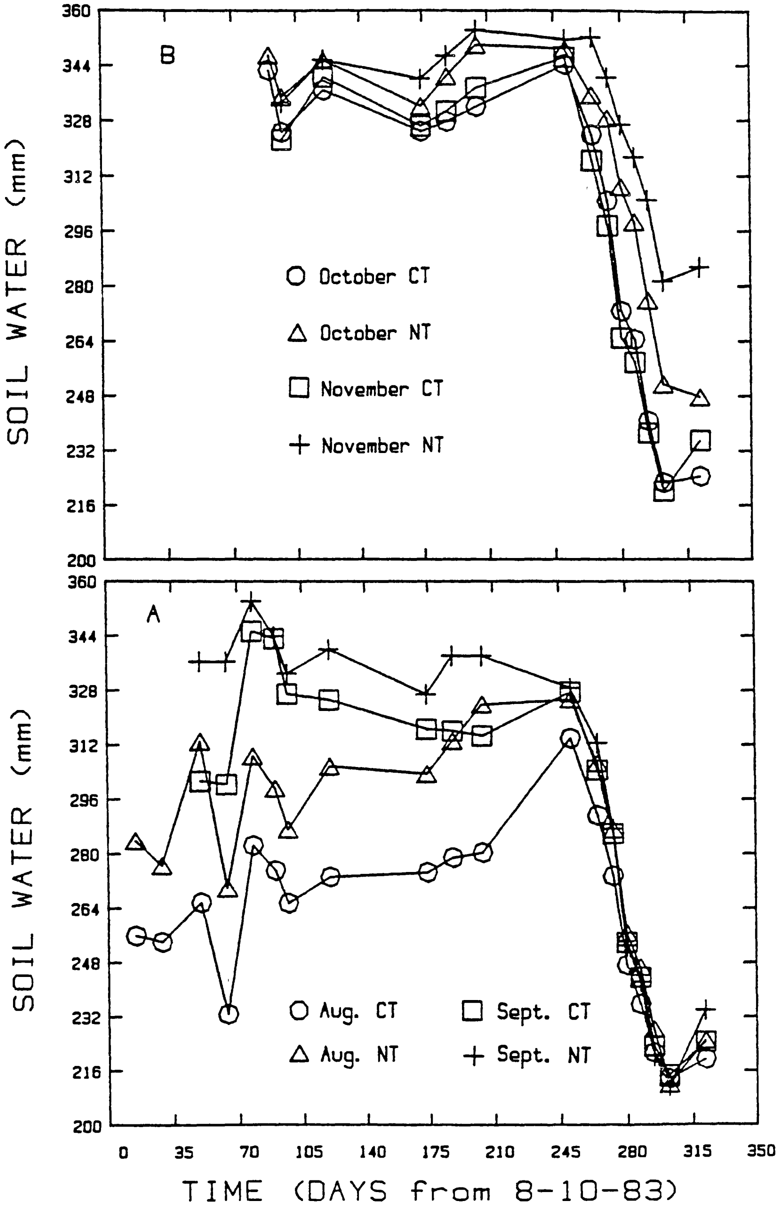

Fig. 8. Water Content of the 120 cm Soil Profile. Lahoma. (A) August and September and (B) October and November Planting Date.

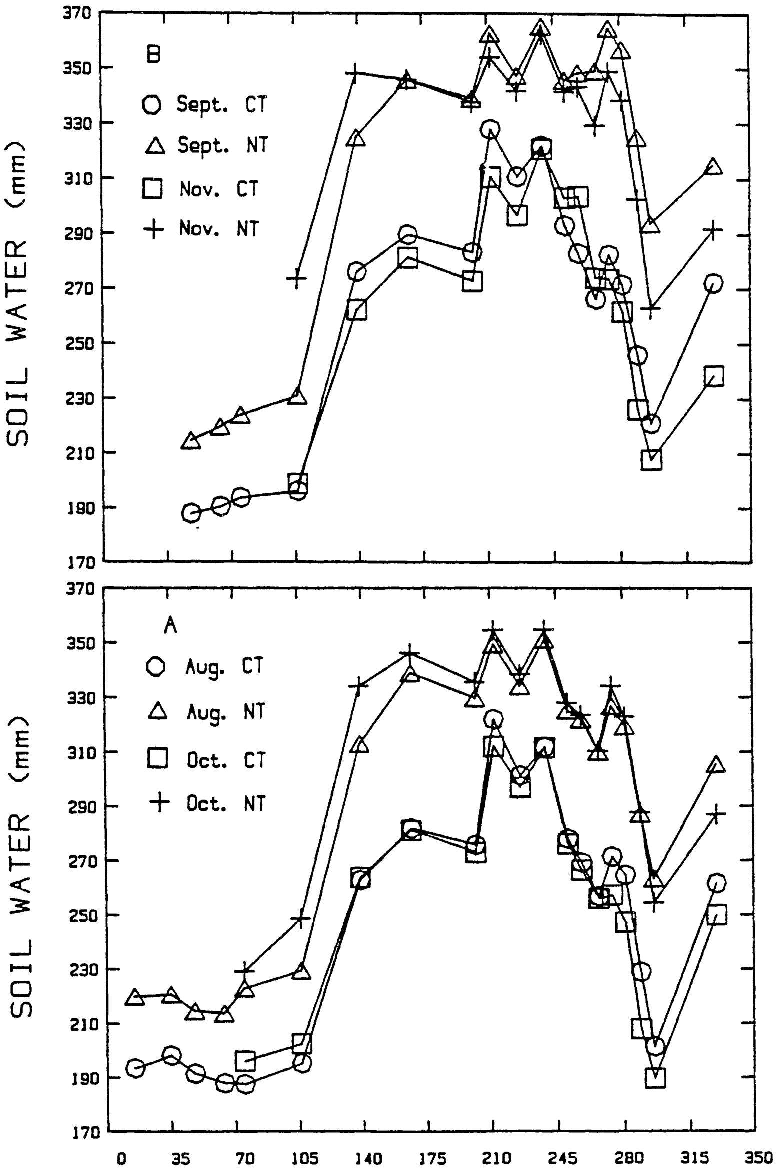

Fig. 9. Water Content of the 120 cm Soil Profile. Lahoma. (A) August and October CT and NT. (B) September and November CT and NT.

# LITERATURE CITED

Blevins, R.L., Doyle Cook, S.H. Phillips, and R.E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

Ciha, A.J. 1982. Yield and yield components of four spring wheat cultivars grown under three tillage systems. Agron. J. 74:317-320.

Cochran, V.L., L.F. Elliott, and R.I. Papendick. 1982. Effect of crop residue management and tillage on water use efficiency and yield of winter wheat. Agron. J. 74:929-932.

Conservation Tillage Information Center. 1984. 1983 National survey conservation tillage practices. Conservation Tillage Information Center. Ft. Wayne, IN.

Davidson, J.M. and P.W. Santelmann. 1973. An evaluation of various tillage systems for wheat. Okla. Agric. Exp. Stn. Bul. B-711.

Fenster, C.R., M.G. Boosalis, and J.L. Wirhing. 1972. Date of planting studies of winter wheat and winter barley in relation to root and crown rot grain yields and quality. Nebr. Agric. Exp. Stn. Research Bull. 250.

Fenster, C.R. and G.A. Peterson. 1979. Effects of no-tillage fallow as compared to conventional tillage in a wheat-fallow system. Nebr. Agric. Exp. Stn. Bul. 289.

Fenster, C.R. and G.A. Wicks. 1982. Fallow systems for winter wheat in western Nebraska. Agron. J. 74:9-13.

Johnson, Wendell C. and Ronald G. Davis. 1980. Yield-water relationships of summer-fallowed winter wheat a precision study in the Texas panhandle. USDA-ARR-S-5/July.

Lafever, H.N. and L.G. Campbell. 1977. Timely winter wheat seeding important for top yields, 56-59. In Ohio Report August. 1977.

Owensby, C.E. 1973. Modified step-point systen for botanical composition and basal cover estimates. J. Range Manage. 26:302-303.

Russelle, M.P. and F.E. Bulton. 1980. Soil temperature effects on winter wheat and winter barley emergence in the field. Agron. J. 72:823-827.

Smika, D.E. 1983. Soil water changes as related to position of wheat straw mulch on the soil surface. Soil Sci. Soc. Am. J. 47:988-991.

Smika, D.E., and R. Ellis Jr. 1971. Soil temperature and wheat straw mulch effects on wheat plant development and nutrient concentration. Agron. J. 63:388-391.

Steel, Robert G.D. and James H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York.

Tanaka, D.L. 1985. Chemical and stubble-mulch fallow influences on seasonal soil water contents. Soil Sci. Soc. Am. J. 49:728-733.

Unger, Paul W. 1978. Straw-mulch rate effects on soil water storage and sorghum yield. Soil Sci. Soc. Am. J. 42:486-491.

Unger, Paul W. and Ordie R. Jones. 1981. Effect of soil water content and a growing season straw mulch on grain sorghum. Soil Sci. Soc. Am. J. 45:129-134.

Wicks, G.A. and D.E. Smika. 1973. Chemical fallow in a winter wheat-fallow rotation. Jour. of The Weed Sci. Soc. of Am. 21(2):97-102.

Zingg, A.W. and C.J. Whitfield. 1957. A summary of research experience with stubble-mulch farming in the western states. Tech. Bul. No. 1166 USDA.

# CHAPTER V

# YIELD OF MONOCULTURE WINTER WHEAT AS INFLUENCED BY TILLAGE AND PLANTING DATE

## ABSTRACT

The study was conducted for three crop years (1982-85) at Stillwater, Oklahoma on a Pulaski course-loamy, mixed, thermic, Typic Ustifluvent soil and at Lahoma, Oklahoma on a Grant fine, mixed, Thermic Argiustoll soil. Two tillage treatments [conventional (CT) and no-tillage (NT)] were used as main unit treatments and four dates of planting (mid-August, mid-September, mid-October, and mid-November) were the subunit treatments. The objectives of the study was to determine if and to what extent the above tillage and dates of planting affect grain yield of monoculture winter wheat (*Triticum aestivum* L.) produced in the South Central Great Plains. Yield data were collected using two, randomly selected one meter sections of row per plot for the number of heads per area and ten randomly selected one head subsamples per plot for the kernels per head. A field size combine was used to determine grain yield in 1983 and 1984 and a plot combine was used in 1985.

The planting date effect on yield was significant at both locations in all years of the study except for those at Stillwater for the 1982-83 crop year. The mid-September and mid-October planting dates consistantly had higher grain yields than the mid-August and mid-November planting dates. There was no significant tillage by planting date interaction for grain yield and in that no one tillage treatment consistantly porduced higher yields it appears that the ideal planting date for both tillage systems is the same. This is not what one would have expected. With the reported increased soil water and lower seed zone soil temperatures there should have been a yield advantage infavor of the NT. There was a trend for earlier emergence and establishment in the early planted NT when compared to early planted CT but this did not transulate into increased grain yield.

Additional index words: No-till, seeding date, Triticum aestivum L.

## INTRODUCTION

Planting winter wheat (Triticum aestivum L.) using no-till (NT) methods is a production practice gaining acceptance in Oklahoma and other Great Plains states (CTIC 1984). In the evaluation of monoculture wheat production yields, these NT methods must be considered. Several researchers have addressed the effect of tillage methods on wheat yields in wheat-fallow and wheat sorghum-fallow systems (Fenster and Peterson, 1979; Wicks and Smika, 1973; Ciha, 1982; Johnson and Davis, 1980; and Cochran et al., 1982). However, there is considerable disagreement as to exactly what effect the tillage practice employed has on yield. Previous work at Oklahoma State with monoculture wheat (Davidson and Santelmann, 1973) reports yield decreases under NT conditions when compared to conventional tillage (CT) practices. In the above research, the wheat was planted at the usual planting times for the location in which the research was being conducted. But, with the reported increase in soil moisture and lower soil temperature (Blevins et al., 1971; Tanaka, 1985; Fenster and Wicks, 1982; Unger, 1978; Smika, 1983; Russelle and Bolton, 1980; Fenster and Peterson, 1979; and Smika and Ellis, 1971) it may be possible that the yield of monoculture NT wheat planted before the usual planting time for a given location will be equal to or higher than that of monoculture CT wheat planted at the same time.

There is limited information concerning the interactions of tillage and planting date on the yield of winter wheat. Fenster et al. (1972) showed an increase in grain yield as planting date was delayed from mid-August to late September and a decrease in yield as planting was delayed from late September to early October. They study also showed that CT yielded more than NT in the early plantings, but in the later plantings, the NT yielded more than the CT. Darwinkel et al. (1977) showed that delaying the planting of CT wheat caused a distinct reduction in yield, but planting earlier (prior to the usual planting time) increased yields only slightly. Their study did not include NT treatments. In a study by Knapp and Knapp (1978) under CT yields decreased with delayed planting.

Lafever and Campbell (1977) and Fenster et al. (1972) point out that an optimum date of seeding exists for an area based on precipitation and elevation. These optimums are for maximum grain yield under CT and may not be applicable in NT production. Therefore, the objective of this study was to determine if and to what extent tillage and planting date affect the grain yield of monoculture winter wheat produced in South Central Great Plains.

## MATERIALS AND METHODS

The study was conducted on a Pulaski coarse-loamy, mixed, thermic Typic Ustifluvent (fine sandy loam 0-2 percent slope) soil at the Oklahoma State University North Agronomy Research farm, Stillwater, Oklahoma, and on a Grant fine, mixed, thermic Argiustoll (silt loam 3-5 percent slope) soil at the Oklahoma State University North Central Research Station, Lahoma, Oklahoma. Data were collected over three growing seasons, 1982-85 at both locations. Both sites had been in wheat the year prior to the beginning of the study.

A randomized block design with a split plot arrangement was used in the study. The main plots consisted of conventional tillage (CT) and no tillage (NT). At Stillwater, the CT consisted of moldboard plowing to a depth of 20 cm as soon after harvest as soil conditions allowed. These plots were then disked, as needed, for weed control and seedbed preparation. Final seedbed preparation consisted of running a mulch treader over the plots just prior to planting. At Lahoma, the CT plots were disk with an offset disked immediately after harvest. These plots were then disked or swept with 30.5 cm sweeps spaced 30.5 cm apart as needed, for weed control and residue incorporation. At both locations the NT consisted of planting directly into the residue of the previous year's crop. Weed control in the NT plots during the fallow period was achieved through the use of Glyphosate (Roundup) as needed. MPCA, Chlorproham, Sencor, and/or Mobay SMY-1500 were used to control weeds during the wheat production period.

The subplot treatment consisted of four planting dates (Table 1). The hard red winter wheat, TAM W-101 (Triticum aestivum L.) was used throughout the study. Planting in 1982 was performed with a modified John Deere hoe drill. In 1983 and 1984, a Crustbuster double disk opener No-Till drill was utilized. A row spacing of 25 cm and a seeding rate of 67 kg $ha^{-1}$ was used in all three years of the study at both locations. Planting depth ranged from 2 cm to 4 cm depending on soil moisture conditions at the time of planting. The plot size was 7.6 by 22.9 meters at the Stillwater location and 7.6 by 38 meters at the Lahoma location.

Soil fertility was maintained by using the Oklahoma State University Soil Testing Lab indexes to determine the total amount of nitrogen, phosphorus, and potassium needed. These needs were met through broadcast application of nitrogen as Ammonium Nitrate (34-0-0) and potassium as Muriate of Potash (0-0-60) prior to planting. Phosphorus was applied in the rows at planting. Diamonium Phosphate (18-46-0) was the source in 1982 and 1984. In 1983, liquid 10-34-0 was used as a source of phosphorus. Rates used were designed to assure adequate nutrient availability recognizing differences may exist between tillage systems. Therefore, 100 kg $ha^{-1}$ N and 32 kg $ha^{-1}$ P were applied each year and potash was added where needed.

Excessive fall growth resulted in a need to remove some of the foliage from the early planted treatments. In the fall of 1983 the

August NT plots at Stillwater and all the August plots at Lahoma were clipped. In the fall of 1984, the August and September NT plots at Stillwater were clipped. Clipping was preformed with a Carter harvester at a height of 10 to 15 cm above the soil surface. The amount of dry material removed in the clipping process was calculated and its nitrogen content determined. Nitrogen fertilizer was then applied to the plots to replace the equivalent amount removed from that plot.

Heads per meter of row (H/M) were determined by randomly collecting two, one meter sections of row subsamples per plot. kernels per head (K/H) were determined using 10 single head subsamples randomly selected from each plot. Subsamples for determining grain yield (Yield) and 1000 kernel weight (KW) data were collected using a Gleaner A combine with a 3 meter header at both locations in 1983 and at the Lahoma location in 1984. In 1984, a small plot combine with a 1.5 meter header was used at the Stillwater location and at both locations in 1985. Grain yields were adjusted to a moisture content of 135 g $kg^{-1}$ and a test weight of 772.2 kg $m^{-3}$ each year.

The split plot analysis of variance procedure was used to determine the F values for heads per area, kernels per head, kernel weight and grain yield data. If the calculated F values were significant and no significant interaction existed the F Test was used to determine significance differences between tillage means and the Duncan Multiple Range Test was used to determine significant differences in the planting date means. If significant tillage by date interactions existed the procedure for split-plot design and analysis as outlined by Steel and Torrie (1960) was used.

## RESULTS AND DISCUSSION

Several treatments did not germinate and were replanted at a later date (Table 1). These treatments were eliminated from the analysis of the data. Also eliminated were the 1983-84 October CT and NT treatments at Lahoma and the August and September CT treatments at Stillwater for 1984-85. The two treatments at Lahoma were planted late due to wet conditions, and the two at Stillwater germinated and became established after sufficient precipitation occurred around mid-October.

The presence of a definite pattern with one tillage treatment having consistantly higher yields than the other did not develop. The CT yield was significantly larger than the NT in 1983-84 at Lahoma and in 1984-85 at Stillwater. The NT yield was significantly larger than the CT in 1982-83 at Stillwater (Tables 2 and 3). It can be seen from Table 3 that the trend for equal or higher yields in NT compared to CT also exist in 1982-83 and 1984-85 at Lahoma.

The date effect on yield was significant at both locations in all years of the study except for those at Stillwater for the 1982-83 crop year. The grain yields at both locations during the study followed the pattern of increased yields as the planting date was delayed from mid-August to mid-September and October. As the planting date was delayed from mid-October to mid-November, a yield decrease was observed. This pattern was also observed by Fenster et al. (1972).

The yields from the mid-September and October planting dates were consistently the highest with neither planting date having a definite yield advantage. There was no significant planting date by tillage interaction so the ideal planting date for both tillage systems appears to be the same. But, from the literature one would have expected the NT to have a yield advantage over the CT. Some likely reasons as to why the early planted NT treatments did not have higher yields may be disease and/or insect related. It may also be true that even though as repotred, the NT systems have lower seed zone soil temperatures and increased seed zone soil water compared to CT systems these differences are not sufficient to give the early planted NT winter wheat the yield advantave one would expect.

The yield components of H/M, K/H, and KW had significant ($P = 0.05$) tillage by date interactions. At Stillwater a significant interaction existed for H/M and K/H in 1983-84 (Table4). At a Lahoma significant interaction existed for HDMT in 1982-83 and for K/H and KW in 1984-85 (Table 5).

When significant interactions did not exist, the NT treatments had a significantly greater number of H/M in only one instance - that being at Lahoma in 1982-83. As with grain yield, the mid-September and October planting dates usually had the highest number of H/M.

The CT treatments always had a greater number of K/H than the NT treatments. This is also true of the KW except for Lahoma in 1984-85. In the treatments where NT had more H/M there seems to have been an adjustment in the K/H and KW values such that no significant increase in yields were realized. The values for the above yield components within a tillage followed the same trend as the grain yield data with September and October having the highest values. Therefore, it appears that the planting date yield differences were caused by the sum of all yield components not predominately any single yield component.

The results of this study indicate that the potential yield increase of NT monoculture winter wheat does not exist. The early seeded NT treatments had comparable yields to those of the early seeded CT treatments. But, they did not have yields that were significantly higher than the mid-September or mid-October NT or CT planted treatments.

The apparent trend for earlier emergence and establishment in the early seeded NT winter wheat compared to CT was fallowed by a trend for a greater number of heads per area by planting date. However, a trend for a greater number of heads per area in the early planting dates compared to the later planting dates did not appear to exists. This most likely was a contributing factor in the lower yields for the earlier planted treatments.

It therefore appears that the optimum planting date for maximum grain yield of winter wheat under either tillage system (CT or NT) is within the mid-September to mid-October planting dates of this study.

Table 1. Subplot Planting Dates for Stillwater (Swtr) and Lahoma (Lhma) for the Crop Years 1982-5.

| | August | | | September | | | October | | | November | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year | | | | | | | | | | | |
| Locn | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 | 82 | 83 | 84 |
| Swtr | --[1] | --[2] | 15 | 13 | 24 | 19 | 15 | 14 | 15 | 17 | 16 | 14 |
| Lhma | 24 | 16 | 16 | 14 | 23 | 18 | 19 | N2[3] | 15 | 16 | 15 | 15 |

1. Planted August 27 but did not germinate. Was replanted September 24, 1982.
2. Planted August 17 CT but did not germinate. Replanted the CT plots October 14, 1983.
3. Wet conditions forced the delay from Oct. 15 to Nov 2.

Table 2. Means for Heads per Meter of Row (H/M), Kernels per Head (K/H), Kernel Weight per 1000 (KW), and Grain Yield (Yield) by Tillage and Planting Date. Stillwater.

| Planting Date | H/M |  |  | K/H |  |  | KW |  |  | Yield |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | CT | NT | AVE | CT | NT | AVE | CT | NT | AVE | CT | NT | AVE |
|  |  |  |  |  |  | 1982-3 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm $1000^{-1}$-------- |  |  | ---------Mg $Ha^{-1}$-------- |  |  |
| 8/23 | --- | --- | --- | -- | -- | -- | ---- | ---- | ---- | ---- | ---- | ---- |
| 9/13 | 118 | 117 | 118c$^{+}$ | 22 | 22 | 22a | 24.7 | 25.5 | 25.1b | 2.58 | 3.11 | 2.85a |
| 10/15 | 159 | 153 | 156a | 22 | 20 | 21a | 32.4 | 31.4 | 31.9a | 3.50 | 3.47 | 3.48a |
| 11/17 | 142 | 132 | 137b | 20 | 20 | 20a | 29.3 | 31.8 | 30.6a | 3.10 | 3.14 | 3.11a |
| AVE | 140 | 134 | --- | 21 | 21 | -- | 29.6 | 28.8 | ---- | 3.05$^{*}$ | 3.24 | ---- |
|  |  |  |  |  |  | 1983-4 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm $1000^{-1}$-------- |  |  | ---------Mg $Ha^{-1}$-------- |  |  |
| 8/15 | --- | 210 | ---$^{++}$ | -- | 22 | --$^{++}$ | ---- | 28.1 | ---- | ---- | 3.37 | ---- |
| 9/24 | 195 | 250 | 222 | 26 | 22 | 24 | 32.9 | 29.0 | 31.0a | 4.42 | 4.29 | 4.36a |
| 10/24 | 194 | 219 | 292 | 28 | 21 | 24 | 30.8 | 29.2 | 30.0a | 3.96 | 3.68 | 3.82ab |
| 11/16 | 136 | 116 | 126 | 26 | 30 | 28 | 31.1 | 31.4 | 31.2a | 2.79 | 2.42 | 2.61c |
| AVE | 174 | 196 | --- | 26 | 24 | -- | 31.6 | 29.4 | ---- | 3.72 | 3.44 | ---- |
|  |  |  |  |  |  | 1984-5 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm $1000^{-1}$-------- |  |  | ---------Mg $Ha^{-1}$-------- |  |  |
| 8/15 | --- | 169 | --- | -- | 24 | -- | ---- | 27.0 | ---- | ---- | 2.29 | ---- |
| 9/19 | --- | 130 | --- | -- | 24 | -- | ---- | 28.3 | ---- | ---- | 2.44 | ---- |
| 10/15 | 150 | 113 | 131a | 24 | 22 | 23b | 29.3 | 28.1 | 28.7a | 2.70 | 2.40 | 2.55a |
| 11/14 | 108 | 56 | 82b | 36 | 31 | 34a | 27.1 | 25.8 | 26.4a | 2.14 | .89 | 1.52b |
| AVE | 128 | 117 | --- | 30 | 25 | -- | ---- | 27.3 | ---- | 2.42$^{*}$ | 2.00 | ---- |

[*] Tillage means significant at the P = 0.05 level.

[+] Date means followed by different letters are significantly different at the P = 0.05 level as determined by the Duncan Multiple Range Test.

[++] Significant interaction exist.

LSD for tillage means within dates and date means within tillages for HDMT 1983-4 = 34.00.

LSD for tillage means within dates and date means within tillages for KNHD 1983-4 = 5.38.

Table 3. Means for Heads per Meter of Row (H/M), Kernels per Head (K/H), Kernel Weight per 1000 (KW), and Grain Yield (Yield) by Tillage and Planting Date. Lahoma.

| Planting Date | H/M |  |  | K/H |  |  | KW |  |  | Yield |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | CT | NT | AVE | CT | NT | AVE | CT | NT | AVE | CT | NT | AVE |
|  |  |  |  |  |  | 1982-3 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm 1000$^{-1}$-------- |  |  | ---------Mg Ha$^{-1}$-------- |  |  |
| 8/14 | 88 | 168 | 128[++] | 26 | 23 | 24a[+] | 30.7 | 30.1 | 30.4bc | 3.15 | 3.02 | 3.10a |
| 9/14 | 113 | 152 | 133 | 26 | 22 | 24a | 32.7 | 31.5 | 33.1a | 3.28 | 3.36 | 3.32a |
| 10/19 | 96 | 117 | 108 | 26 | 21 | 24a | 30.9 | 32.2 | 31.5ab | 2.64 | 2.84 | 2.74b |
| 11/16 | 91 | 121 | 106 | 24 | 20 | 22a | 29.6 | 30.2 | 29.9c | 2.42 | 2.84 | 2.63b |
| AVE | 97 | 140 | --- | 25 | 22 | -- | 31.0 | 31.0 | ---- | 2.87 | 3.02 | ---- |
|  |  |  |  |  |  | 1983-4 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm 1000$^{-1}$-------- |  |  | ---------Mg Ha$^{-1}$-------- |  |  |
| 9/16 | 134 | 154 | 144b | 22 | 21 | 22a | 17.0 | 14.0 | 15.5b | 3.02 | 2.95 | 2.98b |
| 10/23 | 177 | 168 | 173a | 19 | 18 | 18a | 21.8 | 16.5 | 19.1a | 3.64 | 2.79 | 3.21a |
| 11/2 | --- | --- | --- | -- | -- | -- | ---- | ---- | ---- | ---- | ---- | ---- |
| 11/15 | 140 | 101 | 121b | 22 | 21 | 21a | 16.2 | 15.1 | 15.6a | 2.23 | 2.16 | 2.20b |
| AVE | 150 | 141 | --- | 21 | 20 | -- | 18.3 | 15.6 | ---- | 2.96[*] | 2.63 | ---- |
|  |  |  |  |  |  | 1984-5 |  |  |  |  |  |  |
|  |  |  |  |  |  |  | ---------gm 1000$^{-1}$-------- |  |  | ---------Mg Ha$^{-1}$-------- |  |  |
| 8/16 | 124 | 128 | 126ab | 25 | 22 | 23[++] | 30.1 | 30.6 | 30.4[++] | 2.47 | 2.50 | 2.48b |
| 9/18 | 108 | 112 | 110b | 22 | 24 | 22 | 30.2 | 32.0 | 31.1 | 2.34 | 2.55 | 2.44b |
| 10/15 | 133 | 144 | 138a | 22 | 22 | 22 | 30.3 | 30.1 | 30.2 | 3.10 | 2.84 | 2.96a |
| 11/15 | 90 | 118 | 104b | 30 | 24 | 27 | 20.6 | 25.0 | 22.8 | 1.69 | 1.77 | 1.73c |
| AVE | 114 | 125 | --- | 25 | 23 | -- | 27.8 | 29.4 | ---- | 2.40 | 2.41 | ---- |

[*] Tillage means significant at the P = 0.05 level.

[+] Date means followed by different letters are significantly different at the P = 0.05 level as determined by the Duncan Multiple Range Test.

[++] Significant interaction exist.

LSD for tillage means within dates and date means within tillages for HDMT 1982-3 = 24.8.
LSD for date means within tillage for KNHD 1984-5 = 4.10.
LSD for tillage means within dates for KNHD 1984-5 = 19.65.
LSD for date means within tillage for KWTK 1984-5 = 7.34.
LSD for tillage means within dates for KWTK 1984-5 = 26.25.

Table 4. Analyses of Variance by Year for Heads per Meter of Row (H/M), Kernels per Head (K/H), Kernel Weight per 1000 (KW), and Grain Yield (Yield) Under Two Tillage Systems and Four Planting Dates. Stillwater.

| | | H/M | | K/H | | KW | | Yield | |
|---|---|---|---|---|---|---|---|---|---|
| Source | df | MS | PR>F | MS | PR>F | MS | PR>F | MS | PR>F |
| 1982-83 | | | | | | | | | |
| Till | 1 | 160 | .8179 | 2.04 | .4316 | 3.84 | .5312 | .2225 | .0462 |
| Error A | 3 | 2538 | .0015 | 2.49 | .7824 | 7.67 | .1307 | .0206 | .9602 |
| Date | 2 | 2946 | .0017 | 9.26 | .2962 | 103.42 | .0001 | .8151 | .0514 |
| Till*Date | 2 | 36 | .8700 | 3.04 | .6531 | 6.12 | .2045 | .1761 | .4598 |
| Error B | 12 | 258 | .0033 | 6.88 | .5842 | 3.37 | .0008 | .2124 | .1010 |
| 1983-84 | | | | | | | | | |
| Till | 1 | 1734 | .1550 | 20.17 | .1920 | 16.93 | .2530 | .4050 | .2945 |
| Error A | 3 | 484 | .4531 | 7.17 | .6575 | 8.50 | .2814 | .2523 | .4395 |
| Date | 3 | 14186 | .0001 | 30.78 | .1136 | 5.56 | .4564 | 4.3044 | .0001 |
| Till*Date | 2 | 2814 | .0175 | 64.66 | .0225 | 8.77 | .2668 | .0299 | .8937 |
| Error B | 15 | 525 | .0001 | 13.10 | .0747 | 6.07 | .2088 | .2643 | .0024 |
| 1984-85 | | | | | | | | | |
| Till | 1 | 7832 | .1472 | 49.00 | .0343 | 6.53 | .4024 | 2.4134 | .0025 |
| Error A | 3 | 2073 | .0583 | 3.57 | .6513 | 7.00 | .2523 | .0272 | .9522 |
| Date | 3 | 9839 | .0002 | 154.83 | .0001 | 8.56 | .1795 | 2.1355 | .0025 |
| Till*Date | 1 | 210 | .5744 | 6.25 | .3424 | .01 | .9722 | .9057 | .0789 |
| Error B | 12 | 630 | .0023 | 6.39 | .0003 | 4.45 | .1833 | .2457 | .0273 |

Table 5. Analyses of Variance by Year for Heads per Meter of Row (H/M), Kernels per Head (K/H), Kernel Weight per 1000 (KW), and Grain Yield (Yield) Under Two Tillage Systems and Four Planting Dates. Lahoma.

| | | H/M | | K/H | | KW | | Yield | |
|---|---|---|---|---|---|---|---|---|---|
| Source | df | MS | PR>F | MS | PR>F | MS | PR>F | MS | PR>F |
| 1982-83 | | | | | | | | | |
| Till | 1 | 14620 | .0119 | 108.80 | .0053 | .01 | .9793 | .1701 | .5028 |
| Error A | 3 | 486 | .2009 | 2.03 | .8089 | 6.97 | .0104 | .2943 | .0295 |
| Date | 3 | 1589 | .0069 | 9.69 | .2384 | 7.87 | .0062 | .8118 | .0003 |
| Till*Date | 3 | 1361 | .0127 | 2.67 | .8370 | 2.64 | .1614 | .1082 | .2810 |
| Error B | 18 | 284 | .0001 | 6.29 | .0217 | 1.37 | .0003 | .0784 | .0005 |
| 1983-84 | | | | | | | | | |
| Till | 1 | 532 | .0841 | 6.00 | .1727 | 43.30 | .3577 | .6418 | .0489 |
| Error A | 3 | 82 | .9369 | 1.89 | .9030 | 36.86 | .0067 | .0623 | .7314 |
| Date | 2 | 5453 | .0041 | 27.37 | .1065 | 27.00 | .0241 | 2.2794 | .0004 |
| Till*Date | 2 | 1697 | .0999 | .12 | .9877 | 10.19 | .2007 | .4061 | .0977 |
| Error B | 12 | 604 | .0578 | 10.08 | .5327 | 5.53 | .0146 | .1429 | .0105 |
| 1984-85 | | | | | | | | | |
| Till | 1 | 1024 | .5020 | 34.02 | .1344 | 21.58 | .2496 | .0025 | .8839 |
| Error A | 3 | 1768 | .0302 | 8.20 | .0952 | 10.63 | .0146 | .0978 | .3883 |
| Date | 3 | 1942 | .0221 | 34.78 | .0003 | 123.38 | .0001 | 2.0727 | .0001 |
| Till*Date | 3 | 246 | .6741 | 25.70 | .0016 | 8.18 | .0350 | .0782 | .4837 |
| Error B | 18 | 474 | .0061 | 3.32 | .0005 | 2.30 | .0001 | .0918 | .0003 |

# LITERATURE CITED

Blevins, R.L., Doyle Cook, S.H. Phillips, and R.E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

Ciha, A.J. 1982. Yield and yield components of four spring wheat cultivars grown under three tillage systems. Agron. J. 74:317-320.

Cochran, V.L., L.F. Elliott, and R.I. Papendick. 1982. Effect of crop residue management and tillage on water use efficiency and yield of winter wheat. Agron. J. 74:929-932.

Conservation Tillage Information Center. 1984. 1983 National survey conservation tillage practices. Conservation Tillage Information Center. Ft. Wayne IN.

Darwinkel, A., B.A. Ten Hag and J. Knizenga. 1977. Effect of sowing date and seeding rate on crop development and grain production of winter wheat. Neth. J. Agric. Sci. 25:83-94.

Davidson, J.M. and P.W. Santelmann. 1973. An evaluation of various tillage systems for wheat. Okla. Agric. Exp. Stn. Bull. B-711.

Fenster, C.R., M.G. Boosalis, and J.L. Wirhing. 1972. Date of planting studies of winter wheat and winter barley in relation to root and crown rot grain yields and quality. Nebr. Agric. Exp. Stn. Research Bull. 250.

Fenster, C.R. and G.A. Peterson. 1979. Effects of no-tillage fallow as compared to conventional tillage in a wheat-fallow system. Nebr. Agric. Exp. Stn. Bul. 289.

Fenster, C.R. and G.A. Wicks. 1982. Fallow systems for winter wheat in western Nebraska. Agron. J. 74:9-13.

Johnson, Wendell C. and Ronald G. Davis. 1980. Yield-water relationships of summer-fallowed winter wheat a precision study in the Texas panhandle. USDA-ARR-S-5/July.

Knapp, W.R. and J.S. Knapp. 1978. Response of winter wheat to date of planting and fall fertilization. Agron. J. 70:1048-1053.

Lafever, H.N. and L.G. Campbell. 1977. Timely winter wheat seeding important for top yields, 56-59. In Ohio Report August. 1977.

Owensby, C.E. 1973. Modified step-point system for botanical composition and basal cover estimates. J. Range Manage. 26:302-303.

Russelle, M.P. and F.E. Bulton. 1980. Soil temperature effects on winter wheat and winter barley emergence in the field. Agron. J. 72:823-827.

Smika, D.E. 1983. Soil water changes as related to position of wheat straw mulch on the soil surface. Soil Sci. Soc. Am. J. 47:988-991.

Smika, D.E. and R. Ellis Jr. 1971. Soil temperature and wheat straw mulch effects on wheat plant development and nutrient concentration. Agron. J. 63:388-391.

Steel, Robert G.D. and James H Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York.

Tanaka, D.L. 1985. Chemical and stubble-mulch fallow influences on seasonal soil water contents. Soil Sci. Soc. Am. J. 49:728-733.

Unger, Paul W. 1978. Straw-mulch rate effects on soil water storage and sorghum yield. Soil Sci. Soc. Am. J. 42:486-491.

Wicks, G.A. and D.E. Smika. 1973. Chemical fallow in a winter wheat-fallow rotation. Jour. of The Weed Sci. Soc. of Am. 21(2):97-102.

# CHAPTER VI

## RESULTS AND DISCUSSION

The plots at both locations were initially established under less than ideal conditions. Both locations were in wheat during the 1981-82 crop year. The areas where the research was established had a severe infestation of giant ragweed (Ambrosia trifida, L.) and rough pigweed (Amaranthus retroblesus L.). In 1982, the Stillwater area was mowed with a rotary mower instead of being harvested with a combine. This caused a severe volunteer problem in the 1982-83 August planting date which necessitated replanting it in late September of 1983. The weed problems and the manner of harvesting left the soil with minimal residue cover on the no-till (NT) plots at Stillwater. The plot area at Lahoma was harvested late in the season. The soil water content in the NT plots at both locations during the first year of the study showed the effect of the weed growth through the normal fallow period as discussed in Chapter IV.

During the second and third years of the study weed control through the fallow period was good to excellent and the residue at harvest (Table 1) remained on the NT plots during the fallow period being disturbed only by the drill at the time of planting. It is felt that the presence of this residue allowed for an increase in the seed zone soil moisture (Table 2) in the NT plots when compared to the conventional tillage (CT) plots at the time of planting for the early planting dates. Similar differences between NT and CT seed zone soil water contents were reported by Smika (1976). Because of precipitation prior to or immediately after planting in October and November this difference in seed zone soil water was not present in these planting dates.

The differences in soil water content (SWC) along with the reported lower soil temperatures in NT compared to CT (Russel and Bulton 1980) may have lead to the differences in plant emergences between NT and CT treatments for the August planting as reported in Table 3. Reddy et al. (1985) reported that a soil temperature 26 °C can cause a delay in germination due to the effect of temperature on seed dormancy. Therefore, the lower plant counts in the CT may have been due to less SWC and/or higher soil temperature. It should be noted, however, that the significantly larger number of plants emerged within tillage by date treatments did not translate into increased yield (see Tables 3 and 4 of Chapter V). This is a result of the wheat plant's ability to compensate.

The delayed emergence also did not seem to be a factor related to the decrease in forage production through early jointing (Table 4). In fact, the delay seems to have resulted in increased forage production through early jointing as is evidenced by the values for the August and September CT treatments for 1984-85. One might argue that the fall clipping of the 1983 August NT and 1984 August and September NT treatments at Stillwater and the 1983 August CT and NT treatments at Lahoma had a negetive effect on future growth and yield of the plants in those plots. But, based on the results of Dunphy et al. (1982) the removal of the fall growth from the early planted plots in 1983 and 1984 should have no significant effect on yield. In that excessive growth necessitated the above clipping it is apparent that an increase in fall foliage can be realized with early planting of winter wheat when comparing NT to CT. In 1983 when both the CT and NT August treatments at Lahoma were clipped, the NT treatments produced 2.3 mg $ha^{-1}$ DM and the CT 1.4 mg $ha^{-1}$. When the other early planted NT treatments were clipped, the comparable CT treatments did not have sufficient growth to warrant their being clipped.

Neither the planting date nor the method of tillage seemed to have a significant effect on the heading date where heading date was defined as the time when one-half of the heads were fully extended above the flag leaf.

It appears that over the three years the study was conducted the method of tillage played only a minor role in plant development and yield. The major differences in these parameters occurred between planting dates. The method of tillage did however have a major effect on profile soil water content (PSW) and soil water content (SWC). As discussed in Chapter IV, PSW and SWC became significant by tillage at Lahoma. This difference in PSW and SWC by tillage did not appear to be a yield limiting factor during the duration of the study. Since these growing seasons had near normal precipitation, it appears that water may not be as limiting a factor in winter wheat yields as once thought, except in years of unusual distribution and/or below normal precipitation.

# RECOMENDATIONS FOR FUTURE RESEARCH

The earlier and more uniform emergence and the increased fall growth in the NT treatments compared to the CT treatments for the early planting dates did not produce the expected increased foliage through early jointing nor grain yield. The lack of foliage and grain in the NT treatments when compared to the CT treatments is most likely not related to a lack of soil water. This is evidenced by the fact that the NT at Lahoma consistantly had significantly higher PSW than the CT treatments. Therefore research in the following areas is warranted.

1. What factors are affecting growth and development of the early planted NT winter wheat compared to early planted CT winter wheat between emergence and fall dormancy.
2. Is spring regrowth initiated earlier in CT compared to NT winter wheat such that more foliage is produced under CT conditions in the spring. If so what is the major influence, seed zone soil temperature, leaf zone air temperature, solar radiation, or a combination of these?
3. Is florial initiation earlier or later in CT compared to NT thus causing a difference in the time available for spring vegative growth.

Table 1. Residue (straw) Remaining in the Field at Harvest.

| Planting Date | Stillwater 1983 | Stillwater 1984 | Stillwater 1985 | Lahoma 1983 | Lahoma 1984 | Lahoma 1985 |
|---|---|---|---|---|---|---|
| | Mg $Ha^{-1}$ | | | | | |
| Aug. | ---+ | 4.4a | --- | 7.8a | 6.2a | 5.7a |
| Sept. | 4.8b* | 6.1a | --- | 7.2a | 8.1a | 4.2b |
| Oct. | 6.6a | 4.9a | 5.7a | 4.2b | --- | 6.0a |
| Nov. | 5.2b | 4.1a | 4.5a | 4.3b | 5.6a | 5.4a |

+ Treatments did not germinate and were replanted at a later date or were planted unusually late.

* Date means followed by different letters are significantly different at the P = 0.05 level as determined by the Duncan Multiple Range Test.

Table 2. Soil Moisture at Planting. Stillwater 1984.

| Depth (cm) | August CT | August NT | September CT | September NT |
|---|---|---|---|---|
| | % by weight | | | |
| 0-5 | 4.3 | 11.6* | 3.3 | 11.9* |
| 6-15 | 10.3 | 12.9 | 10.1 | 11.7 |
| 0-15 | 6.7 | 12.4* | 7.9 | 11.7* |

* Tillage means are sighificantly different at the P = 0.05 level.

Table 3. Number of Plants Emerged at Two Weeks After Planting by Year and Location.

| | 1982 | | | 1983 | | | 1984 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stillwater | | | | | | | | |
| | CT | NT | MEAN | CT | NT | MEAN | CT | NT | MEAN |
| AUG. | -- | -- | --[++] | -- | -- | --[++] | -- | 11 | --[++] |
| SEPT. | 35 | 20 | 27 | 25 | 27 | 26 | -- | 18 | -- |
| OCT. | 28 | 31 | 29 | 16 | 19 | 18 | 35 | 37 | 36 |
| NOV. | 31 | 33 | 32 | 23 | 11 | 17 | 26 | 13 | 19 |
| MEAN | 31 | 28 | -- | 22 | 19 | -- | 30 | 20 | -- |
| | Lahoma | | | | | | | | |
| AUG. | 19 | 34 | 26a[+] | 24 | 20 | 22b | 30 | 29 | 30[++] |
| SEPT. | 17 | 30 | 23ab | 25 | 33 | 29a | 29 | 27 | 28 |
| OCT. | 14 | 29 | 21ab | -- | -- | -- | 36 | 40 | 38 |
| NOV. | 16 | 20 | 18b | 22 | 24 | 23ab | 16 | 31 | 24 |
| MEAN | 16 | 28* | -- | 24 | 26 | -- | 28 | 32 | -- |

* Tillage means significant at the P = 0.05 level.

[+] Date means followed by different letters are significantly different at the P = 0.05 level as determined by the Duncan Multiple Range Test.

[++] Significant interaction exist.

LSD for tillage values within dates and date values within tillage for Stillwater 1982 = 15.9, 1983 = 11.5, and 1984 = 9.5.

LSD for tillage values within dates and date values within tillage for Lahoma 1984 = 10.0.

Table 4. Forage Production Through Early Jointing.

| | Stillwater | | | | Lahoma | | | |
|---|---|---|---|---|---|---|---|---|
| | 1984 | | 1985 | | 1984 | | 1985 | |
| | CT | NT | CT | NT | CT | NT | CT | NT |
| | Mg Ha$^{-1}$ | | | | | | | |
| Aug. | 2.50 | 2.96 | 3.84 | 2.36 | 2.69 | 3.59 | 1.59 | 1.85 |
| Sept. | 2.02 | 1.67 | 3.89 | 1.50 | 2.14 | 1.94 | 1.33 | 1.15 |
| Oct. | .64 | .57 | 2.31 | 1.08 | ---- | ---- | 1.59 | 1.60 |

* Replanted October 14, 1983.

\+ Did not germinate until late October.

++ Planting was delayed until November 2 due to wet field conditions.

# LITERATURE CITED

Dunphy, D.J., M.E. McDaniel, and E.C. Holt. 1982. Effect of forage utilization on wheat grain yield. Crop Sci. 22:106-109.

Reddy, L.V., R.J. Metzger, and T.M. Ching. 1985. Effect of temperature on seed dormancy of wheat. Crop Sci. 25:455-458.

Russelle, M.P. and F.E. Bulton. 1980. Soil temperature effects on winter wheat and winter barley emergence in the field. Agron. J. 72:823-827.

Smika, D.E. 1976. Seed zone soil water conditions with reduced tillage in the semiarid Central Great Plains. The Seventh Conference of the International Soil Tillage Research Organization, Sweden, 1976.

2

# VITA

William Frederick Heer

Candidate for the Degree of

Doctor of Philosophy

Thesis: SOIL WATER AVAILABILITY FOR SPRING GROWTH OF WINTER WHEAT (*Triticum aestivum* L.) AS INFLUENCED BY PLANTING DATE AND TILLAGE

Major Field: Agronomy - Soil Science

Biographical:

Personal Data: Born May 29, 1950, in Washington County, Colorado, the son of Mr. and Mrs. Conrad Heer.

Eduaction: Graduated from Sacred Heart High School, Sedalia Missouri, in May, 1968; received the Bachelor of Science degree from Central Missouri State University, Warrensburg, Missouri, in May, 1972; received the Master of Science degree from Central Missouri State University, Warrensburg, Missouri, in May 1974; Completed requirements for the Doctor of Philosophy degree in Agronomy - Soil Science at Oklahoma State University, Stillwater, Oklahoma, in October 1985.

Professional Experience: Assistant Dean of Men and Instructor, Central Missouri State University, Warrensburg, Missouri, 1975-1978; Instructor of Agriculture, Northeast Missouri State University, Kirksville, Missouri, 1978-1982; Graduate Research Assistant-Agronomy, Oklahoma State University, Stillwater, Oklahoma, 1982 to present.

Member: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.