EFFECT OF DELAYED NITROGEN FERTILIZATION ON CORN GRAIN YIELDS

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1997

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December 2006

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AKNOWLEDGEMENTS

I would like to express my gratitude to my advisor Dr. William Raun for his guidance, inspiration and caring. I express my appreciation to my thesis committee members: Dr. Art Klatt and Dr. John Solie for their wise suggestions and help during my graduate studies. Also I would like to thank Dr. Kyle Freeman for his leadership and encouragement. I am grateful to all the members of Soil Fertility project at Oklahoma State University: Brian Arnall, Brenda Tubaňa, Dr. Roger Teal, Dr. Kefyalew Desta, Kyle Lawles, Clint Mack, Byungkyun Chung, Starr Holtz, Pam Turner, Clint Dobson and Brandon England for their friendship and continuous support. I would also like to thank the Oklahoma State University faculty and staff for giving me the skills and the knowledge that I obtained during my study and work at the OSU. Also my thank you goes to my family: mom and dad - Elena and Claude Miller, my husband Stephen and my daughter Willow for their continuous love, support, encouragement and for believing in me. I am very excited to continue my graduate studies at Oklahoma State University and I am very grateful for this opportunity.

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ABSTRACT

Delaying nitrogen (N) fertilization until mid-season may increase nitrogen use efficiency (NUE), and can assist in determination of fertilizer N needed to achieve maximum grain yields based on the crop's yield potential. Previous research showed that corn yield potential can be accurately estimated mid-season using optical sensor measurements at V8. This study was conducted to determine if N fertilization can be delayed until mid-season without decreasing yields. Several combinations of preplant and sidedress N fertilizer applications at various growth stages were evaluated. Higher corn grain yields and NUE's were achieved with preplant N followed by mid-season sidedress at V6-V10 growth stages. Grain yields were decreased when no preplant N was applied and sidedress N was delayed until tasseling. Results suggest that preplant N followed by mid-season sidedress N application at or before V10 is recommended for corn giving a window of opportunity for N fertilization of 15 to 20 days.

CHAPTER I

INTRODUCTION

The typical world-wide Nitrogen Use Efficiency (NUE) reported by Raun and Johnson (1999) for most cereal crops including corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), sorghum (*Sorghum bicolor* L.), rye (*Secale cereale* L.), and millet (*Pennisetum glaucum* L.), is approximately 33% with estimated averages of 29% and 42% for the developing and the developed countries, respectfully. Such a low NUE reflects ineffective N management in agriculture and causes both great economic loss to producers and massive negative effect on the environment. On the global scale, the question of whether NUE can be increased above the average 33% becomes crucial considering the continuous pressure on agricultural producers to meet the demands of a rapidly growing population worldwide.

The highly intensive crop production worldwide results in large amounts of N being removed with the harvested grain, and, therefore, results in natural nutrient depletion year after year. On the other hand, one of the most harmful ecological problems, known to be caused by accelerated agriculture, is run-off from croplands. This results in deterioration of water quality and declining sea-life. One of the most difficult challenge researchers and crop producers face today is to sustain global food security, and minimize the negative impact of intense agriculture on the environment.

To improve fertilizer recommendations, it is necessary to determine the effects of the delayed N application and how long is it possible to delay N application for corn without compromising maximum grain yields. The following hypotheses were tested in this study. (i) NUE can be increased by delaying fertilizer N application to corn until later in the season without compromising grain yield; (ii) supplying all of the nitrogen to the established crop at V6 will enable corn to overcome the stress caused by nitrogen deficiency earlier in the season, when no preplant fertilizer is applied;

(iii) it is possible to achieve high yield with the minimum amount of preplant fertilizer followed by nitrogen application delayed until the V10 growth stage;

(iv) corn will fail to recover if no preplant fertilizer is applied and all of the nitrogen supplied to the crop at the V10 growth stage.

OBJECTIVES

The objectives of this study were to evaluate the effects of delayed N fertilization on corn grain yields (to determine the minimum preplant N needed to achieve maximum yields if sidedress N fertilizer is applied later in-season, and to determine how late in the growing season fertilizer N can be applied without decreasing corn grain yields).

CHAPTER II

LITERATURE REVIEW

Wittwer (1998) referred to crop production as “the world’s most important renewable resource”; to be able to sustain global food security, while using natural resources wisely and minimizing the negative impact of intense agriculture on the environment, represents, perhaps, the most difficult challenge which researchers and crop producers are facing today. As stated by Basra (1998), “crops stand between people and starvation” because cereal grains such as rice, wheat and corn supply the majority of calories (approximately 60%) and protein (50%) for human consumption.

One of the most harmful ecological problems, known to be caused by accelerated agriculture, is run-off from croplands. It results in deterioration of water quality and declining sea-life. The mean annual input of N as a result of fertilizer run-off (61% of which is due to nitrate N) to the Gulf of Mexico has tripled in the last 30 years (Goolsby et al., 2000). This illustrates the damaging effects of improper fertilizer management.

Highly intense crop production worldwide results in large amounts of N being removed with the harvested grain, and, therefore, causes natural nutrient supply of soils to deplete year after year. Maintaining the balance between N lost from the soil and naturally occurring N fixation is not possible, as it previously was, during the pre-chemical era. The use of slow-release organic fertilizers such as manure, application of green manure coupled with adoption of agricultural systems, such as crop rotation and intercropping, allowed for more efficient use of residual N (Joji Arihara National Agriculture Research Center, 2000).

As stated by Evans (1998), because of the need for continuous nutrient inputs to the soil, simply reducing the rates of N fertilizer used in agriculture would obviously prevent crop producers from achieving their major goal – higher yields. Therefore, creating the effective N management system and improving N recommendations and increasing NUE are critical issues, which should be addressed to maintain and increase the sustainability of crop production in the future.

The conventional practices historically used by most crop producers do not address the issue of successfully managing resources. Traditional approaches to fertilizing corn after harvest in the fall is still considered to be more advantageous by many crop producers because it enables them to better distribute their time and labor (Randal et al., 2003) and benefit from better soil conditions and lower fertilizer N prices at this time (Bundy, 1986; Randall and Schmitt, 1998). However, it is necessary to evaluate the risks imposed by fall post-harvest application versus spring application and split N fertilization (40% at planting followed by 60% mid-season).

Recently, Bruns and Abbas (2005) stated that application of full amounts of N fertilizer prior to planting may result in better economic returns than carrying out split N applications. They concluded that the economic loss due to decreased grain yield may be insignificant when compared to additional production costs associated with split fertilization, such as several trips to the field.

Aiming to determine how fertilizer N application timing effects corn grain yield, Torbert et al. (2001) found split and spring fertilization to increase yields compared to fall application. Significantly lower N uptake recorded for fall application (40-60 kgha^{-1}) compared with spring and split fertilization (90-105 kg ha^{-1}) could be explained because of leaching, erosion, and denitrification that are active during the fall-winter periods (Torbert et al., 2001).

According to Wells and Blitzer (1984) and Wells et al. (1992), the most efficient time for N application is at growth stage V6, when corn plants active development significantly increases N plant needs. Nitrogen uptake rate is known to be affected by many factors such as weather, planting date, and time of fertilizer application but is usually highest between V8 and V12 (Russelle et al. 1981). Fast development of corn plants during middle vegetative stage (growth stage V6 and later) results in maximum N uptake, meaning that even N-deficient corn should be able to respond to delayed N application (Binder et al., 2000).

Aldrich (1984), Olson and Kurtz (1982), Russelle et al. (1981), Stanley and Rhoads (1977), and Welch et al. (1971) all agree that the best practice in managing corn is the application of N fertilizer at the time (or near the time) when both the need for N and N uptake are maximum for corn plants because it promotes higher NUE by reducing denitrification, N immobilization and leaching processes.

Studies in winter wheat and soybean production showed similar results in some cases. Nelson et al. (1984) reported that supplying N to the soybean plant during the time of peak seed demand prevents premature senescence, and increases seed yield. Morris et al. (2005) found that the highest grain yield for winter wheat was achieved by application of N fertilizer to the established crop. Fertilization delayed until Feekes 5 enabled the crop to overcome N stress present earlier in the growing season and achieve maximum or near maximum yields (Morris et al. 2005).

Evaluating the impact of in-season fertilization of soybean, Barker and Sawyer (2005), found that, even though N fertilizer applied during reproductive stages increased plant N concentration, it did not result in increased grain N concentration, grain yield or grain quality.

Mixed and site-specific results of split N fertilization of corn indicate that more extensive data is needed to confirm or contradict the effectiveness of this method of corn fertilization. Miller et al. (1975) and Olson et al. (1986) evaluated the efficiency of in-season N application and concluded that both NUE and grain yields can be increased by delaying N fertilization for corn. Results of a seven-year study on timing of N application in corn and soybean production, conducted by Randall et al. (2003), demonstrated that the lowest grain yield was achieved by fall N application versus the highest grain yield with split N fertilization. Evaluation of the economic return for fall and split N application clearly showed advantages for split N application (\$166.70 $ha^{-1}year^{-1}$ for fall applied N; \$239.40 $ha^{-1}year^{-1}$ for split applied N) (Randall et al. 2003).

The effectiveness of split N applications is largely dependent on site-specific conditions such as soil properties and climate (Bundy 1986). Even though fall application of N can be acceptable for some soil types (medium-to-fine-textured soils) combined with specific climate conditions (low winter temperatures decrease nitrification), this early fertilization can cause decreased fertilizer-N effectiveness (10-15% less effective when compared with N fertilizer applied in spring)(Bundy 1986).

Vetsch and Randall (2004) found a significant difference in N recovery: 87% for spring N application compared with only 45% when N was applied in fall. Relative leaf chlorophyll measurements taken at different growth stages were not significantly different for fall and spring applied N. However, starting from growth stage V6, N deficiency was recorded for the plants fertilized in the fall (Vetsch and Randall, 2004).

A wide range of factors affects the decision about when is the best time to apply N fertilizer so that the crop will benefit the most. Among them are fertilizer rate, fertilizer type, method of application, climatic conditions, amount of residual nitrogen present in soil prior to fertilization, and the level of nitrogen deficiency imposed on the crop.

Evaluating corn grain yield response to N fertilizer applied at various rates and times, Schmidt et al. (2002) achieved a maximum grain yield by applying at least 130 kgha^{-1} of N fertilizer. Greater organic matter (OM) content did not decrease corn need in fertilizer N, since the fields with higher OM did not require less N to maximize grain yields. While corn grain yields varied depending on the rate of N applied, higher fertilizer rates did not necessarily increase availability of N to the plant and, consequently, increase grain yield. Schmidt et al. (2002) recommended sidedress application of N fertilizer during the growing season as a means to improve NUE.

In 1999, Ma et al. recorded the highest loss of N during the growing season at the location with the highest rate of N fertilizer applied; net gain of mineral N had occurred throughout the growing season at the check location where there was no N fertilizer applied. This showed that significant amounts of mineralized plant-available N can be contributed to the soil from the atmosphere via precipitation and dry deposition (Ma et al., 1999). Therefore, it is necessary to evaluate the amount of residual N present in soil by conducting a preplant soil test.

Blackmer et al., (1989) found that delaying N fertilization until mid-season allows for more accurate determination of crop need for N, and they suggested carrying out in-season soil test to avoid over application and minimize N loss.

One of the problems associated with the application of N later in the growing season is the suppression of corn grain yield due to N deficiency. Understanding the effects imposed to corn by delayed N application is extremely important for improvement of fertilizer recommendations because the effectiveness of delayed N application to corn is strongly dependent on the degree of N deficiency at that time (Binder et al., 2000). Lower grain yield was achieved by late fertilization of slightly N deficient corn; slight increase in yield was observed for severely deficient corn fertilized late in season, but the maximum yield was not achieved. Severely N-deficient corn showed high N response compared with less N-deficient corn, but did not result in higher grain yield (Binder et al., 2000).

Using chlorophyll meter readings, Varvel et al. (1997) calculated a SI (sufficiency index) to determine the appropriate timing for in-season N fertilization for corn. Nitrogen was applied when index values were below 95%. They further reported that maximum yields for corn could not be achieved by late in-season fertilization if sufficiency index values at V8 were below 90%. Therefore, the suggestion was made that N fertilization before V8 growth stage was critical for corn.

Scharf et al. (2002) found, that N fertilization even as late as stage V11 did not result in irreversible yield loss, even for corn showing very significant N stress. Delaying N application until growth stages V12 and V16 caused a loss of just 3% in grain yield. Scharf et al. (2002) concluded that the benefits of the delayed N fertilization in corn outweigh the risk of grain yield loss.

Evaluating NUE and N response in winter wheat production, Wuest and Cassman (1992) observed higher N recovery (55% to 80%) when fertilizer was applied mid-season compared to N recovery of 30% - 55% in the case of preplant N application.

Supplying only the necessary amount of N to satisfy the crop need at the specific fertilizer application time would result in lesser amounts of residual NO^-_3 in soil and, therefore, decrease the risk of N being lost from soil (Andraski et al. 2000).

Results from Solie et al. (1996) and Stone et al. (1996) show that on-the-go optical sensing and variable rate application are practical and reliable tools for determining optimum N rate, placement methods and timing of mid-season fertilization. They showed that it is possible to successfully address the issue of spatial variability present in the field by using sensors which measure light reflected of plant canopy and determine normalized difference vegetative index (NDVI). Precision sensing at high resolutions (one square meter) enables accurate prediction of yield potential and estimation of N fertilizer needed, increasing N uptake and decreasing the risk of N loss, and, therefore, increasing NUE (Stone et al. 1996).

Teal et al. (2006) showed that corn grain yield potential can be accurately estimated mid-season using NDVI at the V8 growth stage. There is a need to investigate whether sidedress N fertilization in corn can be delayed until mid-season without leading to irreversible grain yield loss.

CHAPTER III

MATERIALS AND METHODS

Experiments were conducted at three locations in 2005 and 2006: Stillwater Research Station near Lake Carl Blackwell (irrigated), OK, Efaw Research Farm (rainfed), near Stillwater, OK, and Haskell, OK at the Eastern Oklahoma Research Station (rainfed). A completely randomized block design with three replications was used to evaluate 14 treatments at all sites. Various combinations of preplant and sidedress N fertilizer applications at several growth stages (V6, V10, and VT) were evaluated to determine the optimum nutrient management strategy for corn production (Table 1). At all sites the size of the individual plots was 3.1 x 6.2 m with 3.1 m alleys.

Prior to planting, composite soil samples (0-15 cm) were collected from each site and analyzed for NO3-N, NH4-N, total N, organic C, P, and K. Preplant soil samples were taken on 03-30-05 at Efaw, on 04-04-05 at Haskell, and on 03-28-05 at Lake Carl Blackwell, and results are reported in Table 2. The summary of field activities for 2005 and 2006 cropping years is reported in Table 3.

In 2005, “Pioneer 33B51” variety was planted at Efaw and Lake Carl Blackwell, and “Triumph 1416Bt” at Haskell. In 2006, “Pioneer 33B51” was planted at all sites. The seeding rates were 59,280 plants ha^{-1} for the rainfed sites (Efaw and Haskell), and 74,100 plants ha^{-1} for irrigated site (at Lake Carl Blackwell) in 2005. In 2006, the seeding rates were 54,340 plants ha^{-1} at Efaw, 79,040 plants ha^{-1} at Lake Carl Blackwell, and 61,750 plants ha^{-1} at Haskell.

Preplant N fertilizer as ammonium nitrate (34% N) and urea (46%N) were broadcasted manually and incorporated into the soil at planting in 2005 and 2006, respectively. Sidedress fertilizer N was applied mid-season as urea ammonium nitrate (UAN) (28-0-0) in both years according to the treatment structure (Table 1). Sidedress N was applied along each row at the base of the plants in a continuous stream using 50-200 ml syringes. Preplant and sidedress N fertilization procedures, rates and actual amounts applied are summarized in Table 5. The center 2 rows from each 4-row plot were harvested with a Massey 8XP self propelled combine. Grain sub-samples were collected, oven-dried at 70 C for 72 hours and processed to pass a 106 µm (140 mesh screen) and analyzed for total N content using a Carlo Erba NA 1500 dry combustion analyzer (Schepers et al. 1989). Total N uptake (kg ha^{-1}) was determined by multiplying grain yield (kg ha^{-1}) by grain percent N. Nitrogen use efficiency was determined using the difference method (Varvel and Peterson, 1991).

Statistical analysis was performed using SAS for Windows (SAS, 2002). Analysis of variance (ANOVA) was used to evaluate the effect of treatments on grain yield and NUE. Multiple comparisons of treatment means were also evaluated. Linear and quadratic polynomial orthogonal contrasts were used to assess trends in grain yield to N fertilizer rates.

CHAPTER IV

RESULTS AND DISCUSSION

CROPPING YEAR 2005

GRAIN YIELD

EFAW

Grain yields responded to fertilizer N, giving a 2000 kg ha^{-1} increase from 90 kg N ha^{-1} when compared to the 0-N check (Treatments 1 and 2) (Table 4). At Efaw, when the sidedress N fertilizer rates were increased from 0 to 180 kg ha^{-1}, grain yields increased linearly regardless of the sidedress application timing (Treatments 1, 4, 5 vs 1, 6, 7 vs 1, 8, 9) (Table 4). Comparison of one time sidedress application at the three growth stages (V6, V10 and VT) with split application (half of total N applied preplant and the remaining half sidedressed at each respective growth stage) generally showed a significant increase in grain yield when N fertilizer was split applied (Treatments 4 and 14, 6 and 13, 5 and 10, 7 and 11, 9 and 12) (Table 4). In general, the highest grain yields at Efaw were obtained with split fertilization and higher total N application (Table 4). There were no statistically significant differences in grain yield associated with timing of sidedress fertilizer applications.

LAKE CARL BLACKWELL

Grain yields at Lake Carl Blackwell increased linearly with an increase in sidedress N fertilizer rate from 0 to 180 kg N ha^{-1} when sidedress applications were made at the V10 growth stage (Treaments 1, 6, and 7) (Table 4). When no preplant N was applied and the sidedress applications were made at V6 and VT stages, yields peaked at the 90 kg N ha^{-1} rate (Treatments 4, 5 vs 8, 9) (Table 4). At V6, plots with 90 kg N ha^{-1} yielded 647 kg ha^{-1} more than plots that received 180 kg N ha^{-1}. Similarly, when fertilization was delayed until the VT growth stage, application of 90 kg N ha^{-1} resulted in 1117 kg ha^{-1} additional yield compared with 180 kg N ha^{-1}.

The significant reduction in grain yields observed with higher N fertilizer rates may be explained by imbalance between vegetative biomass production and grain production. Preplant application of 90 kg N ha^{-1} followed by 90 kg ha^{-1} sidedress N at VT resulted in 3057 kg ha^{-1} more grain yield than the single 180 kg N ha^{-1} sidedress application (Treatments 12 and 9) (Table 4). Treatments with split applications at various growth stages also generally resulted in increased grain production at Lake Carl Blackwell.

At the fertilizer N rates evaluated, grain yields for treatments with sidedress applications at V6 were significantly higher ($p<0.05$) compared to those with delayed fertilization at the VT growth stage (Treatments 4, 5, 10, 14 vs 8, 9, 12) (Table 4). Overall, treatments where fertilizer N was applied earlier in the growing season (V6 growth stage) yielded more than treatments where sidedress N was delayed until tasseling (VT growth stage) (Figure 1).

HASKELL

Yield levels were low at this site and as such, response to N fertilization was more difficult to discern. However, preplant N applications demonstrated a linear response to applied N (Treatments 1, 2, and 3) (Table 4). Preplant applications, as well as fertilization earlier during the growing season, were important in grain production at Haskell in 2005. The highest yields were generally obtained with the application of 180 kg N ha^{-1} prior to planting with no additional sidedress fertilization and with the 90-90 split sidedressed at V6 (Treatments 3 and 10) (Table 4).

With the 180 kg N ha^{-1}, treatment that received 90 kg N ha^{-1}preplant and 90 kg N ha^{-1} at V6, yields were 4742 kg ha^{-1} and significantly superior ($p<0.05$) to applying all N at V6 (Treatments 10 and 5) (Table 4).

Grain yields gradually decreased from 4641 kg ha^{-1} (plots receiving all N preplant) to 4107 kg ha^{-1} (sidedress fertilizer applied at V6) to 3852 kg ha^{-1} (sidedress application at V10) to 3535 kg ha^{-1} (sidedress at VT) (Figure 2). Delaying fertilizer N application until the VT growth stage resulted in a significant reduction in grain yields compared to treatments that were fertilized at V6 growth stage (Figure 2) independent of the fertilizer rate.

NITROGEN USE EFFICIENCY

EFAW

The highest fertilizer N use efficiency of 48% was obtained at Efaw with 90 kg N ha^{-1} split applied (preplant plus sidedress at V10) (Treatment 13) (Table 5). The lowest NUE's were achieved for treatments that received no N preplant and where high rates of sidedress N were delayed until late mid-season (V10-VT growth stages) (Treatments 7 and 9) (Table 5). Since the need for fertilizer during crop establishment and rapid development was not satisfied earlier in the growing season, even the application of large amounts of N later on did not allow the crop to "catch up" and achieve maximum yields.

Increased NUE was generally observed with split fertilizer application compared to treatments that received all fertilizer N at one time (Treatments 13 vs 6, and 14 vs 4) (Table 5).

LAKE CARL BLACKWELL

The highest NUE of 96% was achieved for the treatment that received no N preplant and N applied early in the growing season, which allowed the crop to "catch up" and produce near maximum grain yields (Treatment 4) (Table 6). The lowest NUE was obtained for the treatment with no N applied preplant, and where sidedress was delayed until tasseling (VT growth stage), which also resulted in loss of potential grain yield (Treatment 9) (Table 6). This shows that fertilizer use efficiency is proportional to the achieved grain yield and gradually decreases with increased fertilizer rates applied.

In general, split fertilizer applications resulted in greater NUE's compared to treatments with no N preplant, and all fertilizer N applied mid-season. Consequently, NUE values for treatments with the total N rate of 90 kg ha^{-1} were 82% (no preplant) compared to 94% obtained with preplant followed by sidedress at the V10 growth stage (Treatments 6 and 13)(Table 6). When a total of 180 kg ha^{-1} fertilizer N was applied, 62% NUE was achieved with split fertilizer application, while only 39% NUE was observed when no N was applied preplant and all fertilizer was applied at VT growth stage (Treatments 12 and 9) (Table 6).

HASKELL

Greater NUE values were achieved when all fertilizer was supplied as preplant (27%) and with the split application when sidedress applied early in the growing season (V6 growth stage) (29%) (Treatments 2 and 14) (Table 7). However, since the application of higher N rates later in the season did not improve yields, the fertilizer N use efficiency was lower. The NUE values tended to gradually decrease with delayed N application, averaged over N rates (Figure 3).

Omitting preplant N and applying 90 kg N ha^{-1} sidedress at V10 resulted in significantly lower ($p<0.05$) NUE value (11%) compared to treatments with split application (18%) (Treatments 6 and 13) (Table 7).

CROPPING YEAR 2006

GRAIN YIELD

EFAW

A linear increase in grain yield was observed when sidedress N rates were increased from 0 kg ha^{-1} to 180 kg ha^{-1}, regardless of application timing (Treatments 1, 4, 5 vs 1, 6, 7 vs 1, 8, 9) (Table 8).

The highest grain yield of 7116 kg ha^{-1} was produced when N was split applied at V6 (Treatment 10) (Table 8). Another high-yielding treatment (6913 kg ha^{-1}) was where all fertilizer was supplied at 180 kg N ha^{-1} preplant (Treatment 3) (Table 8). Comparable grain yields of 6835 and 6813 kg ha^{-1} were obtained with split fertilization (sidedress at V6 and V10 growth stages, respectfully) (Treatments 14 and 13) (Table 8). This showed that although the response to fertilizer N was clearly present at Efaw, the 90 kg ha^{-1} rate was adequate to satisfy crop needs for N, but when split applied.

When a total of 90 kg N ha^{-1} was applied, significantly greater ($p<0.05$) grain yields (6835 kg ha^{-1}) were obtained by splitting N applications compared to only 5467 kg ha^{-1} for the treatment with no preplant N (Treatments 13 and 6)(Table 8).

LAKE CARL BLACKWELL

Statistical analysis indicated a quadratic relationship between N fertilizer rate and grain yield at Lake Carl Blackwell. A significant ($p<0.05$) reduction in grain yield was observed when fertilizer N was doubled. The magnitude of grain yield loss, however, was much larger in 2006, since plots that received 90 kg N ha^{-1} yielded more than twice as much (7482 kg ha^{-1}) than plots with 180 kg N ha^{-1} (3141 kg ha^{-1}) (Treatments 4 and 5)(Table 8).

Likewise, split fertilization resulted in significantly greater ($p<0.05$) grain yield compared to treatments that did not receive any N preplant, and all fertilizer was applied at V6 growth stage (Treatments 5 and 10) (Table 8). The amount of grain yield achieved with split applications was more than 2.5 times greater than that obtained with single sidedress fertilization.

HASKELL

At Haskell, no statistically significant differences in grain yields were observed regardless of N fertilizer rates and/or timing of sidedress application in 2006. Also, yields were generally lower in 2006 compared to the yields achieved in the previous growing season (Tables 4 and 8).

Yield levels were the lowest compared to any other site-year obtained in this study. No response to N fertilizer was observed at this location in 2006. The 0-N check plots that did not receive fertilizer N yielded more than most of the fertilized treatments, regardless of N rate and fertilizer timing (Treatments 1, 3, 4, and 12)(Table 8).

NITROGEN USE EFFICIENCY

EFAW

Greater NUE values were obtained at Efaw in 2006 via split fertilization (53%) of 90 kg N ha^{-1} compared to one time mid-season application at V10 (38%) (Treatments 13 and 6) (Table 9). A similar trend was apparent when fertilizer N was applied at 180 kg N ha^{-1}. Treatments receiving preplant N had significantly greater ($p<0.05$) NUE values than where fertilizer application was delayed until V10 (Treatments 11 and 7) (Table 9). Considerable variability existing within the field may explain the greater NUE value of 30% obtained with the later one time sidedress fertilization at VT compared to 28% NUE observed with split fertilization (Treatments 9 and 12) (Table 9).

Overall, sidedress application timing did not contribute significantly to differences in fertilizer N use efficiency at Efaw.

LAKE CARL BLACKWELL

Unlike 2005, method (split versus one time fertilization) of fertilizer application did not affect NUE (Table 10). However, treatments with no preplant N, and 90 kg N ha^{-1} applied at V6 produced the highest fertilizer N use efficiency of 68% (Treatment 4) (Table 10). The NUE's for treatments with no preplant N and high sidedress N (180 kg ha^{-1}) at V6 were only 11% (Treatment 5) (Table 10). This significantly lower ($p<0.05$) fertilizer N use efficiency is explained by the fact that much lower grain yields (3141 kg ha^{-1}) were obtained with 180 kg N ha^{-1} than with 90 kg N ha^{-1} (7482 kg ha^{-1}) (Treatments 5 and 4) (Table 8).

HASKELL

At Haskell, fertilizer N use efficiencies were extremely low in 2006 due to very low grain yields even for treatments with higher fertilizer N rates. Plots with highest NUE (only 6%) received 45 kg ha^{-1} fertilizer N preplant and another 45 kg ha^{-1} N at V6 (Treatment 14) (Table 11). These plots produced near maximum yields for this location in 2006 (Table 8). In general NUEs at this site were low, since grain N uptake in the check plot was high, thus limiting what could be interpreted from subtle treatment differences. Low NUE's can be explained by lack of crop's response to fertilizer N at this location in 2006.

GRAIN YIELD

Higher corn grain yields were generally achieved in the 2005 season compared to 2006 (Tables 4 and 8). Beneficial climatic conditions such as more abundant rainfall (509mm, 590mm, and 577mm for Efaw, Lake Carl Blackwell, and Haskell, respectively in 2005) compared to only 417mm, 380mm, and 412mm in 2006 for Efaw, Lake Carl Blackwell, and Haskell, respectively contributed to higher grain yields in 2005 cropping year, especially at the rainfed sites. Low levels of soil moisture at all sites (especially in 2006) both pre-season and during the growing season (Figures A-3, A-4, and A-5) resulted in moisture stress, which may have decreased N uptake. Higher soil and especially - air temperatures also decreased grain yields in 2006 (Table 3). Corn pollen is known to be sensitive to high temperatures (Hopf et al. 1992). Thus, heat stress present during most of 2006 cropping year may have affected pollination and grain development.

At Lake Carl Blackwell, even though the initial soil test N levels were higher than at the other two locations (Table 2), considerably higher grain yields were achieved during the first year of this study. As a result, smaller amounts of N were likely available in the soil in 2006, which may have influenced crop development and reflected lower grain production.

The statistical analysis of two years of data showed that both year and site location significantly affected grain yields at all three sites ($p<0.05$). No year-by-treatment or site-by-treatment interaction was found at any of the site-years (averages over site and year not reported).

Overall, grain yields responded to 90 kg N ha^{-1}. Split fertilizer applications generally resulted in higher grain yields at most sites. The increase in N fertilizer rate from 0 to 180 kg N ha^{-1} almost always led to greater grain yields (Tables 4 and 8).

Even though the obvious response to N fertilizer was observed comparing the 0-N check treatment, a significant decrease in yield was observed when N was increased from 90 to 180 kg N ha^{-1} at some sites. For instance, in both 2005 and 2006 cropping years, treatment 4 (no N preplant, sidedress N at 90 kg ha^{-1} applied at V6 growth stage) produced significantly higher grain yields versus treatment 5 (no N preplant, sidedress at 180 kg N ha^{-1} at the V6 growth stage) (Tables 4 and 8). Likewise, comparing treatments 8 and 9 at Lake Carl Blackwell in 2005, when the sidedress application was delayed until the VT growth stage, application of higher N fertilizer rates resulted in decreased grain yields (Table 4).

Generally, highest grain yields were achieved with preplant N fertilization followed by sidedress early in the growing season (growth stage V6). Therefore, when no preplant fertilizer N was applied, supplying sidedress N early in the growing season allowed for crop recovery. However, delaying N fertilizer applications until later growth stages (V10-VT) generally resulted in decreased grain yields when no preplant N was applied, meaning that the crop failed to recover from nitrogen stress and failed to “catch-up” and produce maximum grain yields.

NITROGEN USE EFFICIENCY

Statistical analysis showed that there was no year-by-treatment or site-by-treatment interaction associated with fertilizer N use efficiency for both cropping years. Higher NUE values were achieved in 2005 compared to the 2006 cropping year (Tables 5, 6, 7, 9, 10, and 11). The Lake Carl Blackwell site generally had higher NUE's than Efaw and Haskell in both years (Tables 5, 6, 7, 9, 10, and 11). Greater than average worldwide estimated NUE values were achieved during this study for two experimental sites: up to 53% at Efaw in 2005 (Table 5), and up to 96% at Lake Carl Blackwell in 2006 (Table 10). The lowest N use efficiencies were observed at Haskell in both years with extremely low NUE values in 2006 due to the low grain yield produced at this location regardless of the fertilizer N applied (Table 11). Nitrogen use efficiencies increased with mid-season fertilizer N applications and with preplant applications followed by sidedress N at or before the V10 growth stage.

Positive response to preplant fertilizer apparent for the majority of site-years is exemplified in higher NUE values achieved with split N fertilizer applications compared to treatments that received no preplant and a one-time fertilizer application mid-season. Overall, higher NUE's were achieved with mid-season (growth stages V6-V10) N fertilizer applications. Decreased NUE's were observed when sidedress N was delayed until tasseling and higher fertilizer N rates.

Application of preplant N followed by a mid-season sidedress fertilizer N application at or before the V10 growth stage is recommended for corn. Delaying N fertilization until mid-season supplies N at the time when the crops need for N and N uptake are at maximum, and thus facilitates more efficient N fertilizer use.

CHAPTER V

CONCLUSIONS

Results showed that NUE can be increased by delaying fertilizer N application to corn until V6-V10 growth stages without decreasing grain yield. At all site-years, when no preplant N was applied, and all fertilizer N was supplied at the V6 growth stage, corn was able to overcome the stress due to nitrogen deficiency earlier in the season (“catch-up”) and produce maximum or near maximum yields, especially when higher N rate was applied. Maximum or near maximum grain yields were achieved with 45 or 90 kg N ha^{-1} followed by sidedress N fertilization at the V10 growth stage for four out of six site-years. Finally, omitting the preplant and delaying sidedress N until the V10 growth stage resulted in decreased grain yields showing that corn failed to recover from the stress caused by nitrogen deficiency and was not able realize its yield potential. The results suggest that preplant N followed by mid-season sidedress N application at or before the V10 growth stage is recommended for corn. This provides a window of opportunity for sidedress N fertilizer application of approximately 15 to 20 days. Teal et al. (2006) showed that corn grain yield potential can be accurately predicted using NDVI at the V8 growth stage. The results of this study suggest that it is possible to delay sidedress N fertilization in corn until mid-season.

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TABLES

Table 1. Treatment structure for experiments conducted at Efaw, Lake Carl Blackwell, and Haskell, OK, 2005 - 2006.

Treatment	*Preplant N fertilizer application	†Sidedress N fertilizer application	
	N rate (kg ha $^{-1}$)	N rate (kg ha $^{-1}$)	Growth stage
1	0	0	-
2	90	0	-
3	180	0	-
4	0	90	V6
5	0	180	V6
6	0	90	V10
7	0	180	V10
8	0	90	VT
9	0	180	VT
10	90	90	V6
11	90	90	V10
12	90	90	VT
13	45	45	V10
14	45	45	V6

* Preplant N was applied as ammonium nitrate (34-0-0) in 2005 and as urea (46-0-0) in 2006.

† Sidedress N was applied as urea ammonium nitrate (28-0-0).

Table 2. Initial surface (0-15cm) soil chemical characteristics and classification at Efaw, Lake Carl Blackwell, and Haskell, OK, 2005.

Location	pH	NH_4-N	NO_3-N	P	K	Total N	Organic C
		mg kg $^{-1}$				g kg $^{-1}$	
Efaw	5.87	13.86	3.74	20.14	89.50	0.65	10.24
Classification: Easpur soil series: Fine loamy, mixed, thermic Fluventic Haplustolls							
Lake Carl Blackwell	5.63	28.40	4.35	45.10	144.00	0.76	9.87
Classification: Port-oscar silt loam (fine-silty, mixed, super active, thermic Cumulic Haplustolls)							
Haskell	6.11	22.85	2.17	25.33	61.00	0.75	8.93
Classification: Taloka silt loam (fine, mixed, thermic Mollic Albaqualf)							

* pH – 1:1 soil: water; K and P – Mehlich III; NH_4-N and NO_3-N – 2 M KCl, Total N and Organic C – dry combustion.

Table 3. Field activities including planting dates, seeding rates, cultivars, preplant soil sampling dates, preplant N fertilizer application dates, sidedress N fertilizer application dates, herbicide application dates and harvest dates, climatic data including rainfall, average air temperatures, and average soil temperatures for Efaw, Lake Carl Blackwell, and Haskell, OK, 2005 - 2006.

Cropping year 2005			
Field activity	Efaw	Lake Carl Blackwell	Haskell
Planting date	March 30	April 12	April 4
Cultivar	Pioneer 33B51	Pioneer 33B51	Triumph 1416Bt
Seeding rate (lb ac^{-1})	24,000	30,000	24,000
Preplant soil sampling date	March 30	March 28	April 4
Preplant N fertilization date†	March 30	March 28	April 4
Herbicide application date⁎	April 8	May 12	April 6
Sidedress N fertilization at V6‡	May 19	May 19	May 24
Sidedress N fertilization at V10‡	June 2	June 2	June 9
Sidedress N fertilization at VT‡	June 14	June 21	June 20
Harvest date	August 27	September 7	August 29
Rainfall (mm) *	509	590	577
Average air temperatures (C°)*	23	23	23
Average soil temperatures (C°)*	25	27	24

Cropping year 2006			
Field activity	Efaw	Lake Carl Blackwell	Haskell
Planting date	March 30	March 31	April 13
Cultivar	Pioneer 33B51	Pioneer 33B51	Pioneer 33B51
Seeding rate (lb ac^{-1})	22,000	32,000	25,000
Preplant N fertilization date†	March 30	March 31	April 13
Herbicide application date⁎	March 30	March 31	April 13
Sidedress N fertilization at V6‡	May 19	May 16	May 23
Sidedress N fertilization at V10‡	June 2	May 29	June 8
Sidedress N fertilization at VT‡	June19	June 12	June 21
Harvest date	September 1	August 18	August 31
Rainfall (mm)*	417	380	412
Average air temperatures (C°)*	25	24	27
Average soil temperatures (C°)*	26	27	26

† Preplant N fertilizer was applied as ammonium nitrate (34-0-0) in 2005 and as urea (46-0-0) in 2006. ‡ Sidedress N fertilizer was applied as urea ammonium nitrate (28-0-0). ⁎ Herbicide – Bicept II Magnum was applied at 930ml ha^{-1}. * Rainfall, average air and average soil temperatures for the period from planting through harvest.

Table 4. Treatment, preplant N, sidedress N, and mean grain yields and SED's for Efaw, Lake Carl Blackwell, and Haskell, OK, 2005.

Treatment	Preplant N	Sidedress N		Mean grain yield kg ha $^{-1}$		
	kg ha $^{-1}$		Growth stage	Efaw	LCB	Haskell
1	0	0	-	6187	8842	3029
2	90	0	-	8181	12862	4562
3	180	0	-	8546	13814	4720
4	0	90	V6	7570	14210	3889
5	0	180	V6	9049	13563	3279
6	0	90	V10	7691	12852	3537
7	0	180	V10	7970	13927	4168
8	0	90	VT	8175	12571	3483
9	0	180	VT	8433	11454	3401
10	90	90	V6	9104	14228	4742
11	90	90	V10	9144	14345	3730
12	90	90	VT	9056	14502	3720
13	45	45	V10	8543	13405	3973
14	45	45	V6	8272	13683	4519
*SED				679	759	476

* SED – Standard error of the difference between two equally replicated means.

Table 5. Treatment, grain N uptake, and NUE for Efaw, 2005.

Treatment	Preplant N	Sidedress N		Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$		Growth stage		
1	0	0	-	78	.
2	90	0	-	113	37
3	180	0	-	129	28
4	0	90	V6	110	35
5	0	180	V6	143	36
6	0	90	V10	111	35
7	0	180	V10	119	22
8	0	90	VT	113	37
9	0	180	VT	128	27
10	90	90	V6	143	35
11	90	90	V10	142	35
12	90	90	VT	139	33
13	45	45	V10	123	48
14	45	45	V6	116	41
*SED				12	9

* SED – Standard error of the difference between two equally replicated means.

Table 6. Treatment, grain N uptake, and NUE for Lake Carl Blackwell, 2005.

Treatment	Preplant N	Sidedress N	Growth stage	Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$				
1	0	0	-	106	.
2	90	0	-	181	81
3	180	0	-	201	53
4	0	90	V6	201	96
5	0	180	V6	207	56
6	0	90	V10	181	82
7	0	180	V10	210	58
8	0	90	VT	181	82
9	0	180	VT	176	39
10	90	90	V6	218	62
11	90	90	V10	222	64
12	90	90	VT	217	62
13	45	45	V10	195	94
14	45	45	V6	190	87
*SED				16	11

* SED – Standard error of the difference between two equally replicated means.

Table 7. Treatment, grain N uptake, and NUE for Haskell, 2005.

Treatment	Preplant N	Sidedress N	Growth stage	Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$				
1	0	0	-	39	.
2	90	0	-	63	27
3	180	0	-	63	14
4	0	90	V6	56	20
5	0	180	V6	48	6
6	0	90	V10	48	11
7	0	180	V10	61	12
8	0	90	VT	47	10
9	0	180	VT	52	7
10	90	90	V6	69	17
11	90	90	V10	55	9
12	90	90	VT	54	8
13	45	45	V10	55	18
14	45	45	V6	65	29
*SED				7	6

* SED – Standard error of the difference between two equally replicated means.

Table 8. Treatment, preplant N, sidedress N, and mean grain yields and SED's for Efaw, Lake Carl Blackwell, and Haskell, OK, 2006.

Treatment	Preplant N	Sidedress N		Mean grain yield kg ha $^{-1}$		
	kg ha $^{-1}$		Growth stage	Efaw	LCB	Haskell
1	0	0	-	3799	3001	3726
2	90	0	-	6343	6586	3079
3	180	0	-	6913	6405	2732
4	0	90	V6	5754	7482	2970
5	0	180	V6	6577	3141	3153
6	0	90	V10	5467	4141	3116
7	0	180	V10	6370	7468	3708
8	0	90	VT	5829	6158	3474
9	0	180	VT	6713	4868	3397
10	90	90	V6	7116	7971	3938
11	90	90	V10	6600	9073	3013
12	90	90	VT	6153	8127	2782
13	45	45	V10	6835	5579	3000
14	45	45	V6	6813	6094	3793
*SED				660	1983	463

* SED – Standard error of the difference between two equally replicated means.

Table 9. Treatment, grain N uptake, and NUE for Efaw, 2006.

Treatment	Preplant N	Sidedress N		Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$		Growth stage		
1	0	0	-	44	.
2	90	0	-	83	42
3	180	0	-	95	28
4	0	90	V6	78	37
5	0	180	V6	97	29
6	0	90	V10	79	38
7	0	180	V10	96	28
8	0	90	VT	86	46
9	0	180	VT	100	30
10	90	90	V6	105	34
11	90	90	V10	99	30
12	90	90	VT	95	28
13	45	45	V10	92	53
14	45	45	V6	90	51
*SED				10	8

* SED – Standard error of the difference between two equally replicated means.

Table 10. Treatment, grain N uptake, and NUE for Lake Carl Blackwell, 2006.

Treatment	Preplant N	Sidedress N	Growth stage	Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$				
1	0	0	-	40	.
2	90	0	-	84	49
3	180	0	-	98	33
4	0	90	V6	102	68
5	0	180	V6	53	11
6	0	90	V10	65	33
7	0	180	V10	112	38
8	0	90	VT	94	59
9	0	180	VT	78	20
10	90	90	V6	125	48
11	90	90	V10	132	50
12	90	90	VT	113	40
13	45	45	V10	85	48
14	45	45	V6	84	47
*SED				26	22

* SED – Standard error of the difference between two equally replicated means.

Table 11. Treatment, grain N uptake, and NUE for Haskell, 2006.

Treatment	Preplant N	Sidedress N	Growth stage	Grain N uptake, kg ha $^{-1}$	NUE, %
	kg ha $^{-1}$				
1	0	0	-	55	.
2	90	0	-	48	3
3	180	0	-	44	0
4	0	90	V6	46	0
5	0	180	V6	51	1
6	0	90	V10	48	0
7	0	180	V10	59	3
8	0	90	VT	53	2
9	0	180	VT	54	2
10	90	90	V6	61	5
11	90	90	V10	49	0
12	90	90	VT	46	1
13	45	45	V10	47	2
14	45	45	V6	58	6
*SED				7	3

* SED – Standard error of the difference between two equally replicated means.

FIGURES

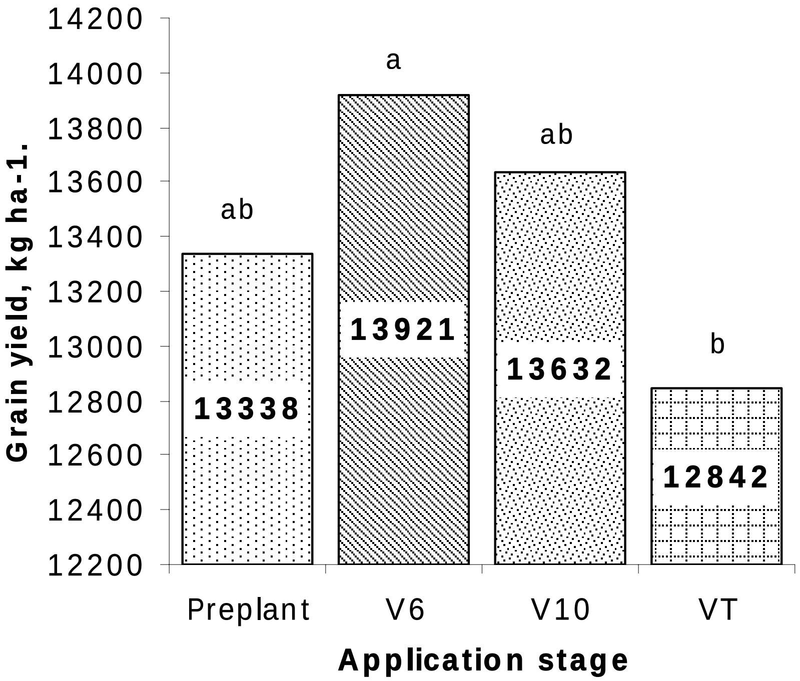

Figure 1. Grain yield as affected by time of fertilizer N application at Lake Carl Blackwell, 2005 averaged over N rates. Bars followed by the same letter were not significantly different at p<0.05 using Least Significant Difference (LSD) mean separation procedure.

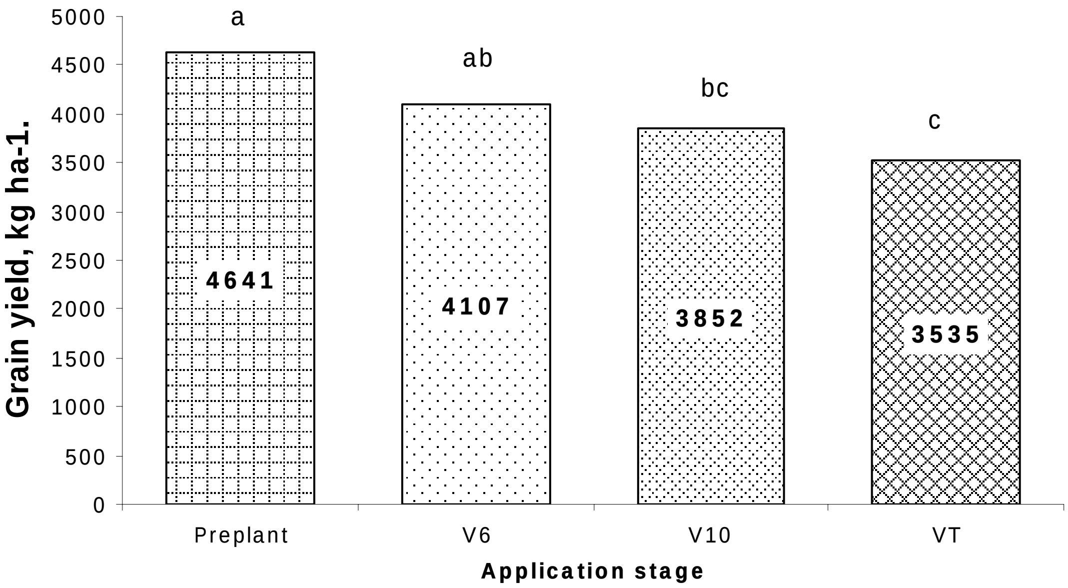

Figure 2. Grain yield as affected by time of fertilizer N application at Haskell, 2005. Bars followed by the same letter are not significantly different at p<0.05 using Least Significant Difference (LSD) mean separation procedure.

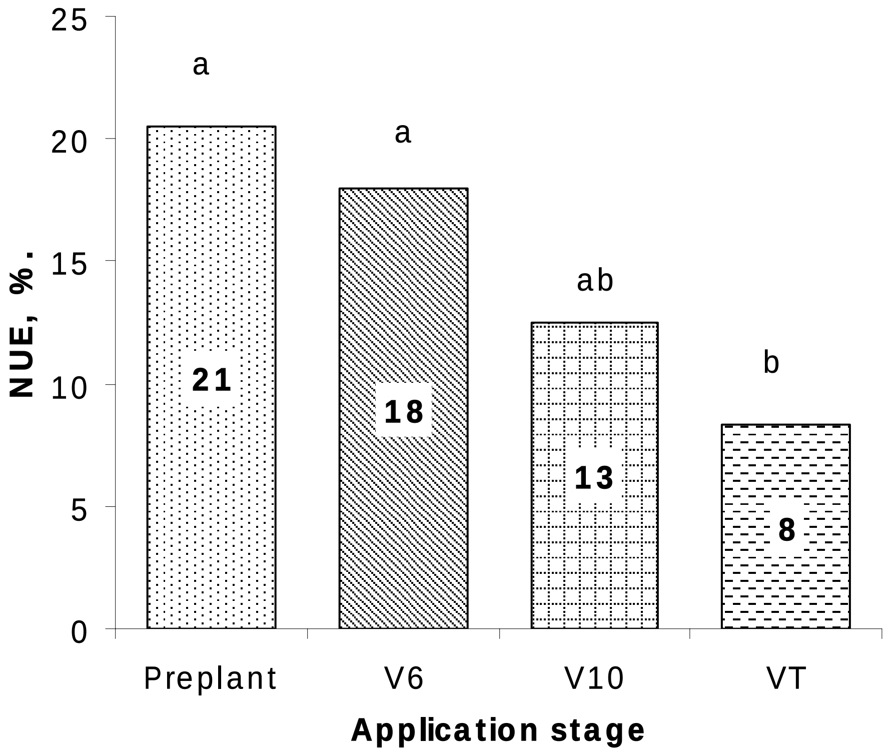

Figure 3. NUE as affected by time of fertilizer N application averaged over N rates applied at Haskell, 2005. Bars followed by the same letter are not significantly different at $p<0.05$ using Least Significant Difference (LSD) mean separation procedure.

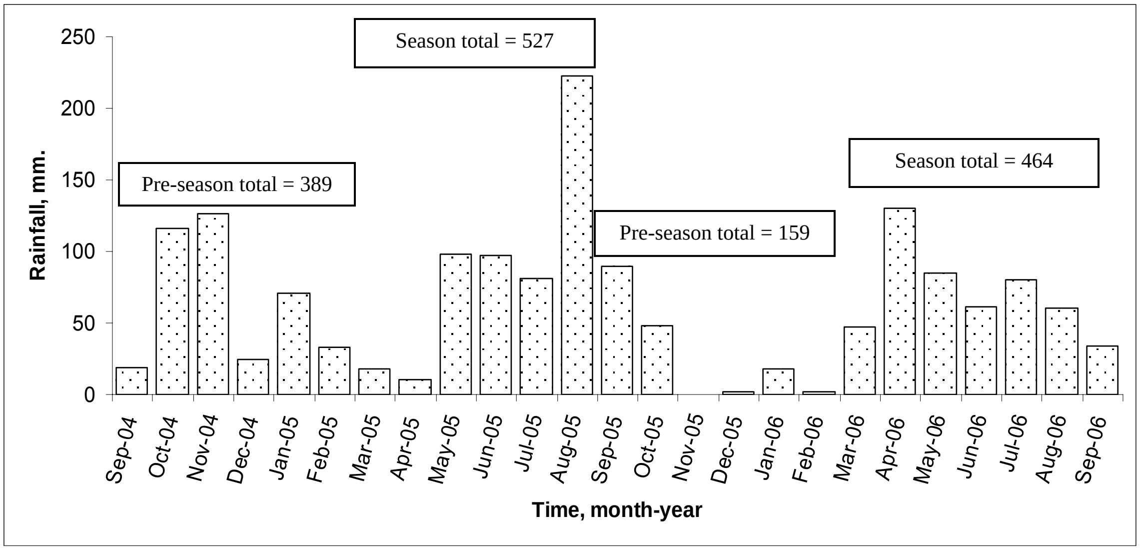

Figure 4. Total precipitation from September 2004 to September 2006 for Efaw, OK.

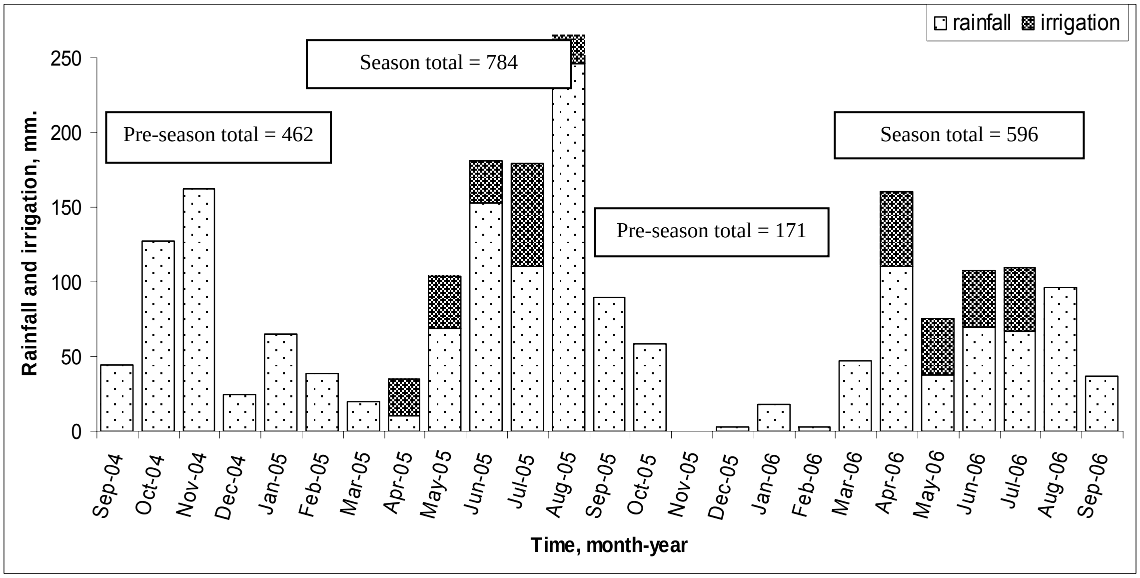

Figure 5. Total precipitation and irrigation applied from September 2004 to September 2006 for Lake Carl Blackwell, OK.

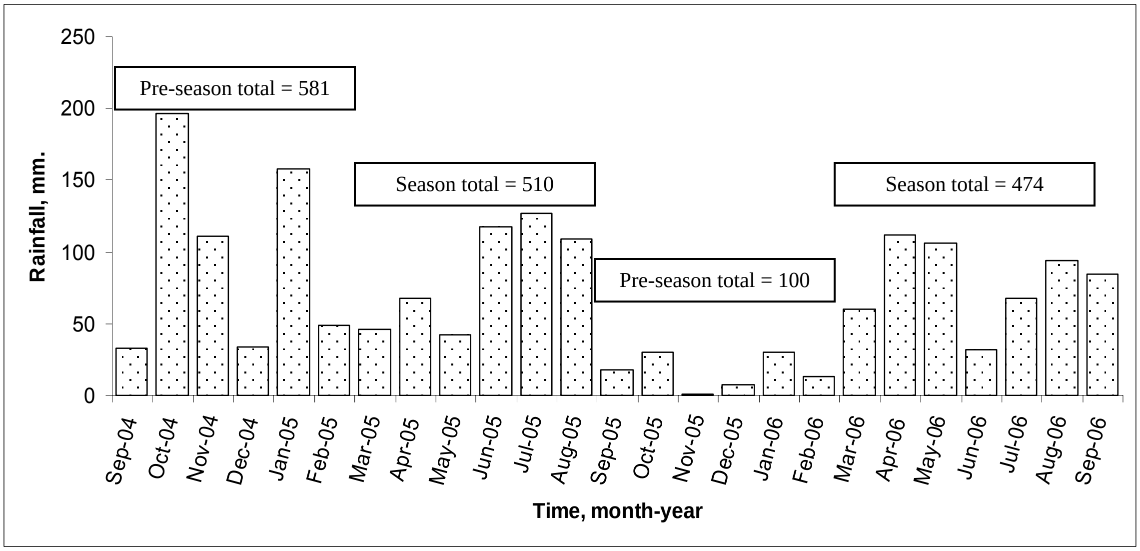

Figure 6. Total precipitation from September 2004 to September 2006 for Haskell, OK.

APPENDIX

Table A-1. Results of linear and quadratic polynomial orthogonal contrasts for grain yield at Efaw, Lake Carl Blackwell, and Haskell, 2005 and 2006.

Treatment	Cropping year 2005			Cropping year 2006		
	Location					
	Efaw	LCB	Haskell	Efaw	LCB	Haskell
Linear: sidedress at V6	***	***	ns	***	ns	ns
Quadratic: sidedress at V6	ns	***	p < 0.1	ns	*	ns
Linear: sidedress at V10	**	***	*	***	*	ns
Quadratic: sidedress at V10	ns	*	ns	ns	ns	ns
Linear: sidedress at VT	**	**	ns	***	ns	ns
Quadratic: sidedress at VT	ns	**	ns	ns	ns	ns
90 sidedress vs split at V6	ns	ns	ns	ns	ns	p < 0.1
90 sidedress vs split at V10	ns	ns	ns	*	ns	ns
180 sidedress vs split at V6	ns	ns	**	ns	*	ns
180 sidedress vs split at V10	p < 0.1	ns	ns	ns	ns	ns
180 sidedress vs split at VT	ns	***	ns	ns	ns	ns

* - Significant at $p< 0.05$; ** - Significant at $p< 0.01$;
*** - Significant at $p< 0.001$; $p < 0.1$ – Significant at $0.05<p<0.1$;
ns – Not statistically significant.

Table A-2. Results of orthogonal contrasts for NUE at Efaw, Lake Carl Blackwell, and Haskell, 2005 and 2006.

Treatment	Cropping year 2005			Cropping year 2006		
	Location					
	Efaw	LCB	Haskell	Efaw	LCB	Haskell
90 sidedress vs split at V10	*	*	*	*	ns	ns
180 sidedress vs split at V6	ns	ns	ns	ns	ns	ns
180 sidedress vs split at V10	ns	ns	ns	*	ns	ns
180 sidedress vs split at VT	ns	*	ns	*	ns	ns

* - Significant at $p< 0.05$; ** - Significant at $p< 0.01$;
*** - Significant at $p< 0.001$; $p < 0.1$ – Significant at $0.05<p<0.1$;
ns – Not statistically significant.

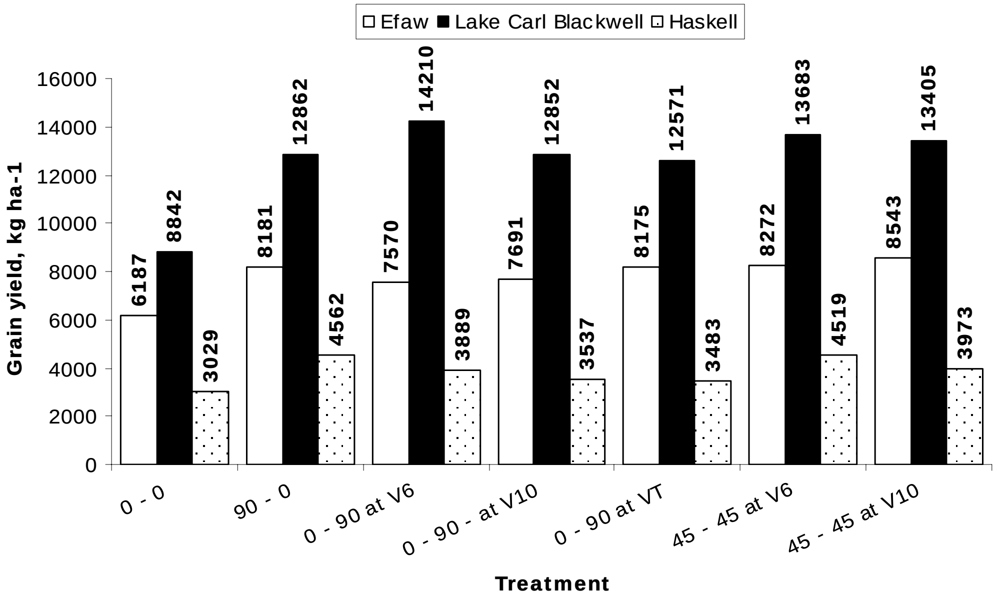

Figure A-1. Grain yield as affected by N fertilizer application timing (total 90 kg ha^{-1}) at Efaw, Lake Carl Blackwell, and Haskell, 2005.

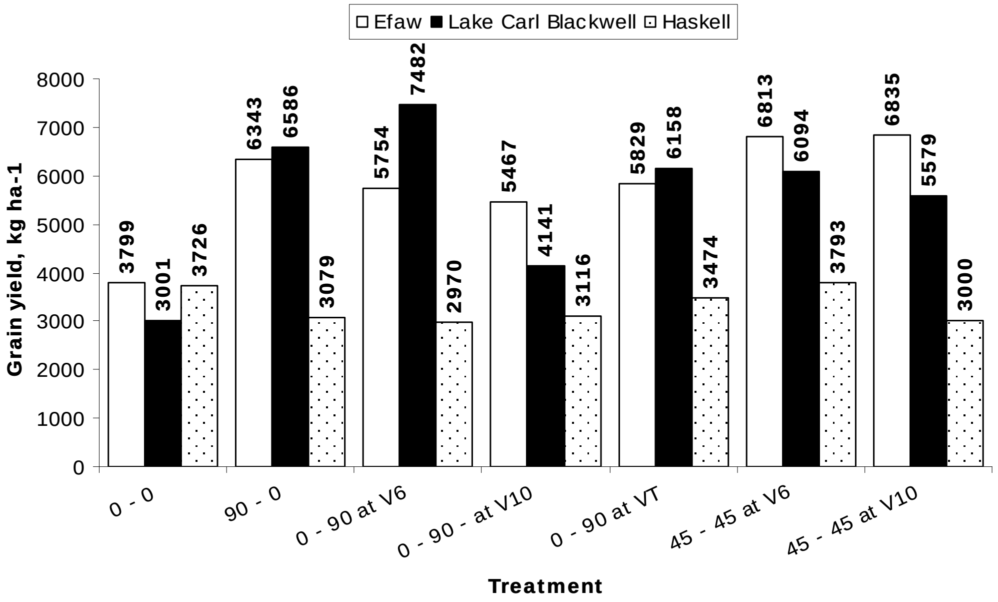

Figure A-2. Grain yield as affected by N fertilizer application timing (total 90 kg ha^{-1}) at Efaw, Lake Carl Blackwell, and Haskell, 2006.

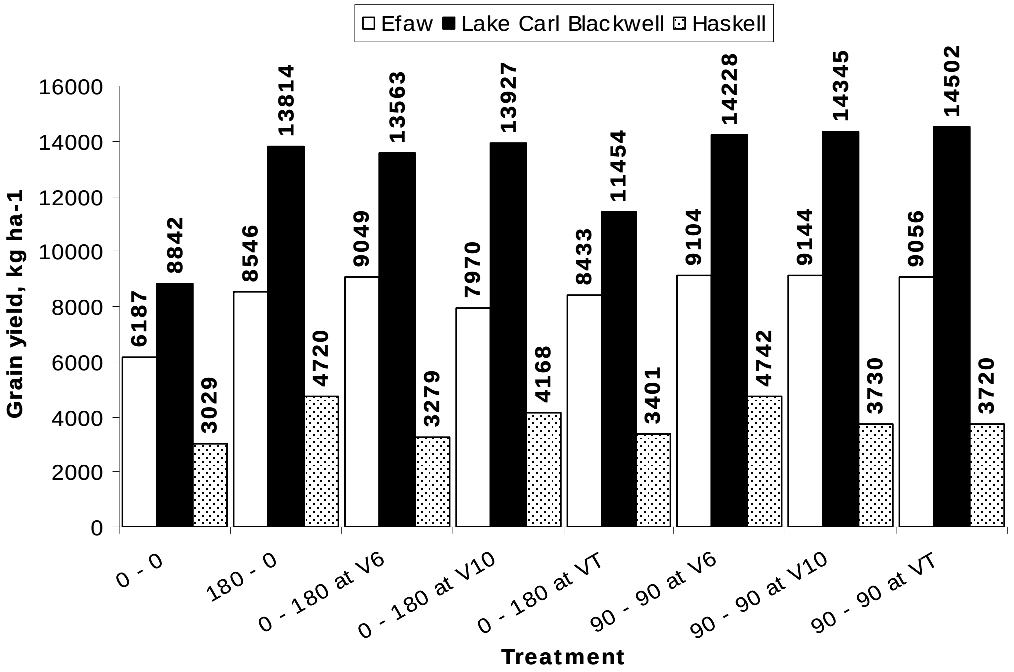

Figure A-3. Grain yield as affected by N fertilizer application timing (total 180 kg ha^{-1}) at Efaw, Lake Carl Blackwell, and Haskell, 2005.

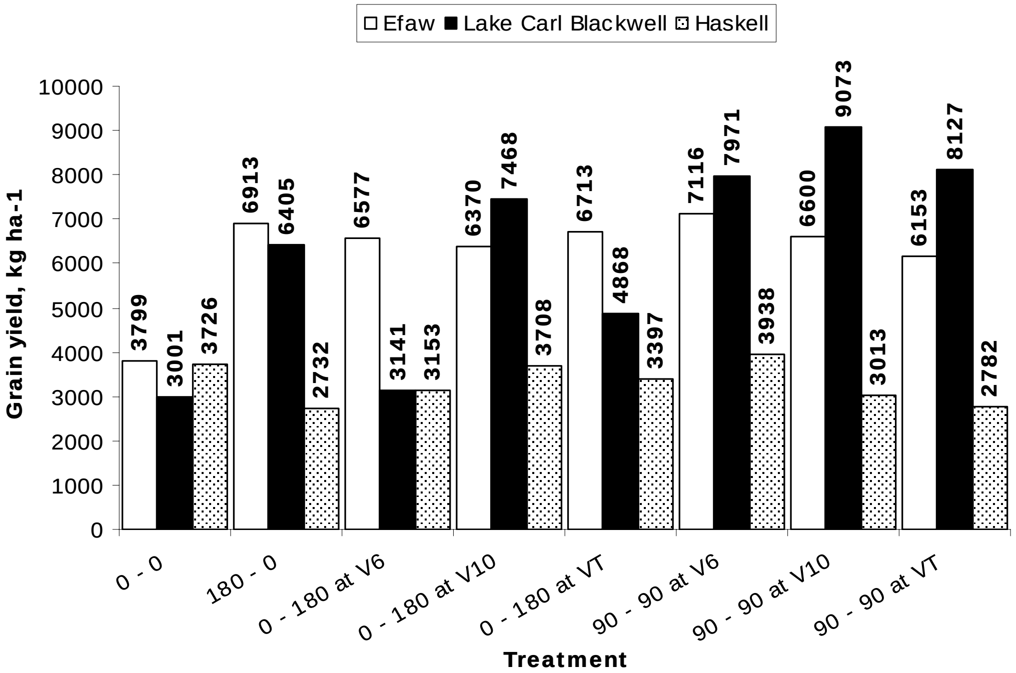

Figure A-4. Grain yield as affected by N fertilizer application timing (total 180 kg ha^{-1}) at Efaw, Lake Carl Blackwell, and Haskell, 2006.

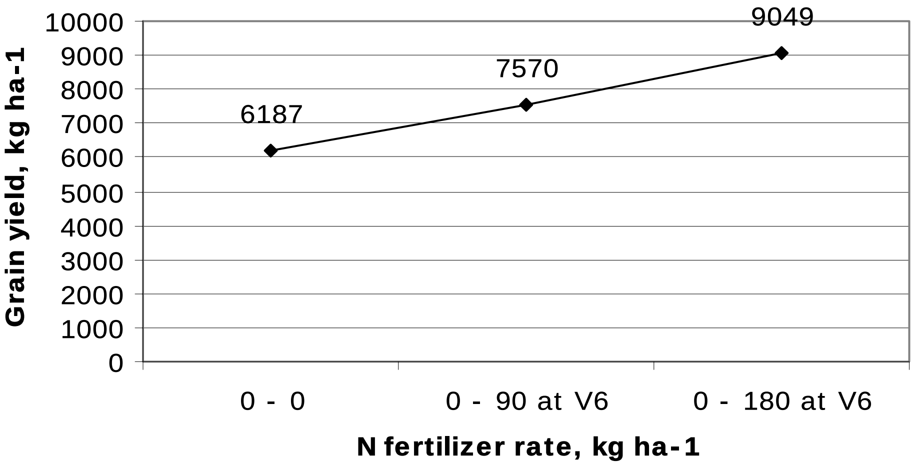

Figure A-5. Grain yield as affected by sidedress N fertilizer rate applied at V6 at Efaw, 2005.

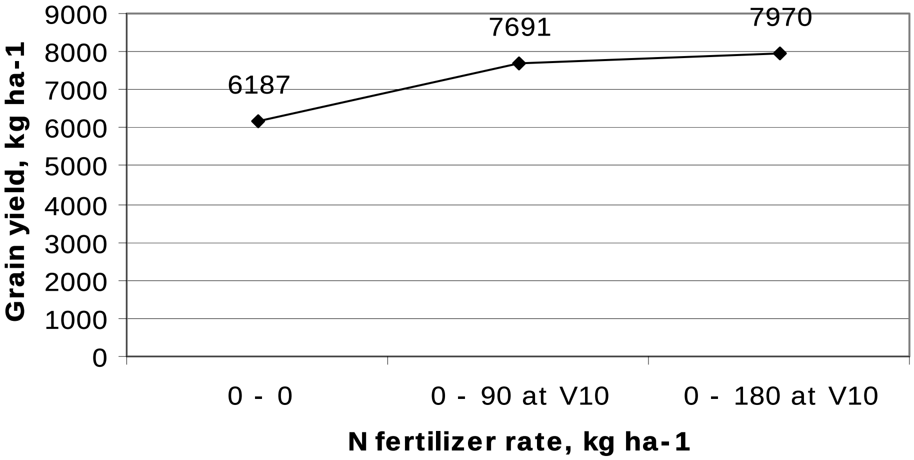

Figure A-6. Grain yield as affected by sidedress N fertilizer rate applied at V10 at Efaw, 2005.

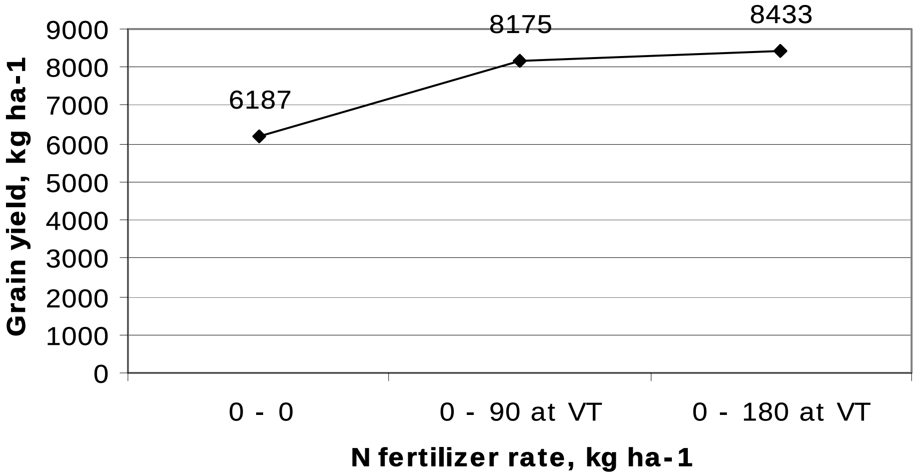

Figure A-7. Grain yield as affected by sidedress N fertilizer applied at VT at Efaw, 2005.

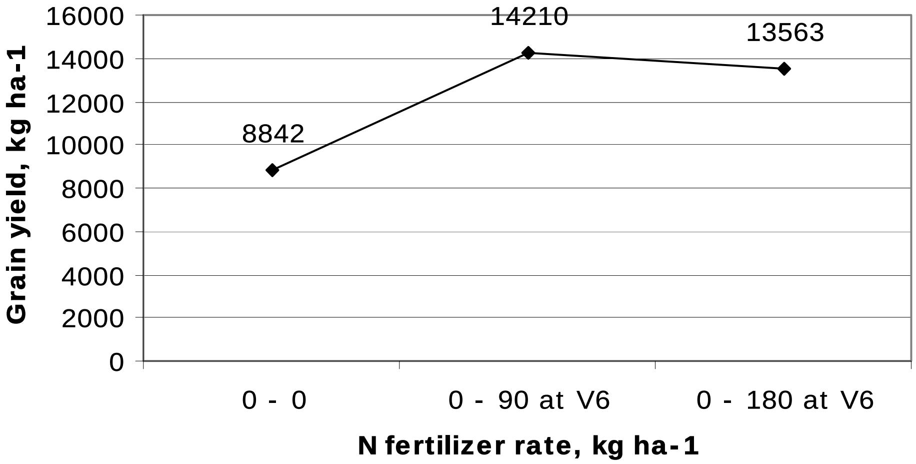

Figure A-8. Grain yield as affected by sidedress N fertilizer applied at V6 at Lake Carl Blackwell, 2005.

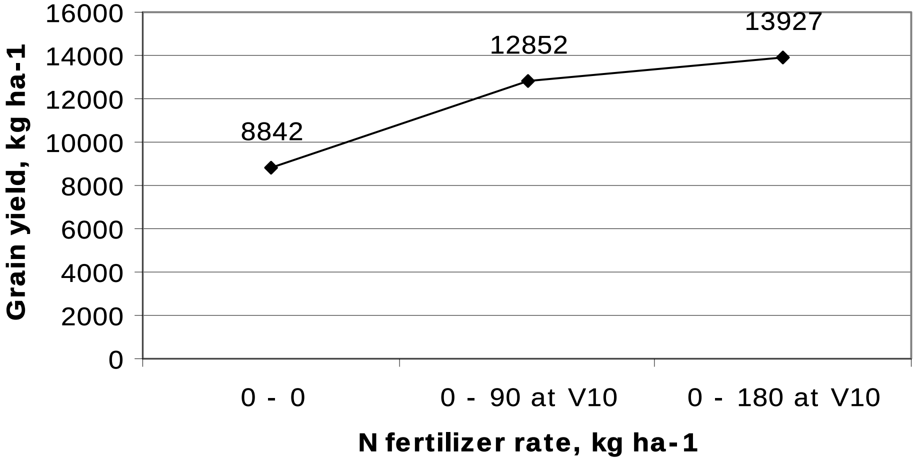

Figure A-9. Grain yield as affected by sidedress N fertilizer applied at V10 at Lake Carl Blackwell, 2005.

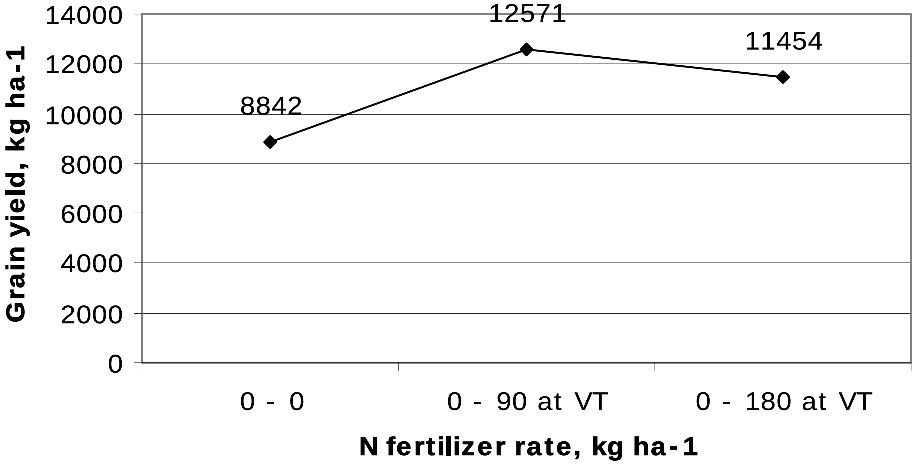

Figure A-10. Grain yield as affected by sidedress N fertilizer applied at VT at Lake Carl Blackwell, 2005.

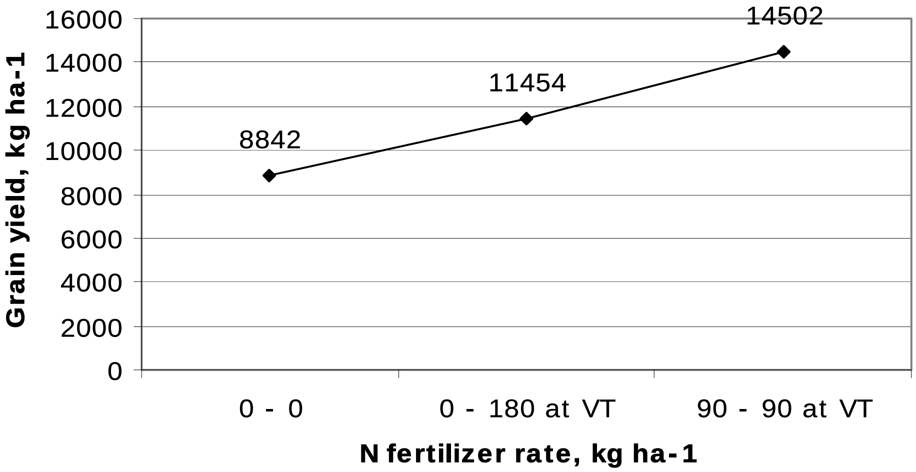

Figure A-11. Grain yield as affected by sidedress N fertilizer (180 kg ha^{-1}) application method at Lake Carl Blackwell, 2005.

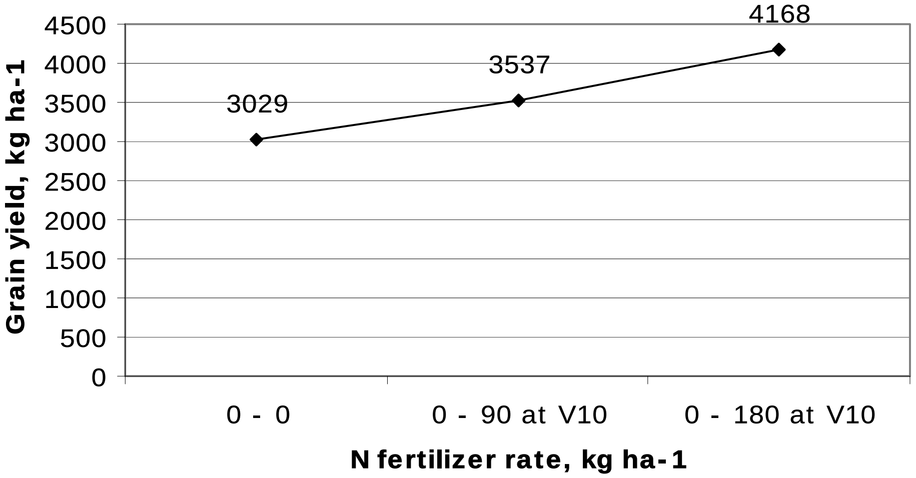

Figure A-12. Grain yield as affected by sidedress N fertilizer applied at V10 at Haskell, 2005.

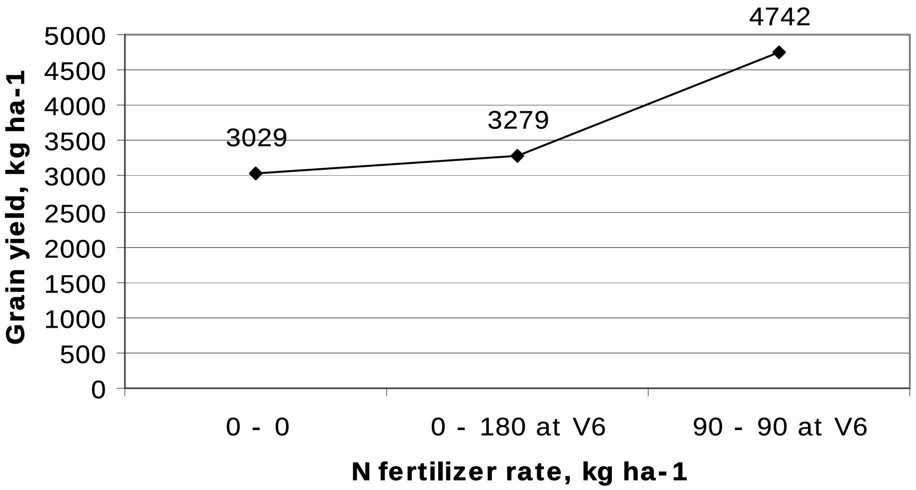

Figure A-13. Grain yield as affected by sidedress N fertilizer (180 kg ha^{-1}) application method at Haskell, 2005.

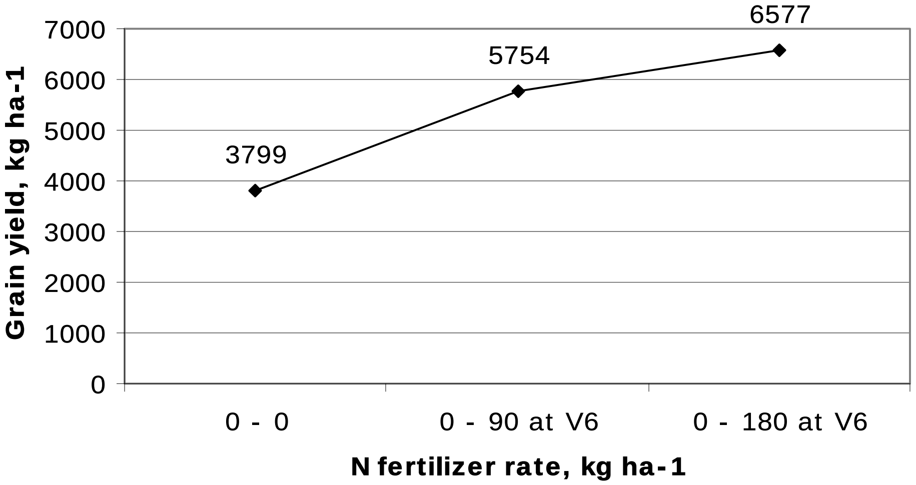

Figure A-14. Grain yield as affected by sidedress N fertilizer applied at V6 at Efaw, 2006.

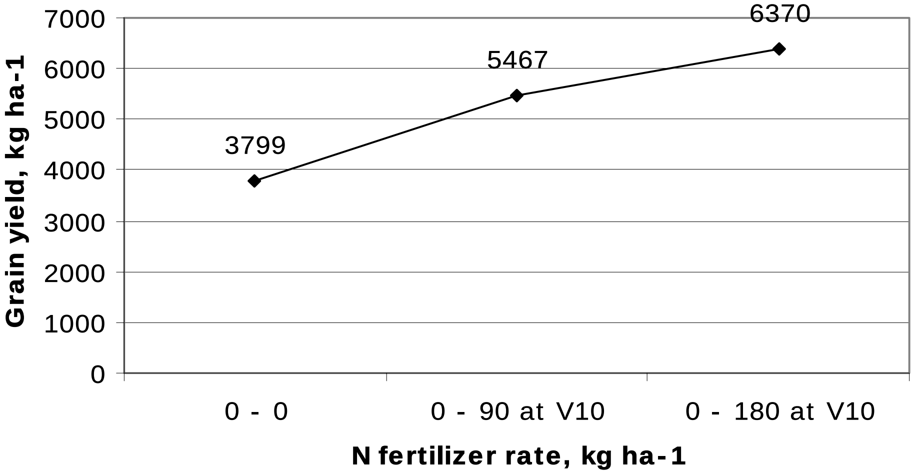

Figure A-15. Grain yield as affected by sidedress N fertilizer applied at V10 at Efaw, 2006.

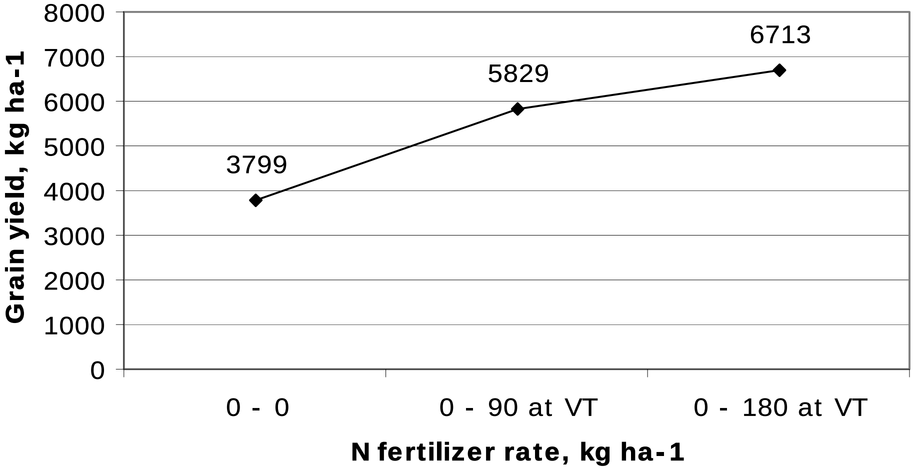

Figure A-16. Grain yield as affected by sidedress N fertilizer applied at VT at Efaw, 2006.

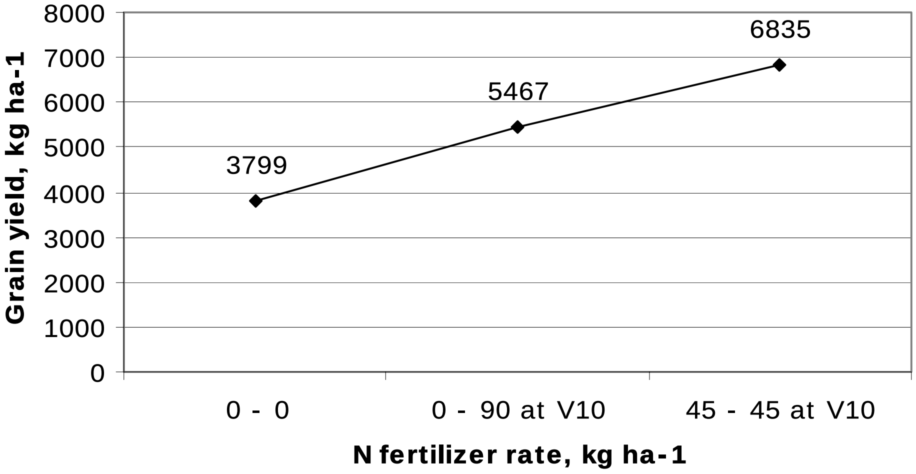

Figure A-17. Grain yield as affected by sidedress N fertilizer (90 kg ha^{-1}) application method at Efaw, 2006.

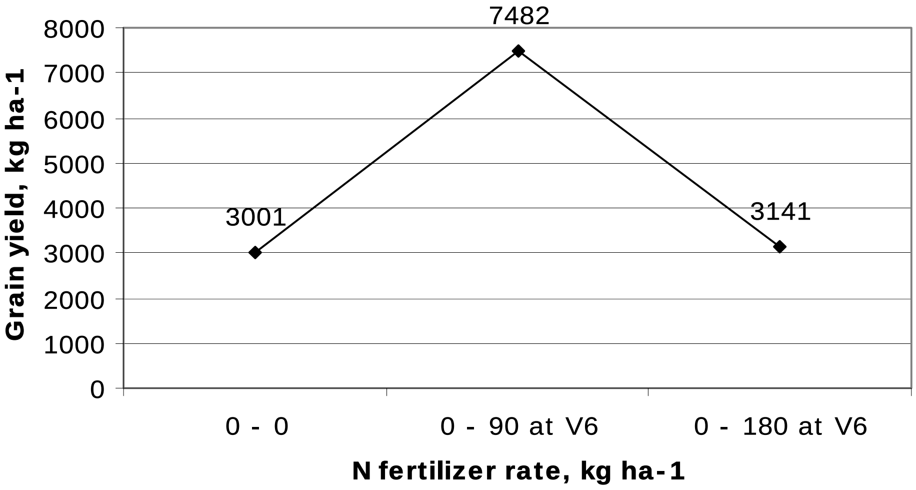

Figure A-18. Grain yield as affected by sidedress N fertilizer applied at V6 at Lake Carl Blackwell, 2006.

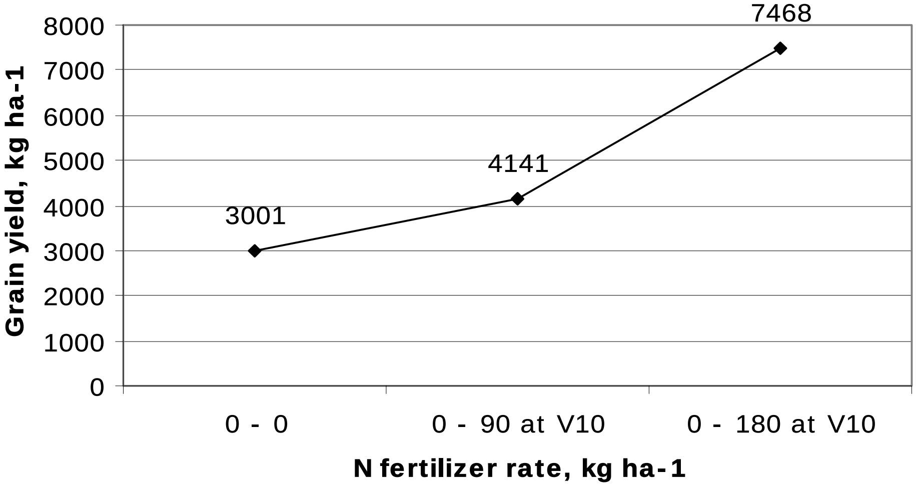

Figure A-19. Grain yield as affected by sidedress N fertilizer applied at V10 at Lake Carl Blackwell, 2006.

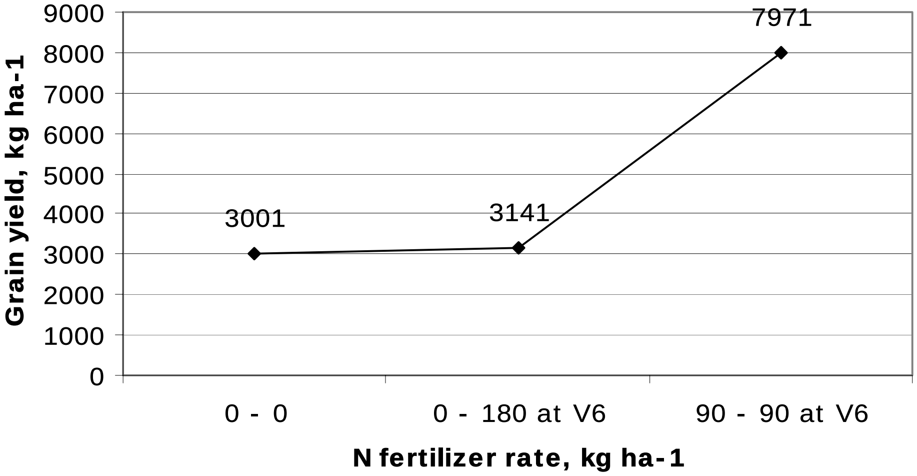

Figure A-20. Grain yield as affected by sidedress N fertilizer (180 kg ha^{-1}) application method at Lake Carl Blackwell, 2006.

VITA

Olga S. Walsh

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF DELAYED NITROGEN FERTILIZATION ON CORN GRAIN YIELDS

Major Field: Plant and Soil Science

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Education: 1993 – 1997: St. Petersburg State University, Department of Biology and Soil Sciences, St. Petersburg, Russia. Bachelor of Science in Soil Sciences (1997), major: soil chemistry. 2004 – 2006: Oklahoma State University, Department of Plant and Soil Sciences, Stillwater, OK, USA. Candidate for the Degree of Master of Science in Plant and Soil Sciences, major: Soil Science.

Professional Memberships: ASA (American Society of Agronomy), CSSA (Crop Science Society of America), SSSA (Soil Science Society of America): Member since 2005.

Name: Olga S. Walsh Date of Degree: December, 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECT OF DELAYED NITROGEN FERTILIZATION ON CORN GRAIN YIELDS

Pages in Study: 45 Candidate for the Degree of Master of Science

Major Field: Plant and Soil Science

Scope and Method of Study:
Delaying sidedress nitrogen (N) fertilizer application until later in the growing season has potential for increasing nitrogen use efficiency (NUE). Delaying N fertilization would also help to determine the amount of fertilizer N needed to be applied to achieve maximum grain yields based on the crops yield potential. This two-year study was conducted in 2005 and 2006 to determine the optimum nitrogen management strategy for corn by evaluating several combinations of preplant and sidedress N fertilizer applications at various growth stages.

Findings and Conclusions:
Higher corn grain yields and NUE’s were achieved with preplant N applications followed by mid-season sidedress fertilization at V6-V10 growth stages. Grain yields were decreased when no preplant N was applied and sidedress N fertilization was delayed until the VT growth stage. Delaying N fertilizer until mid-season supplies N at the time when the crops need for N and N uptake are at maximum, and thus facilitates more efficient N fertilizer use. Results of this study suggest that preplant N followed by mid-season sidedress N application at or before the V10 growth stage is recommended for corn.

ADVISER’S APPROVAL: Dr. William R. Raun