
# Kansas Fertilizer Research 2005

## Report of Progress 957

Agricultural Experiment Station and Cooperative Extension Service

# INTRODUCTION

The 2005 edition of the Kansas Fertilizer Research Report of Progress is a compilation of data collected by researchers across Kansas. Information was contributed by staff members of the Department of Agronomy and Kansas Agricultural Experiment Station, as well as agronomists at Kansas Agronomy Experiment Fields and Agricultural Research or Research-Extension Centers.

The investigators whose work is cited in this report greatly appreciate the cooperation of many county agents, farmers, fertilizer dealers, fertilizer equipment manufacturers, agricultural chemical manufacturers, and the representatives of various firms who contributed time, effort, land, machinery, materials, and laboratory analyses. Without their support, much of the work reported here would not have been possible.

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Cover photo provided by Chad Godsey, KSU Soil Testing Laboratory

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Precipitation Data (Inches)

| 2004 | Manhattan | S.W. KS RES-EXT. CTR Tribune | S.E. KS EXP. STA. Parsons | E. CEN EXP. FLD. Ottawa | HARVY CTY EXP. FLD Hesston S |
|---|---|---|---|---|---|
| August | 6.16 | 3.59 | 2.80 | 4.06 | 2.44 |
| September | 1.35 | 2.32 | 1.55 | 1.19 | 1.31 |
| October | 1.01 | 0.79 | 3.05 | 3.38 | 2.98 |
| November | 1.81 | 1.91 | 6.38 | 5.00 | 1.89 |
| December | 0.46 | 0.25 | 1.05 | 0.37 | 0.21 |
| Total 2004 | 37.17 | 26.30 | 39.17 | 44.84 | 31.43 |
| Dept. Normal | +2.37 | +8.86 | -2.92 | +5.63 | -1.82 |
| 2005 | | | | | |
| January | 0.85 | 0.43 | 4.26 | 4.18 | 3.06 |
| February | 2.96 | 0.60 | 1.73 | 2.40 | 1.75 |
| March | 0.84 | 0.70 | 1.22 | 0.85 | 3.08 |
| April | 0.67 | 1.83 | 2.19 | 1.29 | 1.49 |
| May | 1.45 | 1.64 | 3.36 | 5.09 | 6.00 |
| June | 11.81 | 4.48 | 6.73 | 11.47 | 9.86 |
| July | 2.26 | 1.21 | 3.77 | 5.91 | 3.49 |
| August | 5.61 | 3.85 | 4.53 | 9.59 | 7.01 |
| September | 4.36 | 0.34 | 1.55 | 3.99 | 1.19 |

| 2004 | N. CEN EXP. FLD. Belleville | KANSAS RV VALLEY EXP. FLD. | S. CEN. EXP. FLD. Hutchinson | FT. HAYS EXP. STN. Hays | HARVY CTY EXP. FLD Hesston N |
|---|---|---|---|---|---|
| August | 0.68 | 7.02 | 2.39 | 1.76 | 2.94 |
| September | 2.07 | 0.91 | 1.67 | 2.12 | 1.93 |
| October | 0.52 | 3.32 | 2.64 | 1.83 | 3.49 |
| November | 1.51 | 1.18 | 1.81 | 0.80 | 2.36 |
| December | 0.06 | 0.63 | 0.21 | 0.11 | 0.21 |
| Total 2004 | 22.73 | 36.13 | 38.11 | 24.41 | 33.73 |
| Dept. Normal | -7.92 | +1.92 | +7.79 | +1.78 | +0.48 |
| 2005 | | | | | |
| January | 0.89 | 6.00 | 2.35 | 1.14 | 2.69 |
| February | 2.30 | 2.27 | 1.75 | 1.54 | 1.76 |
| March | 1.19 | 0.72 | 1.07 | 2.99 | 3.07 |
| April | 3.84 | 1.07 | 1.78 | 2.32 | 1.29 |
| May | 1.25 | 3.58 | 2.51 | 1.58 | 5.42 |
| June | 4.91 | 8.23 | 8.95 | 3.00 | 10.07 |
| July | 5.48 | 2.66 | 4.88 | 2.33 | 3.28 |
| August | 4.81 | 9.53 | 6.94 | 3.04 | 5.29 |
| September | 2.89 | 5.40 | 0.47 | 1.75 | 1.69 |

# GRASS FERTILIZATION STUDIES
# KANSAS STATE UNIVERSITY - DEPARTMENT OF AGRONOMY

## EFFECTS OF CHLORIDE RATES AND SOURCES ON BROME IN KANSAS

**C.B. Godsey and D.B. Mengel**

### Summary

Smooth bromegrass is an important agronomic crop in central and eastern Kansas. Preliminary work with chloride (Cl) fertilizer on smooth bromegrass in Kansas indicates that soils testing low in Cl may be responsive to the addition of Cl. Results from this study suggest that Cl fertilization does increase Cl uptake in smooth bromegrass, but no increase in yield was observed.

### Introduction

Limited research has focused on using Cl fertilizers to increase smooth bromegrass production. For wheat and some other cereal grains, Cl has been reported to affect plant diseases, either by suppressing the disease organism or allowing the plant to withstand infection. Preliminary work with Cl fertilizer on smooth bromegrass in Kansas in 2004 indicated that soils testing low (<6ppm) in Cl may be responsive to the addition of Cl. The objectives of these studies were to determine 1) if bromegrass will respond to Cl fertilizer in Kansas and 2) if there is a critical Cl concentration in bromegrass leaves before boot stage, below which the crop is likely to respond to Cl fertilization.

### Procedures

Four field sites in Kansas were identified that had a history of brome production and no Cl fertilizer previously applied. Selected soil characteristics are given in Table 1. Sites were located in Riley, Saline, Nemaha, and Franklin counties. Treatments consisted of four Cl rates (0, 10, 20, 30 lb Cl/a) and two Cl sources (KCl, $NH_4Cl$). Treatments were balanced at 90 lb N/a. All plots received 30 lb P/a and 10 lb S/a. Treatments were replicated four times in a randomized complete-block design and were applied in late February 2005. Plots were harvested at the end of May. Tissue samples were collected before boot stage to determine Cl concentration. Yields were measured by harvesting a 30-inch section of each plot and weighing the biomass. A sub-sample from each plot was collected and dried to determine moisture content.

### Results

Results from this study are presented in Table 2. Chloride concentration of soil samples collected from each site indicated that Ottawa and Riley County sites were the only sites testing medium to low for Cl concentration ($\leq$6 ppm). On average, Cl concentration in tissue increased with increasing rates of Cl at all sites. Specifically, the 30 lb Cl/a rate increased leaf Cl concentration an average of 65% across locations, compared with the control. Forage yields were generally low, with the exception of the Saline County site. This was due to insufficient soil moisture at the other three locations. Significant differences in yield were found at the Riley and Saline County sites, but treatment response was variable and inconsistent. The results of this study indicate that a yield response is unlikely to occur when leaf Cl concentration is greater than 600 ppm and soil test Cl values are greater than 6 ppm. But lack of moisture may have masked treatment effects.

Table 1. Selected soil characteristics (0 to 6 inches) at locations.

| Site | pH | SMP Buffer | O.M. | $NO_3$-N | Mehlich 3 P | $NH_4$OAc K | $SO_4$-S | Cl |
|---|---|---|---|---|---|---|---|---|
| | | | % | - - - - - - | - - - - - - | ppm | - - - - - - | - - - - - - |
| Nemaha | 6.2 | 6.7 | 4.3 | 24 | 20 | 243 | 20 | 20 |
| Saline | 5.8 | 6.6 | 3.4 | 1 | 11 | 314 | 10 | 7 |
| Ottawa | 6.4 | 6.9 | 3.9 | 1 | 5 | 145 | 11 | 6 |
| Riley | 5.9 | 6.7 | 2.8 | 2 | 16 | 254 | 9 | 6 |

Table 2. Chloride concentration in leaves before boot stage and forage yield at all four locations.

| Cl | Cl | Riley Co. | | Nemaha Co. | | Saline Co. | | Franklin Co. | |
|---|---|---|---|---|---|---|---|---|---|
| Rate | Source | Cl* | Yield | Cl | Yield | Cl | Yield | Cl | Yield |
| lb/a | | ppm | lb/a | ppm | lb/a | ppm | lb/a | ppm | lb/a |
| 0 | --- | 768 | 3872 | 7594 | 5483 | 601 | 7279 | 1164 | 4702 |
| 10 | $NH_4Cl$ | 1763 | 3526 | 7783 | 5459 | 1262 | 6779 | 2382 | 4583 |
| 10 | KCl | 1895 | 4606 | 8297 | 5613 | 1206 | 7247 | 2772 | 4738 |
| 20 | $NH_4Cl$ | 2846 | 3236 | 9052 | 5361 | 2095 | 7064 | 3771 | 4427 |
| 20 | KCl | 3369 | 3811 | 9636 | 5778 | 1838 | 6338 | 4270 | 5158 |
| 30 | $NH_4Cl$ | 3798 | 3184 | 8159 | 5761 | 2268 | 6871 | 5037 | 4796 |
| 30 | KCl | 4195 | 3355 | 11948 | 5515 | 2584 | 6611 | 5395 | 4931 |
| LSD (0.10) | | 391 | 670 | 1790 | NS | 249 | 469 | 599 | NS |
| Mean Values: | | | | | | | | | |
| Cl Source | None | 768 | 3872 | 7594 | 5483 | 601 | 7279 | 1164 | 4702 |
| | $NH_4Cl$ | 2802 | 3316 | 8331 | 5527 | 1875 | 6905 | 3430 | 4602 |
| | KCl | 3153 | 3924 | 9960 | 5636 | 1876 | 6732 | 4146 | 4942 |
| LSD (0.10) | | 226 | 387 | 1266 | NS | NS | NS | 346 | 323 |
| Cl Rate | 0 | 768 | 3872 | 7594 | 5483 | 601 | 7279 | 1164 | 4702 |
| | 10 | 1829 | 4066 | 8040 | 5536 | 1234 | 7013 | 2577 | 4660 |
| | 20 | 3107 | 3523 | 9344 | 5570 | 1966 | 6701 | 4020 | 4793 |
| | 30 | 3997 | 3269 | 10054 | 5638 | 2426 | 6741 | 5216 | 4864 |
| LSD (0.10) | | 391 | 474 | 1033 | NS | 176 | 332 | 424 | NS |

* Cl tissue concentrations were determined before boot stage.

# SOIL FERTILITY RESEARCH
# SOUTHWEST RESEARCH - EXTENSION CENTER

## NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED CORN

**A.J. Schlegel**

### Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated corn in western Kansas. In 2005, N and P applied alone increased yields about 60 and 11 bu/a, respectively; but N and P applied together increased yields as much as 142 bu/a. Averaged across the past 10 years, corn yields were increased more than 125 bu/a by N and P fertilization. Application of 120 lb N/a (with P) was sufficient to produce ~90% of maximum yield in 2005, which was slightly less than the 10-year average. Phosphorus increased corn yields from 60 to 104 bu/a (average about 85 bu/a) when applied with at least 120 lb N/a. Application of 80 lb $P_2O_5$/a increased yields 2 to 22 bu/a, compared with 40 lb $P_2O_5$/a when applied with at least 120 lb N/a.

### Introduction

This study was initiated in 1961 to determine responses of continuous corn and grain sorghum grown under flood irrigation to N, P, and K fertilization. The study was conducted on a Ulysses silt loam soil with an inherently high K content. No yield benefit to corn from K fertilization was observed in 30 years, and soil K content remained high, so the K treatment was discontinued in 1992 and replaced with a higher P rate.

### Procedures

Initial fertilizer treatments in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb N/a, without P and K; with 40 lb $P_2O_5$/a and zero K; and with 40 lb $P_2O_5$/a and 40 lb $K_2O$/a. In 1992, the treatments were changed, with the K variable being replaced by a higher rate of P (80 lb/$P_2O_5$/a). All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. The corn hybrids were Pioneer 3225 (1995-97), Pioneer 3395IR (1998), Pioneer 33A14 (2000), Pioneer 33R93 (2001 and 2002), DeKalb C60-12 (2003), and Pioneer 34N45 (2004 and 2005), planted at about 30-32,000 seeds/a in late April or early May. Hail damaged the 2005 and 2002 crop and destroyed the 1999 crop. The corn was irrigated to minimize water stress. Furrow irrigation was used through 2000, and sprinkler irrigation has been used since 2001. The center 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 15.5% moisture.

### Results

Corn yields in 2005 were slightly less than the 10-year average because of hail damage on August 19 (Table 1). Nitrogen alone increased yields up to 60 bu/a, whereas P alone increased yields only about 11 bu/a. But N and P applied together increased corn yields up to 142 bu/a. Only 120 lb N/a with P was required to obtain about 90% of maximum yields. Over the past 10 years, 120 lb N/a with P has produced about 95% of maximum yield. Corn yields were 5 bu/a greater with 80 than with 40 lb $P_2O_5$/a in 2005, which is consistent with the 10-year average. In 2005, however, with N rates of 120 lb N/a or greater the higher P rate increased yields about 10 bu/a.

Table 1. Effect of N and P fertilizers on irrigated corn, Tribune, Kansas, 1996-2005.

| | | Grain Yield | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen | $P_2O_5$ | 1996 | 1997 | 1998* | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Mean |
| - - - - lb/a - - - - | | - - - - - - - - - - - - - - - - - - - - - - bu/a- - - - - - - - - - - - - - - - - - - - - - | | | | | | | | | |
| 0 | 0 | 58 | 66 | 49 | 131 | 54 | 39 | 79 | 67 | 49 | 66 |
| 0 | 40 | 64 | 79 | 55 | 152 | 43 | 43 | 95 | 97 | 60 | 77 |
| 0 | 80 | 73 | 83 | 55 | 153 | 48 | 44 | 93 | 98 | 51 | 78 |
| 40 | 0 | 87 | 86 | 76 | 150 | 71 | 47 | 107 | 92 | 63 | 87 |
| 40 | 40 | 111 | 111 | 107 | 195 | 127 | 69 | 147 | 154 | 101 | 125 |
| 40 | 80 | 106 | 114 | 95 | 202 | 129 | 76 | 150 | 148 | 100 | 125 |
| 80 | 0 | 95 | 130 | 95 | 149 | 75 | 53 | 122 | 118 | 75 | 101 |
| 80 | 40 | 164 | 153 | 155 | 205 | 169 | 81 | 188 | 209 | 141 | 163 |
| 80 | 80 | 159 | 155 | 149 | 211 | 182 | 84 | 186 | 205 | 147 | 164 |
| 120 | 0 | 97 | 105 | 92 | 143 | 56 | 50 | 122 | 103 | 66 | 93 |
| 120 | 40 | 185 | 173 | 180 | 204 | 177 | 78 | 194 | 228 | 162 | 176 |
| 120 | 80 | 183 | 162 | 179 | 224 | 191 | 85 | 200 | 234 | 170 | 181 |
| 160 | 0 | 103 | 108 | 101 | 154 | 76 | 50 | 127 | 136 | 83 | 104 |
| 160 | 40 | 185 | 169 | 186 | 203 | 186 | 80 | 190 | 231 | 170 | 178 |
| 160 | 80 | 195 | 187 | 185 | 214 | 188 | 85 | 197 | 240 | 172 | 185 |
| 200 | 0 | 110 | 110 | 130 | 165 | 130 | 67 | 141 | 162 | 109 | 125 |
| 200 | 40 | 180 | 185 | 188 | 207 | 177 | 79 | 197 | 234 | 169 | 179 |
| 200 | 80 | 190 | 193 | 197 | 218 | 194 | 95 | 201 | 239 | 191 | 191 |
| ANOVA | | | | | | | | | | | |
| N | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Linear | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Quadratic | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| $P_2O_5$ | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Linear | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Quadratic | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.007 | 0.001 | 0.001 | 0.001 | 0.001 |
| N x P | | 0.001 | 0.001 | 0.001 | 0.008 | 0.001 | 0.133 | 0.001 | 0.001 | 0.001 | 0.001 |
| MEANS | | | | | | | | | | | |
| N, lb/a | 0 | 65 | 76 | 53 | 145 | 48 | 42 | 89 | 87 | 53 | 73 |
| | 40 | 102 | 104 | 93 | 182 | 109 | 64 | 135 | 132 | 88 | 112 |
| | 80 | 139 | 146 | 133 | 188 | 142 | 73 | 165 | 178 | 121 | 143 |
| | 120 | 155 | 147 | 150 | 190 | 142 | 71 | 172 | 188 | 133 | 150 |
| | 160 | 161 | 155 | 157 | 190 | 150 | 71 | 172 | 203 | 142 | 156 |
| | 200 | 160 | 163 | 172 | 197 | 167 | 80 | 180 | 212 | 156 | 165 |
| | LSD (0.05) | 10 | 12 | 11 | 10 | 15 | 8 | 9 | 11 | 10 | 6 |
| $P_2O_5$, lb/a | 0 | 92 | 101 | 91 | 149 | 77 | 51 | 116 | 113 | 74 | 96 |
| | 40 | 148 | 145 | 145 | 194 | 147 | 72 | 168 | 192 | 134 | 149 |
| | 80 | 151 | 149 | 143 | 204 | 155 | 78 | 171 | 194 | 139 | 154 |
| | LSD (0.05) | 7 | 9 | 7 | 7 | 10 | 6 | 6 | 8 | 7 | 4 |

* There was no yield data for 1999 because of hail damage. Hail reduced yields in 2002 and 2005.

# ANIMAL WASTE APPLICATIONS FOR IRRIGATED CORN

**A.J. Schlegel, L. Stone, H.D. Bond, and M. Alam**

## Summary

Animal wastes are routinely applied to cropland to recycle nutrients, build soil quality, and increase crop productivity. This study evaluates established best management practices for land application of animal wastes on irrigated corn. Swine (effluent water from a lagoon) and cattle (solid manure from a beef feedlot) wastes have been applied annually since 1999 at rates to meet estimated corn phosphorus (P) or nitrogen (N) requirements, along with a rate double the N requirement. Other treatments were N fertilizer (60, 120, and 180 lb N/a) and an untreated control. Corn yields were increased by application of animal wastes and N fertilizer. Over-application of cattle manure has not had a negative effect on corn yield. For swine effluent, over-application has not reduced corn yields except in 2004, when the effluent had much greater salt concentration than in previous years, which caused reduced germination and poor early growth.

## Introduction

This study was initiated in 1999 to determine the effect of land application of animal wastes on crop production and soil properties. The two most common animal wastes in western Kansas were evaluated: solid cattle manure from a commercial beef feedlot and effluent water from a lagoon on a commercial swine facility.

## Procedures

The rate of waste application was based on the amount needed to meet estimated crop P requirement, crop N requirement, or twice the N requirement (Table 1). The Kansas Dept. of Agriculture Nutrient Utilization Plan Form was used to calculate animal waste application rates. Expected corn yield was 200 bu/a. Allowable P application rates for the P based treatments were 105 lb $P_2O_5$/a because soil test P was less than 150 ppm Mehlich-3 P. The N recommendation model uses yield goal less credits for residual soil N and previous manure applications to estimate N requirements. For the N-based swine treatment, the residual soil N levels after harvest in 2001, 2002, and 2004 were great enough to eliminate the need for additional N the following year. No swine effluent was applied to the 1xN treatment in 2002, 2003, or 2005 or to the 2xN requirement treatment, because it is based on 1x treatment (Table 1). The same situation occurred for N-based treatments using cattle manure in 2003. Nutrient values used to calculate initial applications of animal wastes were 17.5 lb available N and 25.6 lb available $P_2O_5$ per ton of cattle manure and 6.1 lb available N and 1.4 lb available $P_2O_5$ per 1000 gallon of swine effluent (actual analysis of animal wastes as applied differed somewhat from estimated values, Table 2). Subsequent applications were based on previous analyses. Other nutrient treatments were three rates of N fertilizer (60, 120, and 180 lb N/a), along with an untreated control. The N fertilizer treatments also received a uniform application of 50 lb $P_2O_5$/a. The experimental design was a randomized complete block with four replications. Plot size was 12 rows wide by 45 ft long.

The study was established in border basins to facilitate effluent application and flood irrigation. Swine effluent was flood-applied as part of a pre-plant irrigation each year. Plots not receiving swine effluent were also irrigated at the same time to balance water additions. Cattle manure was hand-broadcast and incorporated. The N fertilizer (granular $NH_4NO_3$) was applied with a 10-ft fertilizer applicator (Rogers Mfg.). The study area was uniformly irrigated during the growing season with flood irrigation in 1999 through 2000 and sprinkler irrigation in 2001 through 2005. The soil is a Ulysses silt loam. Corn was planted at about 33,000 seeds/a in late April or early May each year. Grain yields are not reported for 1999 because of severe hail damage. Hail also damaged the 2002 and 2005 crops. The center four rows of each plot were machine harvested after physiological maturity, with yields adjusted to 15.5% moisture.

## Results

Corn yields increased with all animal waste and N fertilizer applications in 2005, as was true for all years except 2002, when yields were greatly reduced by hail damage (Table 3). The type of animal waste affected yields in 4 of the 6 years, with higher yields from cattle manure than from swine effluent. Averaged across the 6 years, corn yields were 13 bu/a greater after application of cattle manure than after swine effluent on an N application basis. Over-application (2xN) of cattle manure has had no negative impact on grain yield in any year. Over-application of swine effluent reduced yields in 2004 because of considerably greater salt content (2 to 3 times greater electrical conductivity than any previous year) causing germination damage and poor stands. No adverse residual effect from the over-application was observed in 2005.

Table 1. Application rates of animal wastes, Tribune, Kansas, 1999 to 2005.

| Application Basis † | Cattle Manure | | | | | | |
|---|---|---|---|---|---|---|---|
| | ton/a | | | | | | |
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| P req. | 15.0 | 4.1 | 6.6 | 5.8 | 8.8 | 4.9 | 3.3 |
| N req. | 15.0 | 6.6 | 11.3 | 11.7 | 0 | 9.8 | 6.8 |
| 2XN req. | 30.0 | 13.2 | 22.6 | 22.7 | 0 | 19.7 | 13.5 |
| | Swine Effluent | | | | | | |
| | 1000 gal/a | | | | | | |
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| P req. | 28.0 | 75.0 | 61.9 | 63.4 | 66.9 | 74.1 | 73.3 |
| N req. | 28.0 | 9.4 | 37.8 | 0 | 0 | 40.8 | 0 |
| 2XN req. | 56.0 | 18.8 | 75.5 | 0 | 0 | 81.7 | 0 |

†The animal waste applications are based on the estimated requirement of N and P for a 200 bu/a corn crop.

Table 2. Analysis of animal waste as applied, Tribune, Kansas, 1999 to 2005.

| Nutrient Content | Cattle Manure | | | | | | |
|---|---|---|---|---|---|---|---|
| | lb/ton | | | | | | |
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Total N | 27.2 | 36.0 | 33.9 | 25.0 | 28.2 | 29.7 | 31.6 |
| Total $P_2O_5$ | 29.9 | 19.6 | 28.6 | 19.9 | 14.6 | 18.1 | 26.7 |
| | Swine Effluent | | | | | | |
| | lb/1000 gal | | | | | | |
| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
| Total N | 8.65 | 7.33 | 7.83 | 11.62 | 7.58 | 21.42 | 13.19 |
| Total $P_2O_5$ | 1.55 | 2.09 | 2.51 | 1.60 | 0.99 | 2.10 | 1.88 |

Table 3. Effects of animal waste and N fertilizer on irrigated corn, Tribune, Kansas, 2000-2005.

| Nutrient Source | Rate Basis † | Grain Yield 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Mean |
|---|---|---|---|---|---|---|---|---|
| | | - - - - - - - - - - | - - - - - - - - - - | - - - | bu/ | - - - - - - - - - - | - - - - - - - - - - | |
| Cattle manure | P | 197 | 192 | 91 | 174 | 241 | 143 | 173 |
| | N | 195 | 182 | 90 | 175 | 243 | 147 | 172 |
| | 2 X N | 195 | 185 | 92 | 181 | 244 | 155 | 175 |
| Swine effluent | P | 189 | 162 | 74 | 168 | 173 | 135 | 150 |
| | N | 194 | 178 | 72 | 167 | 206 | 136 | 159 |
| | 2 X N | 181 | 174 | 71 | 171 | 129 | 147 | 145 |
| N fertilizer | 60 N | 178 | 149 | 82 | 161 | 170 | 96 | 139 |
| | 120 N | 186 | 173 | 76 | 170 | 236 | 139 | 163 |
| | 180 N | 184 | 172 | 78 | 175 | 235 | 153 | 166 |
| Control | 0 | 158 | 113 | 87 | 97 | 94 | 46 | 99 |
| $LSD_{0.05}$ | | 22 | 20 | 17 | 22 | 36 | 16 | 12 |
| ANOVA | | | | | | | | |
| Treatment | | 0.034 | 0.001 | 0.072 | 0.001 | 0.001 | 0.001 | 0.001 |
| Selected contrasts | | | | | | | | |
| Control vs. treatment | | 0.001 | 0.001 | 0.310 | 0.001 | 0.001 | 0.001 | 0.001 |
| Manure vs. fertilizer | | 0.089 | 0.006 | 0.498 | 0.470 | 0.377 | 0.001 | 0.049 |
| Cattle vs. swine | | 0.220 | 0.009 | 0.001 | 0.218 | 0.001 | 0.045 | 0.001 |
| Cattle 1x vs. 2x | | 0.900 | 0.831 | 0.831 | 0.608 | 0.973 | 0.298 | 0.597 |
| Swine 1x vs. 2x | | 0.237 | 0.633 | 0.875 | 0.730 | 0.001 | 0.159 | 0.031 |
| N rate linear | | 0.591 | 0.024 | 0.639 | 0.203 | 0.001 | 0.001 | 0.001 |
| N rate quadratic | | 0.602 | 0.161 | 0.614 | 0.806 | 0.032 | 0.038 | 0.051 |

†Rate of animal waste applications based on amount needed to meet estimated crop P requirement, N requirement, or twice the N requirement.
No yields reported for 1999 because of severe hail damage. Hail reduced corn yields in 2002 and 2005.

# NITROGEN AND PHOSPHORUS FERTILIZATION OF IRRIGATED GRAIN SORGHUM

A.J. Schlegel

## Summary

Long-term research shows that phosphorus (P) and nitrogen (N) fertilizer must be applied to optimize production of irrigated grain sorghum in western Kansas. In 2003, N and P applied alone increased yields about 50 and 13 bu/a, respectively, but N and P applied together increased yields more than 65 bu/a. Averaged across the past 10 years, sorghum yields were increased more than 50 bu/a by N and P fertilization. Application of 40 lb N/a (with P) was sufficient to produce >90% of maximum yield in 2003 and for the 10-year average. Application of K had no effect on sorghum yield in 2003 or averaged across all years.

## Introduction

This study was initiated in 1961 to determine responses of continuous grain sorghum grown under flood irrigation to N, P, and K fertilization. The study was conducted on a Ulysses silt loam soil with an inherently high K content. The irrigation system was changed from flood to sprinkler in 2001.

## Procedures

Fertilizer treatments initiated in 1961 were N rates of 0, 40, 80, 120, 160, and 200 lb N/a, without P and K; with 40 lb $P_2O_5$/a and zero K; and with 40 lb $P_2O_5$/a and 40 lb $K_2O$/a. All fertilizers were broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Mycogen TE Y-75 from 1992 to 1996, Pioneer 8414 in 1997, and Pioneer 8500/8505 from 1998 to 2005) was planted in late May or early June. Irrigation was used to minimize water stress. Furrow irrigation was used through 2000 and sprinkler irrigation has been used since 2001. The center 2 rows of each plot were machine harvested after physiological maturity. Grain yields were adjusted to 12.5% moisture.

## Results

Grain sorghum yields were reduced by hail in 2005 and were less than the 10-year average (Table 1). Nitrogen alone increased yields as much as 28 bu/a, whereas P alone had no effect on yield. Nitrogen and P applied together increased sorghum yields as much as 50 bu/a. Averaged across the past 10 years, only 40 lb N/a has been required to obtain >90% of maximum yields. Sorghum yields were not affected by K fertilization, which has been true throughout the study period.

Table 1. Effects of N, P, and K fertilizers on irrigated sorghum yields, Tribune, Kansas, 1996-2005.

| N | $P_2O_5$ | $K_2O$ | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - - - - - lb/a - - - - | | | - - - - - - - - - - - - - - - bu/a - - - - - - - - - - - - - - - | | | | | | | | | | |
| 0 | 0 | 0 | 74 | 81 | 77 | 74 | 77 | 76 | 73 | 80 | 57 | 58 | 73 |
| 0 | 40 | 0 | 77 | 75 | 77 | 85 | 87 | 81 | 81 | 93 | 73 | 53 | 79 |
| 0 | 40 | 40 | 79 | 83 | 76 | 84 | 83 | 83 | 82 | 93 | 74 | 54 | 80 |
| 40 | 0 | 0 | 74 | 104 | 91 | 83 | 88 | 92 | 82 | 92 | 60 | 63 | 84 |
| 40 | 40 | 0 | 100 | 114 | 118 | 117 | 116 | 124 | 120 | 140 | 112 | 84 | 116 |
| 40 | 40 | 40 | 101 | 121 | 114 | 114 | 114 | 119 | 121 | 140 | 117 | 84 | 116 |
| 80 | 0 | 0 | 73 | 100 | 111 | 94 | 97 | 110 | 97 | 108 | 73 | 76 | 95 |
| 80 | 40 | 0 | 103 | 121 | 125 | 113 | 116 | 138 | 127 | 139 | 103 | 81 | 118 |
| 80 | 40 | 40 | 103 | 130 | 130 | 123 | 120 | 134 | 131 | 149 | 123 | 92 | 125 |
| 120 | 0 | 0 | 79 | 91 | 102 | 76 | 82 | 98 | 86 | 97 | 66 | 77 | 86 |
| 120 | 40 | 0 | 94 | 124 | 125 | 102 | 116 | 134 | 132 | 135 | 106 | 95 | 118 |
| 120 | 40 | 40 | 99 | 128 | 128 | 105 | 118 | 135 | 127 | 132 | 115 | 98 | 120 |
| 160 | 0 | 0 | 85 | 118 | 118 | 100 | 96 | 118 | 116 | 122 | 86 | 77 | 105 |
| 160 | 40 | 0 | 92 | 116 | 131 | 116 | 118 | 141 | 137 | 146 | 120 | 106 | 124 |
| 160 | 40 | 40 | 91 | 119 | 124 | 107 | 115 | 136 | 133 | 135 | 113 | 91 | 118 |
| 200 | 0 | 0 | 86 | 107 | 121 | 113 | 104 | 132 | 113 | 131 | 100 | 86 | 111 |
| 200 | 40 | 0 | 109 | 126 | 133 | 110 | 114 | 139 | 136 | 132 | 115 | 108 | 123 |
| 200 | 40 | 40 | 95 | 115 | 130 | 120 | 120 | 142 | 143 | 145 | 123 | 101 | 125 |
| ANOVA (P>F) | | | | | | | | | | | | | |
| Nitrogen | | | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Linear | | | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Quadratic | | | 0.116 | 0.001 | 0.001 | 0.227 | 0.001 | 0.001 | 0.001 | 0.001 | 0.018 | 0.005 | 0.001 |
| P-K | | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Zero P vs P | | | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| P vs P-K | | | 0.727 | 0.436 | 0.649 | 0.741 | 0.803 | 0.619 | 0.920 | 0.694 | 0.121 | 0.803 | 0.688 |
| N x P-K | | | 0.185 | 0.045 | 0.186 | 0.482 | 0.061 | 0.058 | 0.030 | 0.008 | 0.022 | 0.195 | 0.018 |
| MEANS | | | | | | | | | | | | | |
| Nitrogen | 0 lb/a | | 77 | 80 | 76 | 81 | 82 | 80 | 79 | 88 | 68 | 55 | 78 |
| | 40 | | 92 | 113 | 108 | 105 | 106 | 112 | 108 | 124 | 96 | 77 | 105 |
| | 80 | | 93 | 117 | 122 | 110 | 111 | 127 | 119 | 132 | 100 | 83 | 113 |
| | 120 | | 91 | 114 | 118 | 95 | 105 | 122 | 115 | 121 | 96 | 90 | 108 |
| | 160 | | 89 | 118 | 124 | 108 | 110 | 132 | 129 | 134 | 107 | 92 | 116 |
| | 200 | | 97 | 116 | 128 | 115 | 113 | 138 | 131 | 136 | 113 | 98 | 120 |
| | LSD (0.05) | | 9 | 10 | 8 | 13 | 7 | 8 | 9 | 10 | 11 | 10 | 7 |
| $P_2O_5$-$K_2O$ | 0 lb/a | | 79 | 100 | 103 | 90 | 91 | 104 | 94 | 105 | 74 | 73 | 92 |
| | 40- 0 | | 96 | 113 | 118 | 107 | 111 | 126 | 122 | 131 | 105 | 88 | 113 |
| | 40-40 | | 95 | 116 | 117 | 109 | 112 | 125 | 123 | 132 | 111 | 87 | 114 |
| | LSD (0.05) | | 7 | 7 | 6 | 9 | 5 | 6 | 6 | 7 | 7 | 7 | 5 |

# NITROGEN RATE EFFECTS ON YIELD AND QUALITY OF BERMUDAGRASS UNDER PIVOT IRRIGATION

G. Sohm, C. Thompson, J. Fritz, R. Hale, and A. Schlegel

## Summary

Little research has been done with variable nitrogen (N) rates on irrigated Bermudagrass (*Cynodon sp.),* especially in areas north of where it is normally grown. The effect of N rates on forage production and quality needs to be evaluated, because N is often the most limiting nutrient and directly affects feed values, especially crude protein. The objectives of this research were to determine the N rate required for optimum economical production of hybrid bermudagrass and to evaluate the effect of N rate on forage quality.

Bermudagrass yield and quality response to different N rates was investigated at Rolla, Kansas, on a Richfield silt loam soil during 2004 and 2005. Individual plots were 8 x 16 ft, and all N treatments were replicated four times in a randomized complete-block design. Treatments consisted of N rates of 0, 150, 300, 600, and 1200 lb/a. A nitrate soil test was taken from the top 2.0-ft profile from each plot, the nitrate quantity was subtracted from the treatment rate, and the balance was applied to each plot as urea. The N was applied in five equal increments, with the first 20% being applied in early April and each additional 20% applied after each cutting. The first cutting was taken when the bermudagrass reached approximately an 8-inch height, and subsequent cuttings were taken every 28 days thereafter. The area harvested was 52 ft² per plot.

Bermudagrass forage yield and quality increased as the N rate increased. In 2004, yields were increased from 4.11 tons/a without N to 8.04 tons/a at the highest N rate. In 2005, forage yields were 1.80 tons/a without N, and were increased up to 8.18 tons/a with N. Application of N increased crude protein from 12.5 to 18.5% in 2004 and from 9.6 to 19.6% in 2005. Total digestible nutrients (TDN) were increased by N application from 66.1 to 68.0% in 2004 and from 64.0 to 67.8% in 2005.

The economical N rate and corresponding forage yield was 475 lb of N producing 6.95 dry matter tons/a in 2004 and 700 lb of N producing 8.23 dry matter tons/a in 2005.

## Introduction

Bermudagrass is normally grown in the more humid areas of the south and southeastern United States, zones 7 to 9 (Figure 1). Because southwestern Kansas is north of this area of adaptation, nutrient and water requirements may differ from those determined in the south.
Therefore, the purpose of this research was to evaluate the production potential of bermudagrass in an area north and west of the normal growing environment for bermudagrass. With N being one of the major nutrients that limit grass production and nutrient feed values, N rate may have the greatest impact on the success or failure of bermudagrass grown in southwestern Kansas.

## Procedures

Field research to evaluate the effects of N on bermudagrass forage under pivot irrigation was conducted at a site located in Morton County, Kansas, on a Richfield silt loam soil.

A nursery of LCB 84X 16-66 experimental hybrid bermudagrass from Oklahoma State University was planted on May 12, 2002. Bermudagrass sprigs were harvested and planted across the entire area on 20-inch by 20-inch spacing (equivalent to a 30 bu/a sprigs) on May 15, 2003. Each plot was 8 ft by 16 ft. The N treatments were established in a randomized complete-block design with four replications. All plots were fertilized with 50 lb of N on May 17, 2003, to facilitate grass establishment.

Soil N tests were taken at 0-6, 6-12, 12-24, 24-36, 36-48, and 48-60 inch increments on March 29, 2004, and January 28, 2005. Soil pH, Bray P1, and soluble K test values were determined from the 0-6-inch samples. N rates were 0, 150, 300, 600, and 1200 lb of N (N in 24-inch soil test + N applied). The N balance for each plot was divided into five equal amounts. The first N application was during early April, along with any phosphate (P). No P was required in 2004. In 2005, MAP was applied to some of the plots, based on soil test, from 0 to 86 lb/a. No P was required on the 0 N rate plots in either year. The remaining N balance was applied to the plots after each cutting. The source of fertilizers used was 46-0-0 (urea) and 11-52-0 (MAP).

The plots received at least 0.75 inches of water (rainfall + irrigation) per week from April through mid-September. Initial grass harvest occurred when the tallest grass reached an 8-inch height (June 8, 2004 and June 1, 2005), and subsequent harvests were on 28-day increments. The grass was harvested from a 52 $ft^2$ area per plot with a rotary mower set at a 2-inch height.

Grass clippings were weighed, and random samples were pulled for feed analysis and moisture content. The crude protein and TDN are reported as a weighted average. Following harvest the fertilizer treatment was applied by hand uniformly throughout the plot area and 0.75-inch irrigation was applied to minimize N loss.

Regression equations were developed for each year to determine forage production as a function of N rate. Dry matter forage was converted to 16% moisture hay at $80.00/ton. The N rate*$0.40/lb was deducted from the gross forage value for each treatment to determine the most economical N rate.

## Results

Year-by-treatment interactions were significant for forage yield, crude protein, and TDN; thus, data for each year will be discussed separately.

In 2004, the total forage yields ranged from 4.11 to 8.04 tons/a of dry matter (Table 1). The N rate did not affect forage yield for the first cutting, but forage yield increased with increasing N rates for the subsequent cuttings.

Yields for 2005 ranged from 1.80 to 8.18 tons/a of dry matter (Table 2). Increasing N rate produced more forage at all cuttings, but yield differences among N rates were greater with the later cuttings.

The crude protein for 2004 ranged from 12.5 to 18.5% and increased with increasing N rate at all cuttings, even though there were no differences among N rates for yield at the first cutting (Table 3).

In 2005, total crude protein from the highest N treatment was twice that of the control treatment (19.6 vs. 9.6%) (Table 4). The crude protein for 2004 and 2005 generally increased with increasing N rates with all cuttings in both years (Tables 3 and 4).

The TDN was higher in 2004 (Table 5) than in 2005 (Table 6) ranging from 66.1 to 68.0% in 2004 and from 64.0 to 67.8% for 2005. Temperatures in 2004 were cooler than normal, which may have lead to the difference in TDN by slowing bermudagrass growth and development between the 28-day harvest intervals.

The regression equation determined for 2004 was $DM=4.3+0.008*N-0.000004*N^2$ with a $R^2=0.83$, and for 2005 was $DM=1.86+0.016*N-0.000009*N^2$ with a $R^2=0.96$. Using these equations and the methods described previously, the economical N rate was determined for each year. In 2004, the economical N rate was 475 lb/a with a return of $495.48/a; in 2005, it was 650 lb/a with a return of $545.48/a.

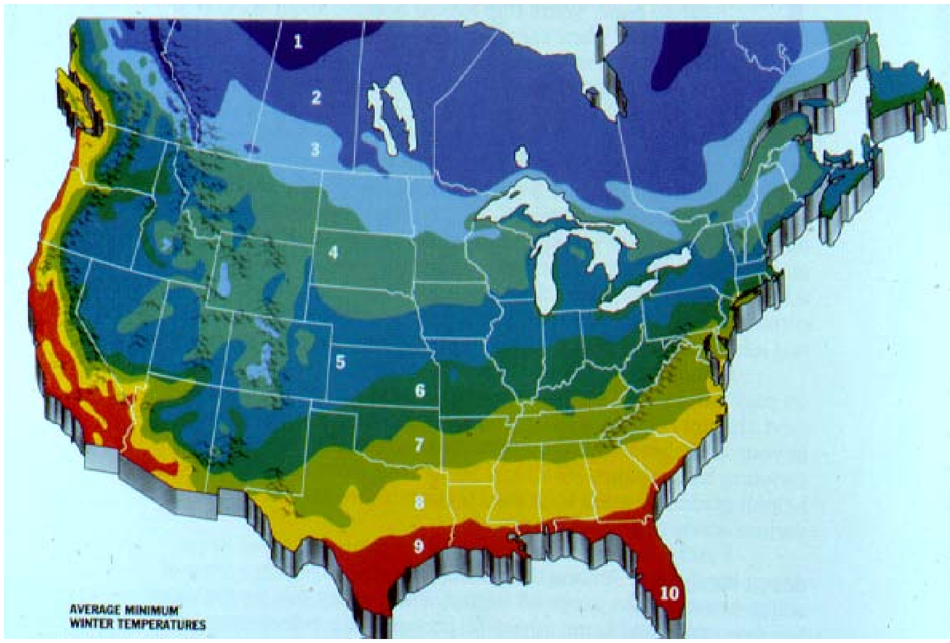


**Figure 1.** Adaptation zones for bermudagrass.

Table 1. 2004 Forage yields (dry matter, tons/a).

| N Rate | June 8 | July 6 | Aug 3 | Aug 31 | Sept 28 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 1.10 | 1.13 | 1.06 | 0.56 | 0.25 | 4.11 |
| 150 | 1.30 | 1.72 | 1.41 | 0.86 | 0.34 | 5.63 |
| 300 | 1.24 | 1.97 | 1.74 | 1.14 | 0.40 | 6.49 |
| 600 | 1.51 | 2.24 | 1.93 | 1.29 | 0.42 | 7.38 |
| 1200 | 1.59 | 2.34 | 2.26 | 1.38 | 0.46 | 8.04 |
| LSD (0.05) | 0.57 | 0.40 | 0.28 | 0.19 | 0.08 | 0.93 |

Table 2. 2005 Forage yields (dry matter, tons/a).

| N Rate | June 1 | June 28 | July 26 | Aug 23 | Sept 20 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 0.32 | 0.55 | 0.29 | 0.32 | 0.31 | 1.80 |
| 150 | 0.65 | 1.08 | 0.74 | 1.04 | 0.41 | 3.93 |
| 300 | 1.12 | 1.60 | 1.41 | 1.65 | 0.50 | 6.28 |
| 600 | 1.49 | 1.98 | 1.75 | 1.99 | 0.80 | 8.01 |
| 1200 | 1.57 | 1.95 | 1.79 | 1.94 | 0.91 | 8.18 |
| LSD (0.05) | 0.16 | 0.17 | 0.23 | 0.17 | 0.13 | 0.65 |

Table 3. 2004 Crude protein (%).

| N Rate | June 8 | July 6 | Aug 3 | Aug 31 | Sept 28 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 10.9 | 13.8 | 12.1 | 13.3 | 12.8 | 12.5 |
| 150 | 11.4 | 13.7 | 12.8 | 13.5 | 14.1 | 12.9 |
| 300 | 12.7 | 18.1 | 15.9 | 17.0 | 17.1 | 16.2 |
| 600 | 14.2 | 18.5 | 17.4 | 20.5 | 20.5 | 17.8 |
| 1200 | 14.3 | 19.0 | 18.9 | 21.0 | 21.4 | 18.5 |
| LSD (0.05) | 2.1 | 2.9 | 2.7 | 3.0 | 1.6 | 2.4 |

Table 4. 2005 Crude protein (%).

| N Rate | June 1 | June 28 | July 26 | Aug 23 | Sept 20 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 11.7 | 8.8 | 9.0 | 10.0 | 9.1 | 9.6 |
| 150 | 12.6 | 11.2 | 10.5 | 11.0 | 9.6 | 11.1 |
| 300 | 14.4 | 12.9 | 12.8 | 13.7 | 13.2 | 13.4 |
| 600 | 17.5 | 16.2 | 16.9 | 18.0 | 16.6 | 17.0 |
| 1200 | 19.3 | 19.9 | 18.6 | 20.2 | 20.3 | 19.6 |
| LSD (0.05) | 1.1 | 1.1 | 1.2 | 1.0 | 1.2 | 0.6 |

Table 5. 2004 Total digestible nutrients (%).

| N Rate | June 8 | July 6 | Aug 3 | Aug 31 | Sept 28 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 65.7 | 65.2 | 66.2 | 68.4 | 65.6 | 66.1 |
| 150 | 66.0 | 64.6 | 66.2 | 68.5 | 65.4 | 66.0 |
| 300 | 65.9 | 66.5 | 66.7 | 69.2 | 67.1 | 66.9 |
| 600 | 67.6 | 65.6 | 68.2 | 70.3 | 68.7 | 67.7 |
| 1200 | 67.6 | 65.9 | 68.5 | 70.8 | 69.3 | 68.0 |
| LSD (0.05) | 1.7 | 1.1 | 1.9 | 1.4 | 0.8 | 1.1 |

Table 6. 2005 Total digestible nutrients (%).

| N Rate | June 1 | June 28 | July 26 | Aug 23 | Sept 20 | Total |
|---|---|---|---|---|---|---|
| lb/a | | | | | | |
| 0 | 66.7 | 62.0 | 64.4 | 63.6 | 64.6 | 64.0 |
| 150 | 67.3 | 64.0 | 66.5 | 64.0 | 64.4 | 65.0 |
| 300 | 67.2 | 64.6 | 66.9 | 64.9 | 66.0 | 65.8 |
| 600 | 67.8 | 65.7 | 68.1 | 65.3 | 68.2 | 66.7 |
| 1200 | 68.9 | 67.2 | 68.7 | 66.1 | 69.4 | 67.8 |
| LSD (0.05) | 0.7 | 0.8 | 1.3 | 1.0 | 1.2 | 0.4 |

# SOIL FERTILITY RESEARCH
# SOUTHEAST AGRICULTURAL RESEARCH CENTER

## NITROGEN MANAGEMENT OF SORGHUM GROWN FOR GRAIN AND FORAGE

**D.W. Sweeney and J.L. Moyer**

### Summary

Sorghum grain yield was increased by N rates of up to 120 lb/a or more, but not by timing of N fertilizer application. Stover forage was greatest with 120 lb N/a, when at least two-thirds of the N was applied preplant, and when stover was harvested immediately after grain removal.

### Introduction

With increased economic constraints, producers need to find ways to increase revenue by improving production efficiency with minimal additional inputs. After sorghum is harvested for grain, the stover that remains has the potential to be used as livestock feed. Because of sorghum's perennial characteristics, the stover could be harvested immediately after grain harvest or left to acquire additional photosynthate until frost.

### Procedures

The experiment was established on a Parsons silt loam in 2003. The experimental design was a 4 × 3 factorial arrangement of a randomized complete block with four replications. Fertilizer N rates were 40, 80, 120, and 160 lb/a. Fertilizer application timings were 1) 100% applied preplant, 2) two-thirds of the amount applied preplant and one-third applied as a sidedress at the eight-leaf stage, and 3) one-third of the amount applied preplant and two-thirds applied sidedress. A no-N control treatment also was included in each replication.

### Results

Sorghum grain yield was affected by N rate (Fig. 1), but not by the timing of N fertilizer application (data not shown). A year-by-N rate interaction was observed (Fig. 1). In 2003, yield response to N was maximized at 120 lb/a, and was 22 bu/a greater than yield with no nitrogen. In 2004, however, yield did not seem to be maximized at 160 lb N/a, and was more than 50 bu/a greater at 160 lb N/a than yield with no nitrogen.

Averaged across years, stover harvested for forage after grain harvest was maximized at 120 lb N/a, and was nearly 1 ton/a more forage than yield with no nitrogen (Fig. 2). Stover yield was less when two-thirds of the N was applied as a sidedress, compared with applying all N preplant or applying only one-third as a sidedress (data not shown). The response to N rate was similar for stover left until a killing frost, with maximum forage obtained with 120 lb N/a (Fig. 2). But, in both years, the sorghum did not maintain dry matter, losing about half of the potential forage between harvest and frost. Thus, if a producer uses the stover as a feed source, it should be used as soon as possible after grain harvest.

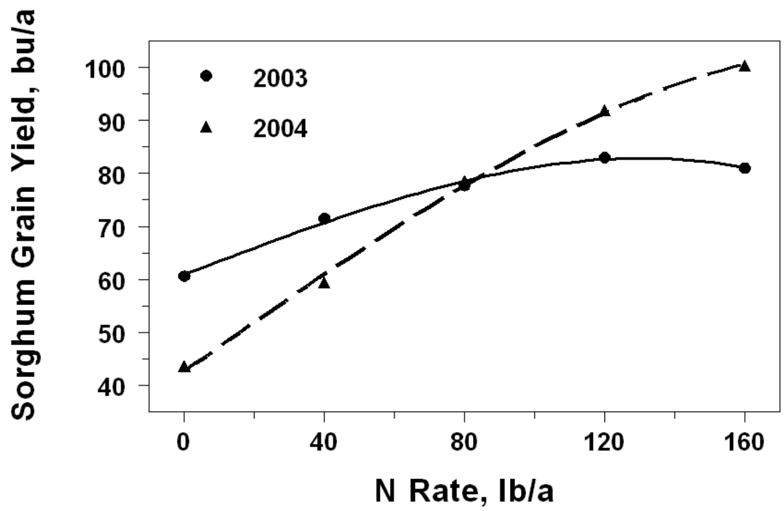


**Figure 1.** Effect of N rate on sorghum grain yield in 2003 and 2004, Southeast Agricultural Research Center.

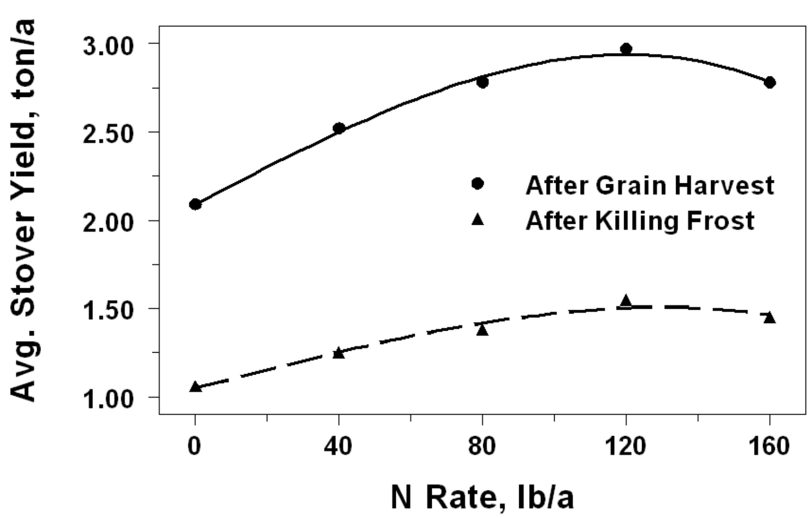


**Figure 2.** Effect of N rate on stover yield for forage averaged across two years, Southeast Agricultural Research Center.

# USE OF STRIP-TILLAGE FOR CORN PRODUCTION IN A CLAYPAN SOIL[1]

**D.W. Sweeney, R.E. Lamond, and G.L. Kilgore**


## Summary

Averaged across years, tillage selection did not significantly affect short-season corn yields. Early-spring fertilization and knife (subsurface band) applications of N and P solutions resulted in greater yield than did N-P fertilizer application in late fall or dribble application.


## Introduction

The use of conservation-tillage systems is promoted to reduce the potential for sediment and nutrient losses. In the claypan soils of southeastern Kansas, crops grown with no tillage may yield less than in systems involving some tillage operation. But strip tillage provides a tilled seed-bed zone where early-spring soil temperatures might be greater, while leaving residues intact between the rows as a conservation measure similar to no tillage.

## Procedures

The experiment was established on a Parsons silt loam in late fall 2002. The experimental design was a split-plot arrangement of a randomized complete block with three replications. The four tillage systems constituting the whole plots were: 1) strip tillage in late fall, 2) strip tillage in early spring, 3) reduced tillage (1 pass with tandem disk in late fall and 1 pass in early spring), and 4) no tillage. The subplots were a 2×2 factorial arrangement of fertilizer timing and fertilizer placement. Fertilizer application timing was targeted for late fall or early spring. Fertilizer placement was dribble [surface band] or knife [subsurface band at 4 in-depth]. Fertilizer rates of 120 lb N/a and 40 lb $P_2O_5$/a were applied in each fluid-fertilizer scheme. Fertilization was done on Dec. 17, 2002, and on April 1, 2003. Short-season corn was planted on April 3, 2003, and harvested on Aug. 25, 2003. For the second year, fertilization was done on Dec. 2, 2003, and on April 5, 2004. Short-season corn was planted on April 6, 2004, and harvested on Sept. 3, 2004.

## Results

Averaged across the two years, short-season corn yields averaged 123 bu/a with strip tillage done in late fall, 118 bu/a with strip tillage done in spring, 131 bu/a with reduced tillage, and 111 bu/a with no tillage. Because of variable data, these differences were not statistically different. Fertilization done in early spring resulted in average corn yields of 125 bu/a, significantly ($P<0.10$) more than yield with late-fall fertilization (116 bu/a). Knife (subsurface band) applications resulted in statistically greater yield than dribble (surface band) applications did (125 vs. 117 bu/a).

[1] This research was partly funded by the Kansas Corn Commission.

# EFFECTS OF PREVIOUS CROP, NITROGEN AND PHOSPHORUS PLACEMENT METHOD, AND TIME OF NITROGEN APPLICATION ON YIELD OF WHEAT PLANTED NO-TILL

K.W. Kelley and D.W. Sweeney

## Summary

No-till wheat yields were influenced significantly by previous crop, fertilizer nitrogen (N) and phosphorus (P) placement method, and timing of N. Grain yields averaged 70 bu/a following soybean, 65 bu/a following corn, and 57 bu/a following grain sorghum. Subsurface placement of fertilizer N (28% N) and P (10 - 34 - 0) resulted in greater wheat yields than surface strip-band or surface broadcast applications did, regardless of previous crop. In 2005, wheat yields were significantly greater when most of the fertilizer N was applied in late winter, especially when fertilizer N was surface-applied. Results also indicate that, where fertilizer N was subsurface-applied (coulter-chisel in fall and/or spoke-wheel in late winter), wheat yields following corn or soybean were influenced very little by timing of N application.

## Introduction

In southeastern Kansas, wheat is commonly planted after a summer crop, such as corn, grain sorghum, or soybean, to diversify crop rotation. Improved equipment technology has made no-till planting of wheat more feasible in high-residue conditions. The benefits of no-till planted wheat are reduced labor and tillage costs and less soil erosion. Leaving previous crop residues near the soil surface, however, affects fertilizer N and P management for no-till wheat. The objectives of this research were to evaluate the effects of previous crop, N and P placement method, and time of N application on grain yield of wheat planted no-till.

## Procedures

The experiment was a split-plot design, in which the main plot was previous crop (corn, grain sorghum, and soybean) and subplots consisted of a factorial arrangement of two fertilizer management schemes (three placement methods of N and P and four different times of N applications). The application methods of liquid N (28% N) and P (10 - 34 - 0) consisted of: 1) subsurface [coulter-knife in fall on 15-inch spacing and spoke-wheel in late winter on 10-inch spacing], 2) surface-applied in 15-inch strip bands, and 3) broadcast on soil surface. The times of N applications were: 1) all in the fall, 2) 1/4 fall + 3/4 late winter, 3) 1/2 fall + 1/2 in late winter, and 4) 3/4 fall + 1/4 late winter. Liquid N (120 lb N/a) and P (68 lb $P_2O_5$/a) rates were constant over all plots, except for control plots. Phosphorus fertilizer was fall-applied in combination with the different N application methods. All plots also received 120 lb $K_2O$/a as a preplant broadcast application. Wheat was planted with a no-till drill in 7.5-inch spacing at a seeding rate of 100 lb/a.

## Results

Wheat yields were influenced significantly by previous crop, N and P application method, and timing of N fertilizer (Table 1). Grain yields averaged 70 bu/a following soybean, 65 bu/a following corn, and 57 bu/a following grain sorghum. Above-normal rainfall in November (6.4 inches) and January (4.3 inches) also influenced wheat yield responses to fertilizer N.

Grain yields for the different fertilizer N and P placement methods, when averaged over previous crops and fertilizer N schemes, were 75 bu/a for subsurface, 60 bu/a for surface strip-band, and 57 bu/a for surface broadcast. Results indicate that subsurface placement of fertilizer N and P significantly increases fertilizer nutrient efficiency, compared with surface applications. In addition, wheat yields often were greater for surface strip-banding of N and P than for surface broadcast applications.

Timing of fertilizer N also influenced wheat yields. Because of the greater-than-normal rainfall during late fall of 2004 and early winter of 2005, significant N losses likely occurred when N was applied before planting. Yield differences between timings of N applications were greater for surface-applied N than for subsurface treatments. Grain yields were greatest for surface-band and surface-broadcast treatments when most of the fertilizer N was top-dressed in late winter, regardless of previous crop. When wheat followed corn or soybean and fertilizer N was subsurface applied, however, timing of N had only a slight affect on yield. Nitrogen losses from denitrification or immobilization evidently were greatly reduced with subsurface placement.

Although subsurface placement of fertilizer N and P often results in greater wheat yield, compared with surface applications, producers will have to determine whether the additional cost of equipment and labor can be justified. In addition, wheat planted no-till following corn or soybean often has a greater yield potential than wheat following grain sorghum does, especially where fertilizer is surface-applied. Results also indicate that for optimum yield potential, timing of fertilizer N for no-till wheat is critical, and depends upon both rainfall patterns and placement method.

Table 1. Effect of previous crop, nitrogen and phosphorus placement method, and time of N application on no-till wheat yield, Southeast Agricultural Research Center, Parsons Unit, 2005.

| Fertilizer | Time of Nitrogen | | Yield of Wheat Following | | |
|---|---|---|---|---|---|
| N and P† Placement Method | Fall | Late-winter | Corn | Grain Sorghum | Soybean |
| | lbs N/a | | -------------------- bu/a -------------------- | | |
| Surface strip-band | 30 | 90 | 68.1 | 61.2 | 72.8 |
| | 60 | 60 | 61.1 | 58.8 | 69.5 |
| | 90 | 30 | 59.9 | 51.0 | 64.6 |
| | 120 | 0 | 54.3 | 46.7 | 56.6 |
| Surface broadcast | 30 | 90 | 65.6 | 55.4 | 71.1 |
| | 60 | 60 | 61.9 | 50.6 | 70.4 |
| | 90 | 30 | 55.4 | 46.2 | 58.6 |
| | 120 | 0 | 52.1 | 38.9 | 55.0 |
| Subsurface | 30 | 90 | 73.1 | 71.9 | 82.6 |
| (knife + spoke)‡ | 60 | 60 | 73.5 | 73.0 | 82.4 |
| | 90 | 30 | 75.1 | 67.9 | 81.3 |
| | 120 | 0 | 73.5 | 63.6 | 79.4 |
| AVG | | | (64.5) | (57.1) | (70.3) |
| Knife control | | | 32.4 | 19.0 | 31.3 |
| Control | | | 32.8 | 19.5 | 30.9 |
| LSD (0.05): | Same previous crop | | | 3.7 | |
| | Different crop | | | 4.7 | |

† N source = liquid 28 % N. Phosphorus (68 lb/a $P_2O_5$ as liquid 10-34-0) applied with N placement treatments.

‡ Coulter-knifed applicator in fall and spoke-wheel applicator in late winter.

Potash (120 lb/a $K_2O$ as muriate of potash) broadcast applied before planting.

Variety: Overley; seeding rate of 100 lbs/a. Planting date: Oct. 21, 2004

# SOIL FERTILITY RESEARCH NORTH CENTRAL KANSAS EXPERIMENT FIELD

## MAXIMIZING IRRIGATED CORN YIELDS IN THE GREAT PLAINS

W.B. Gordon

### Summary

This experiment was conducted in 2000 through 2002 on a producer's field in the Republican River Valley, on a Carr sandy loam soil, and in 2003 and 2004 on the North Central Kansas Experiment Field, on a Crete silt loam soil. Treatments consisted of two plant populations (28,000 and 42,000 plants/a) and nine fertility treatments consisting of three N rates (160, 230, and 300 lb/a), in combination with rates of P, K, and S. Results from the 3-year study on the Carr sandy loam soil show a clear interaction between plant density and fertility management. Increasing plant density had no effect on yield unless fertility was increased simultaneously, and one-third of the fertility response was lost if plant density was not increased. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response. The addition of P, K, and S increased yield by 88 bu/a over the N-alone treatment. Results from the 2-year study on the Crete silt loam soil were similar. The low-fertility-level yields were decreased when population was increased. When additional fertility was added, corn yield responded to higher plant populations. Addition of P, K, and S all resulted in yield increases, although the magnitude of the sulfur response was not as great as it was on the sandy Carr soil. Results of this experiment illustrate the importance of using a systems approach when attempting to increase yield levels.

### Introduction

With advances in genetic improvement of corn, yields continue to rise. Modern hybrids suffer less yield reduction under conditions of water and temperature stress. Hybrids no longer suffer major yield loss due to insect, weed, and disease infestations. Newer hybrids have the ability to increase yields in response to higher plant populations. Since 1970, the national average corn yield has increased at a rate of 1.75 bu/a per year. Corn yields reached an all time high of 142 bu/a in 2003. But yields obtained in university hybrid performance trials and in state corn grower contests have been much greater. The average corn yield increase during the period 1970 to 2003 in Republic County, Kansas, was the same as the national average. But yields in KSU's Irrigated Corn Hybrid Performance Test increased at the rate of 2.8 bu/a per year. There is a large gap between attainable yields and present average yields. One important aspect of yield advance is that it comes from synergistic interactions between plant breeding efforts and improved agronomic practices. Innovations in each field successively open up opportunities for the other. The overall objective of the research project is to find practical ways of narrowing the existing gap between average and obtainable yield. This study evaluates more intensive fertility management at standard and high plant populations.

### Procedures

The experiment was conducted in 2000 through 2002 on a producer's field located in the Republican River Valley near the North Central Kansas Experiment Field, at Scandia, KS, on a Carr sandy loam soil. In 2003 and 2004, the experiment was conducted at the Experiment Field on a Crete silt loam soil. On the site with Carr sandy loam, analysis by the Kansas State University Soil Testing laboratory showed that the initial soil pH was 6.8, organic matter was 2%, Bray-1 P was 20 ppm, exchangeable K was 240 ppm, and $SO_4$-S was 6 ppm. Soil test values for the Crete silt loam site were: pH, 6.5; organic matter, 2.6%; Bray-1 P, 25 ppm, exchangeable K 170 ppm, and $SO_4$-S, 15 ppm. Treatments included two plant populations (28,000 and 42,000 plants/a) and nine fertility treatments. Fertility treatments consisted of three nitrogen (N) rates (160, 230, and 300 lb/a) applied in two split applications (1/2 preplant and 1/2 at V4) in combination with 1) current soil test recommendations for P, K, and S (this would consist of 30 lb $P_2O_5$/a at these two sites); 2) 100 lb $P_2O_5$/a + 80 lb $K_2O$/a + 40 lb $SO_4$-S/a applied preplant, and the three N rates applied in two split applications (1/2 preplant and 1/2 at V4 stage); and 3) 100 lb $P_2O_5$/a + 80 lb $K_2O$/a + 40 lb $SO_4$-S/a applied preplant, with N applied in four split applications (preplant, V4, V8, and tassel). In 2001, treatments were included to determine which elements were providing yield increases. Additional treatments included an unfertilized check; 300 lb N/a alone; 300 lb N/a + 100 lb $P_2O_5$/a; 300 lb N/a + 100 lb $P_2O_5$/a + 80 lb $K_2O$/a; and 300 lb N + 100 lb $P_2O_5$/a + 80 lb $K_2O$/a + 40 lb $SO_4$-S/a. Preplant applications were made 14 to 20 days before planting each year. Fertilizer sources were ammonium nitrate, monoammonium phosphate (MAP), ammonium sulfate, and potassium chloride (KCL). The experiment was fully irrigated. Irrigation was scheduled by using neutron attenuation methods. Irrigation water was applied when 30% of the available water in the top 36 inches of soil was depleted.

## Results

The results from the 3-year study on the Carr sandy loam soil clearly illustrate the interaction between plant density and fertility management (Table 1). Increasing plant density had no effect on yield unless fertility was increased simultaneously, and one-third of the fertility response was lost if plant density was not increased. Fertility levels must be adequate to take advantage of the added yield potential of modern hybrids grown at high plant populations. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response (Table 2). The addition of P, K, and S increased yield by 88 bu/a over the N-alone treatment.

Results from the 2-year study on the Crete silt loam were similar (Table 3). In the low-fertility treatment, yields were decreased when population was increased. When additional fertility was added, corn yield responded to higher plant populations. As in the experiment on the Carr soil, one third of the fertility response was lost if plant population was not increased. Addition of P to the N increased yield by 56 bu/a (Table 4). Addition of K further increased yield by 13 bu/a, and adding sulfur to the mix further increased yield by 9 bu/a. With both soils, yield increased with increasing N rate to the 230 lb N/a rate. Increasing the number of N applications from 2 to 4 did not increase yields on either soil in any year of the experiment.

Results of this experiment have shown a clear interaction between plant density and fertility management, thus illustrating the importance of using a systems approach when attempting to increase yield levels. This 5-year study also points out the need for soil test calibration and fertility-management research that is conducted at high yield levels. Standard soil test recommendations on these two soils would not have produced maximum yield.

Table 1. Maximizing irrigated corn yields, Carr sandy loam soil, 2000 through 2002.

| Population plants/a | $P_2O_5 + K_2O$ + S (lb/a)† 30+ 0 +0 | $P_2O_5 + K_2O$ + S (lb/a)† 100 +80 + 40 | Response |
|---|---|---|---|
| | - - - - - - - - | -bu/a - - - - - - - - | |
| 28,000 | 162 | 205 | 43 |
| 42,000 | 159 | 223 | 64 |
| Response | -3 | 18 | |

†Plus 230 lb/a N (1/2 preplant; 1/2 at V4).

Table 2. Maximizing irrigated corn yields, Carr sandy loam soil, 2001 and 2002.

| Fertility Treatment | bu/a |
|---|---|
| Unfertilized check | 80 |
| N | 151 |
| N + P | 179 |
| N + P + K | 221 |
| N + P + K + S | 239 |
| LSD (0.05) | 10 |

Table 3. Maximizing irrigated corn yields, Crete silt loam Soil, 2003 and 2004.

| Population | $P_2O_5 + K_2O$ + S (lb/a) | | Response |
|---|---|---|---|
| plants/a | 30 + 0 + 0 | 100 + 80 + 40 | |
| | - - - - - - - - - - - - - - - - bu/a | - - - - - - - - - - - - - - - - | |
| 28,000 | 202 | 225 | 23 |
| 42000 | 196 | 262 | 66 |
| Response | -6 | 37 | |

Table 4. Maximizing irrigated corn yields, Crete silt loam soil, 2003 and 2004.

| Fertility Treatment | bu/a |
|---|---|
| Unfertilized check | 137 |
| N | 187 |
| N + P | 243 |
| N + P + K | 256 |
| N + P + K + S | 265 |
| LSD (0.05) | 7 |

# USE OF STRIP TILLAGE FOR CORN PRODUCTION IN KANSAS

W.B. Gordon and R.E. Lamond

## Summary

Conservation-tillage production systems are being used by an increasing number of producers. Early-season plant growth and nutrient uptake can be poorer in no-till than in conventional-tillage systems. Strip tillage may offer many of the soil-saving advantages of the no-till system while establishing a seed-bed that is similar to conventional tillage. Field studies were conducted at Belleville, Kansas, to compare the effectiveness of strip tillage and no-till, and to assess the effects of fall versus spring applications of N-P-K-S fertilizer on growth nutrient uptake and yield of corn.

The 2003 growing season was characterized by much-below-normal rainfall. Corn yields were severely reduced by the hot, dry conditions. Even though grain yields were low, strip tillage improved early-season growth and nutrient uptake of corn. Strip tillage shortened the time from emergence to mid-silk by 7 days and also reduced grain moisture content at harvest. Strip-tillage plots yielded 15 bu/a more than no-till plots did. In 2004, the growing season was nearly ideal, except for an early-season hail storm that reduced plant population. Yields were very good, and the use of strip tillage increased yields by 16 bu/a over no-till corn. Soil temperature was consistently warmer in strip tillage than in no-till in both 2003 and 2004. A very hot, dry period occurred in late June and early July in 2005. This period was followed by very favorable growing conditions, however, and yields were good. When averaged over fertility treatment, strip-tillage corn yielded 12 bu/a greater than no-till.

In all 3 years of the experiment, yield, early-season growth, and number of days from emergence to mid-silk were greatly improved in strip tillage, compared with no-till. Fall fertilization was as effective as spring fertilization. Strip tillage seems to be an attractive alternative to no-till for Great Plains producers.

## Introduction

Production systems that limit tillage are being used by an increasing number of producers in the central Great Plains because of several inherent advantages. These include reduction of soil erosion losses, increased soil water use-efficiency, and improved soil quality. But early-season plant growth can be poorer in reduced-tillage systems than in conventional systems. The large amount of surface residue present in a no-till system can reduce seed zone temperatures. Lower-than-optimum soil temperature can reduce the rate of root growth and nutrient uptake by plants. Soils can also be wetter in the early spring with no-till systems. Wet soils can delay planting. Early-season planting is done so that silking will occur when temperature and rainfall are more favorable. Strip tillage may provide an environment that preserves the soil and provide nutrient-saving advantages of no-till while establishing a seed-bed that is similar to conventional tillage. The objectives of this experiment were to compare the effectiveness of strip tillage and no-till, and to assess the effects of fall application, spring application, or split applications of N-P-K-S fertilizer on growth, grain yield, and nutrient uptake of corn grown in strip-tillage or no-till systems.

## Procedures

This experiment was conducted at the North Central Kansas Experiment Farm near Belleville on a Crete silt loam soil to compare strip-tillage and no-till systems for dryland corn production. Fertilizer treatments consisted of 40, 80, or 120 lb N/a, with 30 lb $P_2O_5$/a, 5 lb $K_2O$/a, and 5 lb S/a. An unfertilized check plot also was included. In the strip-tillage system, fertilizer was either applied in the fall at the time of strip tilling or in the spring at planting. Fertilizer was applied in the spring at planting in the no-till system. Strip tillage was done in wheat stubble in early October in both years of the study. The zone receiving tillage was 5 to 6 inches in width. Fertilizer was placed 5 to 6 inches below the soil surface in the fall with the strip-till system. Spring-applied fertilizer was placed 2 inches to the side and 2 inches below the seed at planting. Nutrients were supplied as 28% UAN, ammonium polyphosphate (10-34-0), and potassium thiosulfate. Corn was planted in early April all 3 years of the experiment. Soil test phosphorus, potassium, and sulfur were in the "high" category.

## Results

Due to the very dry growing season in 2003, grain yields were very low, and response to applied N was variable. Strip tillage improved early-season growth, nutrient uptake, and grain yield of corn, compared with no-till (Table 1). When averaged over fertility treatment, strip-tilled plots reached mid-silk 7 days earlier than no-till plots. The early-season growth advantage seen in the strip-tilled plots carried over all the way to harvest. Grain moisture in the strip-tilled plots was 2.8% lower than in no-till plots. In this very dry year, yield advantage may have been the result of the increased rate of development in the strip-tillage system. The corn plants reached the critical pollination period sooner in the strip-tilled plants, while some stored soil water was still available. The soil water reserve was depleted one week later when the plants in the no-till plots reached mid-silk. In 2004, rainfall was above normal in May, June, and July, and grain yields were very good. A hail storm in early June did reduce plant population by an average of 12%, but surviving plants developed normally and grain yields were very good. When averaged over fertility treatment, strip-tilled plots yielded 16 bu/a more than no-till plots did (Table 2). As in 2003, early-season growth was increased and days from emergence to mid-bloom were decreased in the strip-tillage system. In 2005, weather was not as favorable during corn pollination as in 2004. Late June and early July were hot and dry, but this was followed by moderate temperatures and very favorable rainfall. Yields were still somewhat above average in 2005. Again, grain yields were improved by the use of strip tillage (Table 3).

Soil temperature in the early growing season was warmer in the strip-tillage system than in the no-till system in both 2003 and 2004 (Figures 1 and 2). Soil temperature differences between the two tillage systems persisted into late May. Although final stand did not differ in the two tillage systems, plant emergence in the strip-tillage system reached 100% 3 days sooner than in the no-till system. In all 3 years of the experiment, yields in the strip-tillage system were greater than in no-till at all levels of applied fertilizer (Tables 4, 5, and 6). Under Kansas conditions, fall-applied fertilizer was as effective as spring-applied fertilizer (Tables 7, 8, and 9). Splitting fertilizer application did not significantly improve yields over applying all in either the spring or the fall (Tables 10, 11, and 12).

Strip tillage proved to be an effective production practice in both low- and high-yielding environments. Strip tillage does provide a better early-season environment for plant growth and development, while still preserving a large amount of residue on the soil surface. This system may solve some of the major problems associated with conservation tillage, thus making it more acceptable to producers.

Table 1. Early-season growth, number of days from emergence to mid-silk, grain moisture at harvest, and yield of corn, averaged over fertility treatments, Belleville, Kansas, 2003.

| Treatment | V-6 Dry Weight | Days from Emergence to Mid-silk | Harvest Moisture | Yield |
|---|---|---|---|---|
| | lb/a | | % | bu/a |
| Strip-Tillage | 299 | 56 | 14.5 | 60 |
| No-Tillage | 168 | 66 | 17.5 | 45 |
| LSD (0.05) | 20 | 3 | 1.2 | 7 |

Table 2. Early-season growth, number of days from emergence to mid-silk, grain moisture at harvest, and yield of corn, averaged over fertility treatments, Belleville, Kansas, 2004.

| Treatment | V-6 Dry Weight | Days from Emergence to Mid-silk | Harvest Moisture | Yield |
|---|---|---|---|---|
| | lb/a | | % | bu/a |
| Strip-Tillage | 421 | 55 | 13.8 | 160 |
| No-Tillage | 259 | 66 | 16.2 | 144 |
| LSD (0.05) | 26 | 3 | 1.8 | 10 |

Table 3. Early-season growth, number of days from emergence to mid-silk, grain moisture at harvest, and yield of corn, averaged over fertility treatments, Belleville, Kansas, 2005.

| Treatment | V-6 Dry Weight | Days from Emergence to Mid-silk | Harvest Moisture | Yield |
|---|---|---|---|---|
| | lb/a | | % | bu/a |
| Strip-Tillage | 320 | 55 | 15.3 | 123 |
| No-Tillage | 188 | 64 | 17.6 | 111 |
| LSD (0.05) | 21 | 2 | 1.9 | 9 |

Table 4. Corn grain yield as affected by tillage and spring-applied fertilizer, Belleville, Kansas, 2003.

| Fertilizer | Grain Yield | |
|---|---|---|
| Treatment | Strip-till | No-till |
| lb/a | - - - - - - - - - bu/a - - - - - - - - - | |
| 40-30-5-5 | 52 | 45 |
| 80-30-5-5 | 60 | 48 |
| 120-30-5-5 | 71 | 51 |
| Average | 61 | 48 |
| LSD (0.05) | 5 | |

Table 5. Corn grain yield as affected by tillage and spring-applied fertilizer, Belleville, Kansas, 2004.

| Fertilizer | Grain Yield | |
|---|---|---|
| Treatment | Strip-till | No-till |
| lb/a | - - - - - - - - bu/a - - - - - - - - - - | |
| 40-30-5-5 | 161 | 146 |
| 80-30-5-5 | 174 | 159 |
| 120-30-5-5 | 186 | 165 |
| Average | 174 | 157 |
| LSD (0.05) | 8 | |

Table 6. Corn grain yield as affected by tillage and spring-applied fertilizer, Belleville, Kansas, 2005.

| Fertilizer | Grain Yield | |
|---|---|---|
| Treatment | Strip-till | No-till |
| lb/a | - - - - - - - - bu/a - - - - - - - - - | |
| 40-30-5-5 | 120 | 108 |
| 80-30-5-5 | 126 | 114 |
| 120-30-5-5 | 128 | 115 |
| Average | 125 | 112 |
| LSD (0.05) | 6 | |

Table 7. Corn grain yield as affected by fall- or spring-applied fertilizer in the strip-till system, Belleville, Kansas, 2003.

| | Grain Yield | |
|---|---|---|
| Fertilizer Treatment | Strip-till Fall Fertilize | Strip-till Spring Fertilize |
| lb/a | - - - - - - - - bu/a - - - - - - - - - | |
| 40-30-5-5 | 56 | 52 |
| 80-30-5-5 | 58 | 60 |
| 120-30-5-5 | 68 | 71 |
| Average | 61 | 61 |
| LSD (0.05) | 6 | |

Table 8. Corn grain yield as affected by fall- or spring-applied fertilizer in the strip-till system, Belleville, Kansas, 2004.

| | Grain Yield | |
|---|---|---|
| Fertilizer Treatment | Strip-till Fall Fertilize | Strip-till Spring Fertilize |
| lb/a | - - - - - - - - bu/a - - - - - - - - - | |
| 40-30-5-5 | 161 | 161 |
| 80-30-5-5 | 174 | 174 |
| 120-30-5-5 | 185 | 186 |
| Average | 173 | 174 |
| LSD ( 0.05) | 10 | |

Table 9. Corn grain yield as affected by fall- or spring-applied fertilizer in the strip-till system, Belleville, Kansas, 2005.

| | Grain Yield | |
|---|---|---|
| Fertilizer Treatment | Strip-till Fall Fertilize | Strip-till Spring Fertilize |
| lb/a | - - - - - - - - bu/a - - - - - - - - - | |
| 40-30-5-5 | 120 | 120 |
| 80-30-5-5 | 126 | 126 |
| 120-30-5-5 | 127 | 128 |
| Average | 124 | 125 |
| LSD ( 0.05) | 6 | |

Table 10. Corn grain yield as affected by timing of fertilizer application in the strip-till system, Belleville, Kansas, 2003.

| Fertilizer Treatment | Yield |
|---|---|
| | bu/a |
| 120-30-5-5 Fall | 68 |
| 120-30-5-5 Spring | 71 |
| 120-30-5-5 Split (2/3 fall, 1/3 spring) | 75 |
| LSD (0.05) | NS |

NS = Not significant

Table 11. Corn grain yield as affected by timing of fertilizer application in the strip-till system, Belleville, Kansas, 2004.

| Fertilizer Treatment | Yield |
|---|---|
| | bu/a |
| 120-30-5-5 Fall | 185 |
| 120-30-5-5 Spring | 186 |
| 120-30-5-5 Split (2/3 fall, 1/3 spring) | 186 |
| LSD (0.05) | NS |

NS = Not significant

Table 12. Corn grain yield as affected by timing of fertilizer application in the strip-till system, Belleville, Kansas, 2005.

| Fertilizer treatment | Yield |
|---|---|
| | bu/a |
| 120-30-5-5 Fall | 127 |
| 120-30-5-5 Spring | 128 |
| 120-30-5-5 Split (2/3 fall, 1/3 spring) | 125 |
| LSD (0.05) | NS |

NS = Not significant

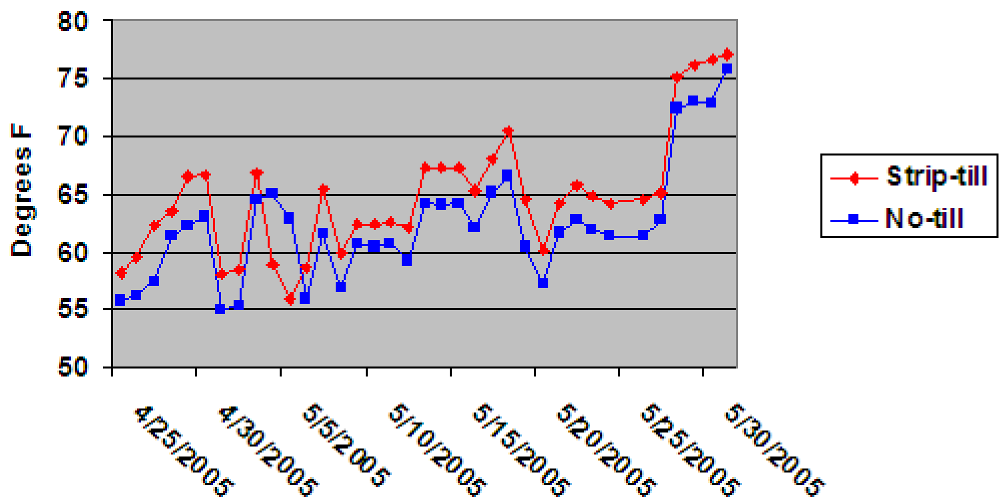


**Figure 1.** Soil temperature at planting depth, Belleville, Kansas, 2003.

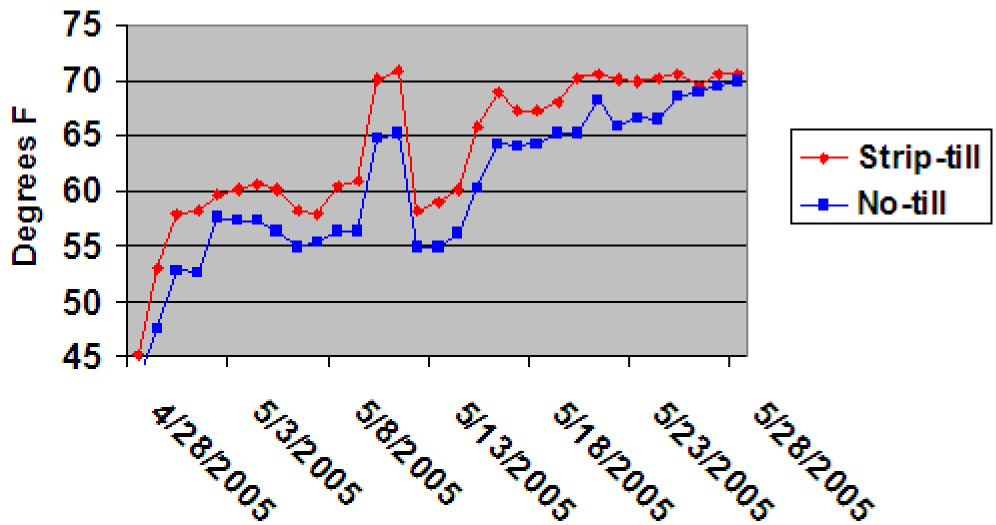


**Figure 2.** Soil temperature at planting depth, Belleville, Kansas, 2004.

# THE USE OF FOLIAR POTASSIUM FOR SOYBEAN PRODUCTION IN REDUCED TILLAGE SYSTEMS

**W.B. Gordon**

## Summary

Potassium (K) deficiency can be a problem on soils that have been managed with reduced-tillage practices. The large amount of residue left on the soil surface can depress soil temperature and interfere with plant growth, nutrient uptake, and, ultimately, grain yield. Soil temperature influences both K uptake by root and K diffusion through the soil.

The appearance of K deficiency in fields managed with conservation tillage has been reported with greater frequency in recent years and has become a concern for producers. In this experiment, preplant broadcast application of Trisert K+(5-0-20-13) was compared with a planting-time starter application of Trisert-K+ and foliar application at 3 growth stages of soybean. The experimental area had been in a ridge-tillage production system since 1984. All treatments improved soybean seed yield over the untreated check plot. Yields were maximized with either planting-time application of Trisert K+ in combination with foliar application of Trisert-K+ at early pod stage or two foliar applications of Trisert-K+ at early vegetative stage and again at early pod stage. Applying three foliar applications of Trisert K+ did not significantly improve yields over two applications. All treatments increased whole-plant K content at beginning seed fill (R5) over the untreated check. Tissue K content was greatest in the treatment receiving three foliar applications of 2.5 gal/a Trisert K+ .

## Introduction

The use of conservation tillage has increased in recent years because of its effectiveness in conserving soil and water. Potassium (K) deficiency can be a problem on soils that have been managed with reduced-tillage practices. The large amount of residue left on the soil surface can depress soil temperature early in the growing season. Low soil temperature can interfere with plant root growth, nutrient availability in soil, and crop nutrient uptake. Soil temperature influences both K uptake by roots and K diffusion through the soil. Low soil water content or zones of soil compaction also can reduce K availability.

In plant physiology, K is the most important cation, not only in regard to concentration in tissues but also with respect to physiological functions. A deficiency in K affects such important physiological processes as respiration, photosynthesis, chlorophyll development, and regulation of stomatal activity. Plants suffering from a K deficiency show a decrease in turgor, making resistance to drought poor. The main function of K in biochemistry is its function in activating many different enzyme systems involved in plant growth and development. Potassium also influences crop maturity and plays a role in reducing disease. The appearance of K deficiency in fields managed with conservation tillage has been reported with greater frequency in recent years and has become a concern for producers. The objective of these studies was to determine if K applied as a starter at planting, alone or in combination with foliar applications of K, could improve K uptake and yield of soybean on soils that had been managed in a ridge-tillage production system.

## Procedures

This field experiment was conducted in 2004 and 2005 on a Crete silt loam soil. The experimental area had been managed in a ridge-tillage system since 1984. Potassium deficiencies had been observed in this area before initiation of the study. Soil test results showed that initial pH was 6.5, organic matter was 2.5%, Bray-1 P and exchangeable K in the top 6 inches of soil were 26 and 280 ppm, respectively. Treatments consisted of the liquid fertilizer Trisert-K+ applied at 2.5 gal/a at the V5 (early vegetative) or R3 (early pod) stage of growth; Trisert-K+ applied at 5 gal/a at the V5 or R3 stages; 2.5 gal/a or 5 gal/a of Trisert-K+ applied at both the V5 and R3 stages of growth; starter-applied Trisert-K+; starter Trisert-K+ in combination with 2.5 gal/a or 5 gal/a Trisert-K+ applied at early pod; 2.5 gal/a Trisert-K+ applied at V5, R3, and R4; and Trisert-K+ applied preplant broadcast. An untreated check plot also was included. Trisert-K+ is a chlorine-free, clear liquid solution containing 5% nitrogen (N), 20% $K_2O$, and 13% sulfur (S). Each gallon of Trisert-K+ contains 0.58 lb N, 2.34 lb $K_2O$, and 1.55 lb sulfur. Starter fertilizer was applied 2 inches to the side and 2 inches below the seed at planting. Foliar fertilizer was applied with a back-pack sprayer using a total spray volume of 20 gal/a. Broadcast applications were made 5 days before planting. The experiment was furrow-irrigated. The Roundup Ready® soybean variety Asgrow 3303 was planted in early May each year at the rate of 12 seeds/ft. The V5 application was made on 5 June in 2004 and 6 June in 2005. The R3 application was made on 8 July and 12 July in 2004 and 2005, respectively, and the R4 application was made on Aug 17 in 2004 and on 13 Aug in 2005.

## Results

All K fertilizer treatments improved soybean yields and whole-plant K concentration over the untreated check plot, except for the broadcast application (Table 1). Seed yields were maximized with either starter application of Trisert-K+ in combination with foliar application of either 2.5 gal/a or 5 gal/a of Trisert-K+ applied at early pod stage or with two foliar applications of Trisert-K+ at 5 gal/a applied at the early vegetation stage and again at early pod. Three foliar applications of Trisert-K+ did not improve yields over two applications. Seed yield was 5 bu/a greater when starter fertilizer was combined with a single foliar application of Trisert-K+ at the early pod stage than when starter was applied alone. Broadcast application of fertilizer containing K was not as effective as starter plus foliar-applied fertilizer.

Table 1. Potassium fertilizer application effects on soybean yield, Scandia, Kansas, 2004-2005.

| | Yield | | Whole Plant K at Early Pod | |
|---|---|---|---|---|
| Treatment | 2004 | 2005 | 2004 | 2005 |
| | - - - - - bu/a - - - - - | | - - - - - % - - - - - | |
| Trisert-K+- 2.5 gal/a at V5 | 75.7 | 75.9 | 3.12 | 3.10 |
| Trisert-K+-5 gal/a at V5 | 81.6 | 75.9 | 3.32 | 3.33 |
| Trisert-K+- 2.5 gal/a at R3 | 84.9 | 76.5 | 3.54 | 3.51 |
| Trisert-K+- 5.0 gal/a at R3 | 85.6 | 78.6 | 3.48 | 3.47 |
| Trisert-K+- 2.5 gal/a at V5+R3 | 89.3 | 86.2 | 3.57 | 3.51 |
| Trisert-K+ -5gal/a at V5+R3 | 91.8 | 90.1 | 3.66 | 3.68 |
| Starter Trisert-K+-5 gal/a | 85.3 | 78.0 | 3.20 | 3.15 |
| Starter Trisert-K+ plus Trisert-K+- 2.5 gal/a at R3 | 90.7 | 88.6 | 3.59 | 3.62 |
| Starter Trisert-K+ plus TrisertK+- 5 gal/a at R3 | 92.9 | 90.8 | 3.67 | 3.68 |
| Preplant Broadcast KTS | 83.1 | 74.2 | 3.08 | 3.00 |
| Trisert-K+ 2.5 gal/a at V5+R3+R4 | 91.5 | 87.6 | 3.72 | 3.77 |
| Untreated check | 69.5 | 70.1 | 2.82 | 2.67 |
| LSD (0.05) | 2.5 | 2.2 | 0.75 | 0.64 |

# CONTROLLED-RELEASE UREA FOR IRRIGATED CORN PRODUCTION

**W.B. Gordon**

## Summary

No-till production systems are being used by an increasing number of producers in the central Great Plains because of several advantages that include reduction of soil erosion, increased soil water use-efficiency, and improved soil quality. But the large amount of residue left on the soil surface can make nitrogen (N) management difficult. Surface applications of fertilizers containing urea are subject to volatilization losses. Leaching can also be a problem on course-textured soils when N is applied in one preplant application. Slow-release polymer-coated urea products are beginning to become available for agricultural use. The polymer coating allows the urea to be released at a slower rate than uncoated urea would be.

This experiment compared urea, a controlled-release polymer-coated urea (ESN), and ammonium nitrate at 3 nitrogen (N) rates (80, 160, and 240 lb/a). Split applications (1/2 preplant + 1/2 at V4 stage) at the 160 lb N/a rate also were included for urea, ammonium nitrate, and ESN. The V4 application of all the materials was applied in a surface band. Only the preplant applications were broadcast. Other treatments included preplant applications of UAN broadcast and banded, and urea plus the urease inhibitor Agrotain®. The study was conducted at the North Central Kansas Experiment Field on a Crete silt loam soil. The study was furrow-irrigated.

The coated urea product, ESN, resulted in greater yield than urea did at all N rates. Ammonium nitrate and ESN yields were essentially the same at all N rates. Grain yield was excellent in 2005. Yield increased with increasing N rate up to the 160 lb/a rate with ESN and ammonium nitrate, but continued to increase up to the 240 lb/a rate with uncoated urea. Applying 160 lb N/a in two split applications did not improve yields over applying all N preplant. Applying UAN broadcast was not effective as applying in a dribble band. Applying urea with the urease inhibitor was much more effective than urea alone. The polymer-coated urea product has the potential to make surface application of N in no-till systems more efficient.

## Introduction

Conservation-tillage production systems are being used by an increasing number of producers in the Great Plains because of several inherent advantages. These advantages include reduction of soil erosion losses, increased soil water use-efficiency, and improved soil quality. The large amount of residue left on the soil surface in no-till systems can make N management difficult. Surface application of N fertilizers is a popular practice with producers. When N fertilizers containing urea are placed on the soil surface, they are subject to volatilization losses. Nitrogen immobilization can also be a problem when N fertilizers are surface applied in high-residue production systems. Nitrogen leaching can be both an agronomic and environmental problem on course-textured soils. Polymer-coated urea has the potential to make N management more efficient when surface applied in no-till systems.

## Procedures

This experiment was conducted at the North Central Kansas Experiment Field on a Crete silt loam soil. Soil pH was 6.5, organic matter was 2.15, Bray-1 P was 44 ppm, and exchangeable K was 325 ppm. The corn hybrid DeKalb DKC60-19 was planted without tillage into corn stubble on April 22, 2004, at the rate of 31,000 seeds/a. Nitrogen was applied on the soil surface immediately after planting. Split applications consisted of 1/2 of the N applied immediately after planting and 1/2 applied at the V4 stage. Preplant treatments were all broadcast and V4 treatments were banded. Treatments consisted of controlled-release polymer-coated urea (ESN), urea, and ammonium nitrate, applied at 3 rates (80, 160, and 240 lb/a). A no-N check plot also was included.

Additional treatments were split applications of CRU, urea, ammonium nitrate, UAN (28% N) broadcast and applied in a dribble band, and urea plus the urease inhibitor, Agrotain®, at the 160 lb N/a rate. The experimental area was adequately irrigated throughout the growing season. Plots were harvested on October 28, 2005.

## Results

The ESN controlled-release urea product gave greater corn yield than urea did at all levels of N (Table 1). Yields achieved with ESN application were equal to those with ammonium nitrate. Lower yields with urea indicate that volatilization of N may have been a significant problem. Splitting applications of N did not improve corn yields with any of the materials. Weather conditions were good and yields were excellent. Yields increased with increasing N rate up to the 160 lb/a rate, except with urea, for which yields continued to increase with increasing N up to the 240 lb/a rate. Applying UAN in a dribble band was more effective than broadcasting, and applying urea with the urease inhibitor Agrotain® was more effective than urea alone.

Results of this study suggest that slow-release polymer-coated urea can improve N use efficiency, compared with that of urea and UAN, when surface applied in no-till conditions.

Table 1. Effects of N source and rate on corn grain yield and earleaf N, Scandia, Kansas, 2005.

| N | N | Yield | | Earleaf N | |
|---|---|---|---|---|---|
| Source | Rate | 2005 | 3-Yr Avg | 2005 | 2003-2005 |
| | lb/a | - - - - - bu/a - - - - - | | - - - - - - % - - - - - | |
| | 0-N check | 139 | 127 | 1.78 | 1.74 |
| ESN | 80 | 192 | 177 | 2.93 | 2.43 |
| | 160 | 215 | 199 | 3.08 | 2.63 |
| | 240 | 218 | 215 | 3.10 | 2.63 |
| Urea | 80 | 167 | 155 | 2.79 | 2.25 |
| | 160 | 183 | 171 | 2.90 | 2.36 |
| | 240 | 192 | 194 | 2.95 | 2.46 |
| Am. Nitrate | 80 | 196 | 183 | 2.95 | 2.45 |
| | 160 | 219 | 202 | 3.10 | 2.56 |
| | 240 | 217 | 214 | 3.12 | 2.61 |
| ESN | 80+ 80 split | 216 | 197 | 3.09 | 2.57 |
| Urea | 80+80 split | 188 | 178 | 2.92 | 2.41 |
| Am. nitrate | 80+80 split | 220 | 202 | 3.08 | 2.58 |
| 28% UAN broad | 160 | 185 | 189* | 2.97 | --- |
| 28% UAN dribble | 160 | 210 | 207* | 3.02 | --- |
| Urea + Agrotain® | 160 | 215 | 212* | 3.10 | --- |
| LSD (0.05) | | 6 | | 0.09 | 0.07 |

* 2-year averages (2004 and 2005).

# IMPROVING THE EFFICIENCY OF PHOSPHORUS FERTILIZERS

W.B. Gordon

## Summary

Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or $HPO_4^{-2}$, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of limited water solubility. Crop recovery of applied P fertilizer can be quite low during the season of application. Specialty Fertilizer Products[1] has developed and patented a family of dicarboxylic co-polymers that can be used as a coating on granular phosphate fertilizers or mixed into liquid phosphate fertilizers. The registered trade name for the new product is AVAIL[1]. The polymer is reported to sequester antagonistic cations out of the soil solution, thus keeping P fertilizer in a more available form for plant uptake.

To evaluate the effectiveness of the AVAIL product, experiments were conducted at the North Central Kansas Experiment Field during 2001 through 2004, in which mono-ammonium phosphate (MAP, 11-52-0) coated with AVAIL was used on both corn and soybean. In 2004, AVAIL also was evaluated in liquid ammonium polyphosphate fertilizer (10-34-0) applied as a starter for corn production. Treatments in the corn experiment consisted of applying MAP at rates to give 20, 40, or 60 lb $P_2O_5$/a, either treated with AVAIL or untreated. A no-P check plot also was included. The soybean experiment consisted of applying either treated or untreated MAP at rates to give 30 or 60 lb $P_2O_5$/a. A no-P check was again included. The phosphate fertilizer was banded beside the row in both the corn and soybean experiments. The liquid starter experiment consisted of a no-starter check and a 30-30-5 treatment, applied alone or with AVAIL at a 2% rate. Fertilizer was placed 2 inches to the side and 2 inches below the seed at planting. Soil test P values were in the "medium" category in all experiments.

When averaged over years and P rates, the AVAIL-treated MAP increased corn grain yield by 18 bu/a over the untreated MAP. Tissue P concentration was greater in the AVAIL-treated plots than in untreated plots at both the 6-leaf stage and at mid-silk. When averaged over years and P rates, soybean yield was improved by 9 bu/a by the use of AVAIL-treated P fertilizer. In 2004, liquid starter fertilizer mixed with a 2% solution of AVAIL increased corn grain yield by 13 bu/a over the untreated starter treatment. Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL increased P uptake and yield of corn and soybean.

## Introduction

Phosphorus occurs in soils mainly as inorganic P compounds but also as low concentrations of P in the soil solution. Most soils contain relatively small amounts of total P, and only a small fraction of the total P is available to plants. Most inorganic P compounds in soils have a very low solubility. Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or $HPO_4^{-2}$, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of very limited water solubility. Crop recovery of applied P fertilizer can be quite low during the season of application. Specialty Fertilizer Products has developed and patented a family of dicarboxylic co-polymers that can be used as a coating on granular phosphate fertilizer or mixed into liquid phosphate fertilizers. The registered trade name of the new product is AVAIL. The polymer is reported to sequester antagonistic cations out of the soil solution, thus keeping P fertilizer in a more available form for plant uptake. The objective of this research was to

[1]Mention of a commercial company or a trade name does not imply endorsement by the author or his institution. AVAIL is a registered trademark of Specialty Fertilizer Products, Belton, MO.

evaluate the use of AVAIL with phosphorus fertilizer for corn and soybean production.

## Procedures

Experiments were conducted during 2001 through 2004 at the North Central Kansas Experiment Field on a Crete silt loam soil to evaluate the effectiveness of the dicarboxylic polymer, AVAIL, in increasing P availability and yield of corn and soybean. The corn experiment consisted of applying granular MAP (11-52-0) at rates to give 20, 40, or 60 lb $P_2O_5$/a, either treated with 2% AVAIL or untreated. A no-P check plot also was included. The MAP fertilizer was sub-surface banded at planting. Soil test values at the experimental site were: organic matter, 2.8%; pH , 6.2; and Bray-1 P, 22 ppm. A liquid fertilizer starter test was conducted with corn in 2004. Treatments consisted of liquid starter (30-30-5), applied with or without 2% AVAIL. A no-starter check also was included. The fertilizer was placed 2 inches to the side and 2 inches below the seed at planting. The soybean experiment consisted of applying granular MAP at rates to give 30 or 60 lb $P_2O_5$/a, either with or without AVAIL, plus a no-P check. As in the corn experiment, the MAP was applied in a sub-surface band at planting. Soil test values were: organic matter, 2.5%; pH, 6.7; and Bray-1 P, 23 ppm. Because MAP contains nitrogen and rates were calculated on the basis of P content, N in the form of ammonium nitrate was added so that all treatments received the same amount of N. All experiments were irrigated.

## Results

When averaged over years and P rates, the AVAIL-treated MAP increased corn grain yield by 18 bu/a over the untreated MAP (Table 1). The AVAIL-treated MAP gave greater grain yield at all rates of applied P. Earleaf P concentration at silking was greater in the AVAIL-treated plots than in the untreated plots (Table 2). The use of AVAIL with P fertilizer did result in improved plant P uptake. When AVAIL was applied with liquid starter fertilizer, yields were increased by 13 bu/a over the untreated starter (Table 3). Phosphorus uptake in the AVAIL-treated plots was greater than in the untreated plots at both the 6-leaf stage and at silking.

When averaged over years and P rates, plots treated with MAP plus AVAIL increased soybean yield by 9 bu/a over the untreated-MAP plots (Table 4). Phosphorus uptake at the full bloom stage was increased by the use of AVAIL applied with MAP (Table 5). Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL with P fertilizer increased plant P uptake and yield of corn and soybean.

Table 1. Corn yield response to phosphorus and AVAIL.

| Treatment | 2001 | 2002 | 2003 | Average |
|---|---|---|---|---|
| lb/a $P_2O_5$ | - - - - - - - - - - | - - - - - - - - - bu/a | - - - - - - - - - - | - - - - - - - - - |
| 20 untreated | 188 B* | 142 D | 182 D | 171 D |
| 40 untreated | 191 B | 169 C | 188 C | 182 CD |
| 60 untreated | 190 B | 173 BC | 195 BC | 186 BC |
| 20 + AVAIL | 194 B | 173 BC | 210 B | 192ABC |
| 40 + AVAIL | 195 B | 190 AB | 210 A | 198AB |
| 60 + AVAIL | 209 A | 194 A | 210 A | 204A |
| Check | 174 C | 120 E | 169 A | 154 E |
| LSD (0.05) | 9 | 17 | 10 | 12 |

* Means separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 2. Applied phosphorus and AVAIL effects on corn earleaf P concentration.

| Treatment | 2001 | 2002 | 2003 | Average |
|---|---|---|---|---|
| lb/a $P_2O_5$ | - - - - - - - - - - - - - - - - - - - - bu/a - - | - - - - - - - - - - - - - - - - - - - | | |
| 20 untreated | 0.229 D* | 0.229 E | 0.238 D | 0.232 D |
| 40 untreated | 0.239 C | 0.247 CD | 0.248 C | 0.245 C |
| 60 untreated | 0.251 B | 0.257 B | 0.255 B | 0.254 B |
| 20 + AVAIL | 0.236 C | 0.240 D | 0.244C | 0.240 C |
| 40 + AVAIL | 0.257 A | 0.253 BC | 0.258 B | 0.256 B |
| 60 +AVAIL | 0.261 A | 0.274 A | 0.265 A | 0.267 A |
| Check | 0.199 E | 0.212 F | 0.204 E | 0.205 E |
| LSD (0.05) | 0.005 | 0.007 | 0.006 | 0.006 |

* Means separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 3. AVAIL in liquid starter fertilizer, 2004.

| Treatment | Yield | V6 P Uptake | Earleaf P |
|---|---|---|---|
| | bu/a | lb/a | % |
| No starter | 223 | 1.45 | 0.232 |
| Starter | 247 | 1.98 | 0.267 |
| Starter + 2% AVAIL | 260 | 2.39 | 0.302 |
| LSD (0.05) | 8 | 0.20 | 0.013 |

Table 4. Soybean yield response to phosphorus and AVAIL.

| Treatment | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|
| lb/a $P_2O_5$ | - - - - - - - - - - - - - - - - - - bu/a | - - - - - - - - - - - - - - - - - - - | | |
| 30 untreated | 62 C* | 41 C | 69 C | 58 C |
| 60 untreated | 62 C | 48 B | 74 B | 61 B |
| 30 + AVAIL | 70 B | 57 A | 78 A | 68 A |
| 60 +AVAIL | 73 A | 58 A | 79 A | 70 A |
| Check | 52 D | 32 D | 60 D | 48 D |
| LSD (0.5) | 2 | 3 | 1 | 2 |

*Means were separated by using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 5. Applied phosphorus and AVAIL effects on whole-plant P uptake at full bloom.

| Treatment | 2002 | 2003 | 2004 | Average |
|---|---|---|---|---|
| lb/a $P_2O_5$ | - - - - - - - - - - - - - - - - - - - bu/a- - | - - - - - - - - - - - - - - - - - - - | | |
| 30 untreated | 6.51 C | 7.37 D | 9.64 C | 7.84 B |
| 60 untreated | 6.86 BC | 8.02 C | 10.84 B | 8.57 B |
| 30 + AVAIL | 8.56 AB | 9.16 B | 13.13 A | 10.28 A |
| 60 + AVAIL | 10.20 A | 10.18 A | 12.91 A | 11.09 A |
| Check | 4.17 D | 4.67 E | 5.37 D | 4.64 C |
| LSD (0.05) | 1.15 | 0.91 | 0.45 | 0.83 |

# MAXIMIZING IRRIGATED SOYBEAN YIELDS IN THE GREAT PLAINS

W.B. Gordon

## Summary

In 2004, studies were initiated seeking ways to maximize soybean yields in the central Great Plains. Treatments included row spacing (30- and 7.5-inch rows) plant population (150,000 and 225,000 plants/a), and 7 fertility treatments. Fertility treatments consist of a low P application (KSU soil test recommendations would be 30 lb $P_2O_5$/a at this site), low P-low K, low P-high K, high P-high K, N-P-K, and an unfertilized check plot. In 2005, a treatment was added consisting of 5 lb Mn/a in addition to N-P-K. Phosphorus application rates were 30 or 80 lb $P_2O_5$/a, and K treatments were 80 or 120 lb $K_2O$/a. The N-P-K treatment consisted of application of 20 lb N/a, 80 lb $P_2O_5$/a, and 120 lb $K_2O$/a. Fertilizer was broadcast in mid-March each year. Soybean was sprinkler irrigated. Planting dates were May 8, 2004, and May 10, 2005. Harvest dates were in mid-October each year.

In 2004, increasing plant populations did not increase grain yields nor did reducing row spacing from 30 to 7.5 inches. Increasing plant population in narrow rows reduced yield. Soybean yields did respond to fertilizer application. Applying 80 lb $P_2O_5$/a with 60 lb $K_2O$/a increased yield by 32 bu/a over the unfertilized check plot. Applying additional K or adding N to the mix did not increase yields. Increasing plant population at lower fertility rates decreased yield.

In 2005, soybean yield was not affected by row spacing or plant population, nor was yield affected by any interaction of factors. Fertility treatments did have a dramatic effect on soybean yield. Applying 80 lb $P_2O_5$ /a with 60 lb $K_2O$/a increased yield by 33 bu/a over the unfertilized check plot. Applying additional K or N did not result in any yield increase, but addition of Mn to the mix did significantly increase yield. In high-yield environments, soybean yields can be greatly improved by direct fertilization.

## Introduction

Analysis of corn yield data from hybrid performance tests in Kansas shows that corn yields have increased by an average of 2.5 bu/a per year. Soybean yield trends in performance tests have also been on an upward trend. But average state-wide yields in Kansas have not increased. In a corn-soybean rotation, fertilizer typically is only applied during the corn phase of the rotation. On a per-bushel basis, soybean removes twice as much phosphorus and almost 5 times as much potassium as corn does. To capitalize on genetic improvements in yield, levels of plant nutrients must not be limiting. Other production practices such as plant population and row spacing may interact with fertility management to influence crop yields.

## Procedures

The experiment was conducted on a Crete silt loam soil at the North Central Kansas Experiment Field and included soybean planted at two row spacings (30 and 7.5 inches) and two plant populations (150,000 and 225,000 plants/a). Fertility treatments consisted of a low P application (KSU soil test recommendations would be 30 lb $P_2O_5$/a at this site), low P-low K, low P-high K, high P- high K, N-P-K, N-P-K-Mn, and an unfertilized check plot. Phosphorus application rates were 30 or 80 lb $P_2O_5$/a, and K treatments were 80 or 120 lb $K_2O$/a. The N-P-K treatment consisted of application of 20 lb N/a, 80 lb $P_2O_5$/a, and 120 lb $K_2O$/a. The N-P-K-Mn consisted of the same N-P-K treatment plus 5 lb Mn/a. Soil test values were: pH, 6.9; Bray-1 P, 21 ppm; and exchangeable K, 210 ppm. Fertilizer was broadcast in mid-March. The soybean variety Asgrow 3305 was planted on May 8 in 2004 and on May 10 in 2005. Soybean was sprinkler irrigated.

## Results

In neither year of the experiment did increasing plant populations or reducing row spacing result in any increase in yield. In 2004, increasing plant population in narrow rows actually reduced yield. Soybean yields did respond to fertilizer application. Applying 80 lb $P_2O_5$ /a with 60 lb $K_2O$/a increased yield by 32 bu/a over the unfertilized check plot. Applying additional K or adding N to the mix did not increase yields. Increasing plant population at lower fertility rates decreased yield. In 2005, soybean yield was not affected by row spacing or plant population, nor was yield affected by any interaction of factors. Fertility treatments did have a dramatic effect on soybean yield. Applying 80 lb $P_2O_5$/a with 60 lb $K_2O$/a increased yield by 33 bu/a over the unfertilized check plot. Applying additional K or N did not result in any yield increase, but addition of Mn to the mix did significantly increase yield.

Table 1. Soybean yield as affected by row spacing and plant population (average over fertility treatments), 2004.

| Row | Yield | |
|---|---|---|
| Space | 150,000 plants/a | 255,000 plants/a |
| | ----------- bu/a ----------- | |
| 30 inches | 76 | 77 |
| 7.5 inches | 77 | 73 |
| LSD (0.05) | 3 | |

Table 2. Plant population and fertility effects on soybean yield (average over row spacing), 2004.

| Treatments | 150,000 plants/a | 225,000 plants/a |
|---|---|---|
| | ----------- bu/a ----------- | |
| Check | 53 | 43 |
| Low P | 61 | 53 |
| Low P-Low K | 73 | 69 |
| Low P-High K | 77 | 77 |
| High P-Low K | 85 | 85 |
| High P-High K | 85 | 84 |
| N-P-K | 86 | 85 |
| LSD (0.05) | 2 | |

Table 3. Soybean yield as affected by row spacing and plant population (average over fertility treatments), 2004.

| Row | Yield | |
|---|---|---|
| Space | 150,000 plants/a | 255,000 plants/a |
| | ----------- bu/a ----------- | |
| 30 inches | 78 | 80 |
| 7.5 inches | 80 | 78 |
| LSD (0.05) | NS* | |

* NS = Not Significant

Table 4. Fertility effects on soybean yield, 2005[†]

| Treatments | |
|---|---|
| | bu/a |
| Check | 55 |
| Low P | 63 |
| Low P-Low K | 76 |
| Low P-High K | 81 |
| High P-Low K | 88 |
| High P-High K | 89 |
| N-P-K | 88 |
| N-P-K-Mn | 93 |
| LSD (0.05) | 3 |

[†] Average over row spacing and plant population.

# MANGANESE NUTRITION OF GLYPHOSATE-RESISTANT AND CONVENTIONAL SOYBEAN

**W.B. Gordon**

## Summary

There is evidence to suggest that insertion of the gene that imparts glyphosate resistance in soybean may have altered physiological processes that affect manganese (Mn) uptake and metabolism. This study was conducted to determine if glyphosate-resistant soybean responds differently to applied Mn than conventional soybean does. The glyphosate-resistant soybean variety KS 4202 RR and its conventional isoline were grown on a Crete silt loam soil with a pH of 6.9 at the North Central Kansas Experiment Field. Granular manganese sulfate was applied in late April to give rates of 2.5, 5, and 7.5 lb Mn/a. A no-Mn check plot also was included. Soybean was planted without tillage on May 10, 2005. The experiment was sprinkler irrigated. Yield of the conventional soybean variety was 12 bu/a greater than yield of its glyphosate-tolerant isoline. Addition of Mn improved yield of the glyphosate-resistant variety, but the yield of the conventional isoline decreased with increasing Mn rate.

## Introduction

There is evidence to suggest that yields of glyphosate-resistant soybean may still lag behind that of conventional soybean. Many farmers have noticed that soybean yields, even under optimal conditions, are not as high as expected. In Kansas, average yield seldom exceeds 60 to 65 bu/a, even when soybean is grown with adequate rainfall and/or supplemental irrigation water. The addition of the gene that imparts herbicide resistance may have altered other physiological processes. Some scientists suggest that soybean root exudates have been changed and that plants no longer solublize enough soil manganese. Application of glyphosate also may retard manganese metabolism in the plant. Addition of supplemental manganese at the proper time may correct deficiency symptoms and result in greater soybean yields. There currently is little information on manganese fertilization of soybean in Kansas.

The objective of this research was to determine if glyphosate-resistant soybean responds differently to applied manganese than conventional soybean does and, if so, to develop fertilization strategies that will prevent or correct deficiencies, leading to improved yield for soybean producers.

## Procedures

The glyphosate-resistant soybean variety KS 4202 RR and its conventional isoline were grown on a Crete silt loam soil with sprinkler irrigation. The soil pH in the top 6 inches of soil at the site was 6.9. Manganese (Mn) fertilizer treatment was banded pre-plant soil applications of manganese sulfate at rates of 2.5, 5, or 7.5 lb/a. A no-Mn check treatment was also included. The experimental design was a randomized complete block with a split-plot arrangement. Whole plots were herbicide-resistant and conventional soybean varieties (isolines of KS 4202) and split plots were Mn rates and sources.

## Results

Yields were affected by an interaction between soybean variety and Mn rate. In the glyphosate-resistant variety KS 4202 RR, yields increased with addition of Mn up to the 5 lb/a rate. Yield of the conventional variety KS 4202 was 12 bu/a greater than its glyphosate–resistant isoline KS 4202RR when no Mn was added. Yield of the conventional variety declined with increasing Mn rate. Tissue Mn concentration (uppermost expanded trifoliate at full bloom) in the herbicide-resistant isoline was less than half that of the conventional variety when no Mn was applied.

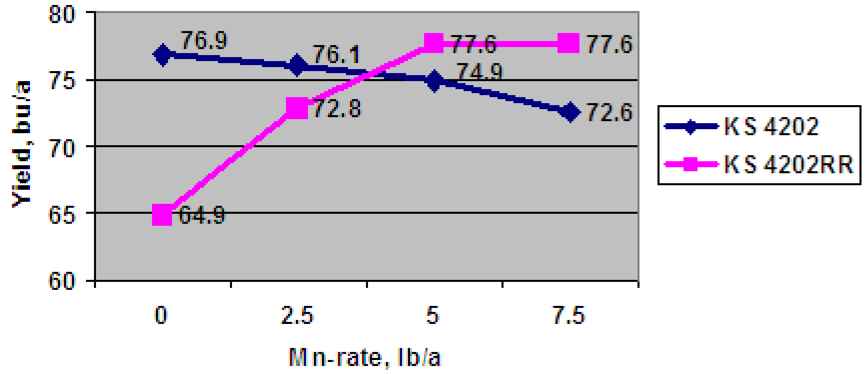


**Figure 1.** Soybean yield response to applied manganese.

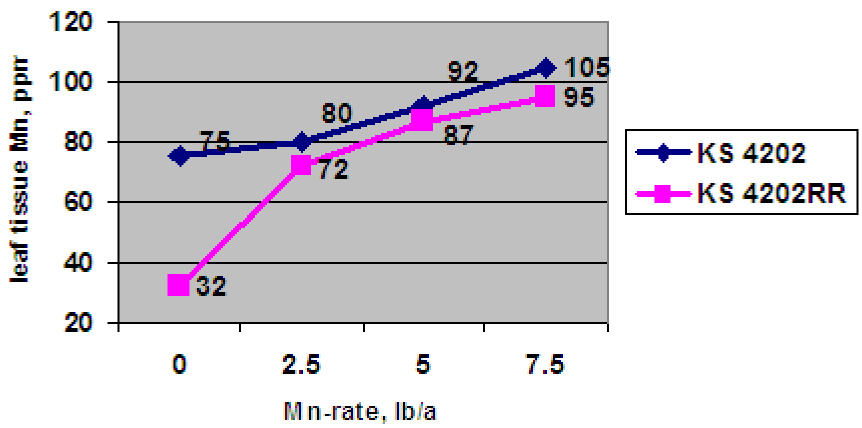


**Figure 2.** Soybean leaf tissue Mn concentration (uppermost expanded trifoliate at full bloom).

# SOIL FERTILITY RESEARCH
# HARVEY COUNTY EXPERIMENT FIELD

## EFFECTS OF LATE-MATURING SOYBEAN AND SUNN HEMP SUMMER COVER CROPS AND NITROGEN RATE ON NO-TILL GRAIN SORGHUM AFTER WHEAT

**M.M. Claassen**

### Summary

Late-maturing Roundup Ready® soybean and sunn hemp drilled in wheat stubble at 60 and 10 lb/a, respectively, produced an average of 2.11 and 3.19 ton/a of above-ground dry matter. Corresponding nitrogen (N) yields of 90 and125 lb/a were potentially available to the succeeding grain sorghum crop. Following cover crops, grain sorghum leaf N concentrations were generally higher at all but the highest rate of fertilizer N. When averaged across N fertilizer rates, soybean and sunn hemp significantly increased sorghum leaf nutrient levels, by 0.15% N and 0.16% N, respectively. Cover crops did not affect grain sorghum plant population, the length of time to reach half bloom stage, or grain test weight. Soybean increased sorghum yields at all but the 90 lb N/a rate, whereas sunn hemp in the rotation improved yields at all N rates. The positive effect of soybean and sunn hemp cover crops was seen in respective sorghum yield improvements of 9.7 and 13.4 bu/a when averaged over N rate. Averaged over cropping systems, yields increased significantly with each 30 lb/a increment of fertilizer N.

### Introduction

Research at the KSU Harvey County Experiment Field over an 8-year period explored the use of hairy vetch as a winter cover crop following wheat in a winter wheat-sorghum rotation. Results of long-term experiments showed that, between September and May, hairy vetch can produce a large amount of dry matter with an N content on the order of 100 lb/a. But significant disadvantages also exist in the use of hairy vetch as a cover crop. These include cost and availability of seed, interference with control of volunteer wheat and winter annual weeds, and the possibility of hairy vetch becoming a weed in wheat after sorghum.

New interest in cover crops has been generated by research in other areas showing the positive effect these crops can have on the overall productivity of no-till systems. In a 2002 pilot project at Hesston, a Group VI maturity soybean grown as a summer cover crop after wheat produced 2.25 ton/a of above-ground dry matter and N yield of 87 lb/a potentially available to the succeeding crop. Soybean cover crop did not affect grain sorghum yield in the following growing season, but, when averaged over N rate, resulted in a 0.15% N increase in flag leaves.

In the current experiment, late-maturing soybean and sunn hemp, a tropical legume, were evaluated as summer cover crops for their impact on no-till sorghum grown in the spring following wheat harvest. In the first cycle of these rotations, the two cover crops produced N yields of 146 and 119 lb/a, respectively. Sunn hemp increased grain sorghum yields by 10.6 bu/a, whereas soybean did not impact sorghum grain production in a season with considerable drought stress. Data presented for 2005 represent the second cycle of wheat-grain sorghum rotations, without and with soybean and sunn hemp cover crops.

### Procedures

The experiment was established on a Geary silt loam site that had been used for hairy vetch cover crop research in a wheat-sorghum rotation from 1995 to 2001. In keeping with the previous experimental design, soybean and sunn hemp were assigned in 2002 to plots where vetch had been grown, and the remaining plots retained the treatment with no cover crop. The existing factorial arrangement of N rates on each cropping system also was retained. The second cyle of these cropping systems with summer cover crops was initiated after wheat harvest in 2004. Weeds in wheat stubble were controlled with Roundup Ultra Max II®

herbicide applied 9 days before cover crop planting. Asgrow AG701 Roundup Ready® soybean and sunn hemp seed were treated with respective rhizobium inoculants and no-till planted in 8-inch rows with a CrustBuster stubble drill on July 9 at 60 lb/a and 10 lb/a, respectively. Sunn hemp began flowering in mid-September, and was terminated at that time by a combination of rolling with a crop roller and applying 22 oz/a of Roundup Ultra Max II®. Soybean was rolled after initial frost in early October. Forage yield of each cover crop was determined by harvesting a 3.28 $ft^2$ area in each plot just before termination. Samples subsequently were analyzed for N content.

Weeds were controlled during the fallow period after cover crops with Roundup Ultra Max II®, 2,4-$D_{LVE}$, and Clarity®. Pioneer 8500 grain sorghum treated with Concept® safener and Cruiser® insecticide was planted at approximately 42,000 seeds/a on May 23, 2005. Atrazine and Dual II Magnum® were applied preemergence for residual weed control shortly after sorghum planting.

All plots received 37 lb of $P_2O_5$/a banded as 0-46-0 at planting. Nitrogen fertilizer treatments were applied as 28-0-0 injected at 10 inches from the row on June 27, 2005. Grain sorghum was combine harvested on September 15.

## Results

During the 9 days preceding cover crop planting, rainfall totaled 1.82 inches. The next rains occurred about two weeks after planting, when 4 inches were received over a 3-day period. Stand establishment was good with both soybean and sunn hemp. Although July rainfall in 2004 was above normal, August and September were drier than usual. Late-maturing soybean reached an average height of 24 inches, showed limited pod development, and produced 2.11 ton/a of above-ground dry matter with an N content of 2.11%, or 90 lb/a (Table 1). Sunn hemp averaged 72 inches in height and produced 3.19 ton/a dry matter with 1.95% N, or 125 lb/a of N. Soybean and sunn hemp suppressed volunteer wheat to some extent, but failed to give the desired level of control ahead of the wheat planting season.

Grain sorghum emerged on May 30, 2005, with final stands averaging 31,795 plants/a. In July and August, average temperatures were 2.1 to 2.7 °F below normal, whereas September was 2.7 °F warmer than usual. During these months, there were only 2 days with temperatures at or above 100 °F. July rainfall was somewhat below normal, resulting in periods of limited drought stress. August brought abundant rains totaling 7 inches, mainly in the second half of the month. September was dry, with less than half of the long-term average rainfall.

Cover crops had no effect on sorghum population or the length of time from planting to half bloom. Both cover crops significantly increased leaf N concentration of sorghum. Across N rates, these increases averaged 0.15% N and 0.16% N, respectively, for soybean and sunn hemp. The positive effect of cover crops on sorghum leaf N concentration was significant at each level of fertilizer N except the 90 lb/a rate following soybean. Cover crops tended to increase the number of heads per sorghum plant slightly. When averaged over N rate, soybean and sunn hemp significantly increased grain sorghum yields, by 9.7 and 13.4 bu/a, respectively. Sorghum test weights were not affected by cover crops.

Nitrogen rates increased the number of sorghum heads per plant and the N content of sorghum leaves. Leaf N increased with each 30 lb/a increment of N fertilizer in all crop rotations except with the highest N rate in sorghum following soybean. Fertilizer N effect on sorghum grain yields followed the same trend as observed in leaf N levels. The main effect of fertilizer N on yield was highly significant, with an increase of 10 bu/a with the last 30 lb/a increment.

Table 1. Effects of soybean and sunn hemp summer cover crops and nitrogen rate on no-till grain sorghum after wheat, Hesston, Kansas, 2005.

| Cover Crop | N Rate† | Cover Crop Yield‡ Forage | Cover Crop Yield‡ N | Grain Sorghum Grain Yield | Bushel Wt | Stand | Half†† Bloom | Heads/ Plant* | Leaf N‡‡ |
|---|---|---|---|---|---|---|---|---|---|
| | lb/a | ton/a | lb/a | bu/a | lb | 1000's/a | days | no. | % |
| None | 0 | ---- | ---- | 49.2 | 55.2 | 32.9 | 68 | 0.91 | 1.86 |
| | 30 | ---- | ---- | 74.0 | 55.3 | 32.9 | 66 | 1.06 | 2.31 |
| | 60 | ---- | ---- | 84.5 | 55.5 | 32.3 | 67 | 1.15 | 2.66 |
| | 90 | ---- | ---- | 96.9 | 55.9 | 29.7 | 66 | 1.40 | 2.88 |
| Soybean | 0 | 2.30 | 93 | 73.4 | 55.8 | 34.2 | 66 | 1.01 | 2.20 |
| | 30 | 2.02 | 87 | 81.3 | 55.3 | 31.4 | 66 | 1.17 | 2.57 |
| | 60 | 2.53 | 109 | 92.8 | 55.5 | 29.9 | 66 | 1.29 | 2.75 |
| | 90 | 1.59 | 69 | 96.3 | 55.8 | 30.8 | 67 | 1.36 | 2.79 |
| Sunn hemp | 0 | 2.95 | 116 | 71.7 | 55.7 | 32.2 | 66 | 1.06 | 2.07 |
| | 30 | 3.10 | 118 | 87.2 | 55.2 | 33.3 | 65 | 1.12 | 2.60 |
| | 60 | 3.26 | 130 | 92.7 | 55.6 | 31.4 | 67 | 1.23 | 2.80 |
| | 90 | 3.47 | 136 | 106.7 | 56.2 | 30.5 | 66 | 1.49 | 2.92 |
| LSD (.05) | | 0.71 | 32 | 9.7 | NS | 3.4 | NS | 0.17 | 0.16 |
| Means: | | | | | | | | | |
| Cover Crop | | | | | | | | | |
| None | | ---- | ---- | 76.2 | 55.4 | 32.0 | 67 | 1.13 | 2.43 |
| Soybean | | 2.11 | 90 | 85.9 | 55.6 | 31.6 | 66 | 1.21 | 2.58 |
| Sunn hemp | | 3.19 | 125 | 89.6 | 55.7 | 31.8 | 66 | 1.23 | 2.59 |
| LSD (.05) | | 0.35 | 16 | 4.9 | NS | NS | NS | 0.09 | 0.08 |
| N Rate | | | | | | | | | |
| 0 | | 2.62 | 105 | 64.8 | 55.6 | 33.1 | 67 | 0.99 | 2.04 |
| 30 | | 2.56 | 102 | 80.8 | 55.3 | 32.5 | 66 | 1.12 | 2.49 |
| 60 | | 2.89 | 119 | 90.0 | 55.5 | 31.2 | 67 | 1.23 | 2.73 |
| 90 | | 2.53 | 103 | 100.0 | 56.0 | 30.3 | 66 | 1.42 | 2.86 |
| LSD (.05) | | NS | NS | 5.6 | NS | 2.0 | NS | 0.10 | 0.09 |

† N applied as 28-0-0 on June 27, 2005.
‡ Oven dry weight and N content for sunn hemp and soybean on September 17 and October 4, 2004, respectively.
†† Days from planting (May 23, 2005) to half bloom.
* Main effect of cover crop on heads/plant significant at p=0.06.
‡‡ Flag leaf at late boot to early heading.

# EFFECTS OF CHLORIDE RATE ON NO-TILL CONTINUOUS WHEAT AND GRAIN SORGHUM

**M.M. Claassen**

## Summary

Experiments were conducted to determine crop response to chloride (Cl) rates in continuous no-till wheat and grain sorghum on soils testing low in Cl. Ammonium chloride (6-0-0-16.5) was broadcast on wheat in early spring and on sorghum preemergence at rates providing 10, 20, and 30 lb/a of Cl. Consistent with soil test results, levels of Cl in leaves of both crops were low in plots receiving no Cl fertilizer. Each increment of Cl fertilizer significantly increased the concentration of Cl in crop leaves. Wheat yields increased by a maximum of 7.6 bu/a with 20 lb/a of Cl. Grain sorghum yields also were highest at 20 lb/a of Cl, with an increase of 4.7 bu/a versus the check treatment receiving no Cl.

## Introduction

Chloride (Cl) is known to be an essential plant nutrient. It plays an important role in the uptake of nutrient cations and in the dynamics of plant water utilization. Although it is required in small amounts, deficiencies or sub-optimal levels can result in yield reduction. Significant yield increases in wheat, corn, and grain sorghum from Cl application in Kansas have been most consistent when soil Cl levels are less than 4 ppm at a soil depth of 0 to 24 inches.

One of the benefits of Cl is its apparent effect in reducing the severity of plant diseases. Cl fertilization in wheat has been shown to suppress fungal diseases such as tan spot, leaf rust, and stripe rust. In grain sorghum and corn, it has been found to suppress stalk rot. The current interest in utilizing stacked crop rotations (consecutive years of the same crop) to enhance the economics of no-till systems raises concern about plant disease control, particularly in wheat. The most notable disease in continuous no-till wheat is tan spot.

The experiments reported here were conducted to assess the benefits of Cl fertilization in continuous no-till wheat and grain sorghum on soils low in Cl.

## Procedures

<u>Wheat</u>

The site was located on Ladysmith silty clay loam soil (North Unit), with a soil Cl level of 2.4 parts per million at 0 to 24 inches. The area had been cropped to no-till wheat in 2003-2004. Jagger wheat was no-till planted on October 21, 2004, at 90 lb/a. A basic fertilizer program on the site provided 120-35-0 lb/a of N–P-K applied as 18-46-0 banded with the seed and 46-0-0 broadcast in early spring. Cl rates of 0, 10, 20, and 30 lb/a were broadcast as ammonium chloride (6-0-0-16.5) on 4- to 6-inch wheat on March16, 2005. Leaf samples for nutrient analyses were collected at late boot to early heading on May 7. Plots were combine harvested on June 24, 2005.

<u>Grain Sorghum</u>

Location of the grain sorghum project also was on Ladysmith silty clay loam soil, about 5 miles distant (South Unit) from the previous site. Soil test indicated 1.9 parts per million Cl at 0 to 24 inches. The previous crop was no-till grain sorghum. Pioneer 8500 grain sorghum was no-till planted May 30, 2005, at 42,000 seeds/a in 30-inch rows. The site was fertilized with 18-46-0 banded 2 inches from the row at planting and 28-0-0 injected 10 inches from the row on July 1, for a total of 90-37-0 lb/a. Cl rates of 0, 10, 20, and 30 lb/a were broadcast as ammonium chloride (6-0-0-16.5) preemergence to sorghum on June 2. Leaf samples for nutrient analyses were collected at the 6- to 8-leaf stage on June 29. Plots were harvested on September 22.

## Results

<u>Wheat</u>

Wheat planting was delayed by rains. Tan spot disease was present throughout the growing season. Leaf rust was significant after mid-May. Leaf Cl concentration with no Cl fertilizer reflected low soil Cl (Table 1). Increases in leaf Cl were significant with each 10-lb increment of Cl fertilizer. Yields also increased significantly, with a maximum benefit of 7.6 bu/a at 20 lb/a of Cl. Grain test weight was not affected by Cl treatments.

Grain Sorghum

Heavy rains totaling 9.85 inches occurred during the first two weeks after Cl application. Sorghum developed with no observed diseases of significance. There was essentially no lodging (Table 2). Consistent with soil test results, Cl concentration was low in leaves of sorghum without Cl fertilizer. As in wheat, Cl concentration in sorghum leaves increased significantly with each increment of Cl fertilizer. Cl treatments had no meaningful effect on crop maturity. Sorghum grain yields were very good, increasing by a maximum of 4.7 bu/a with 20 lb/a of Cl. Grain test weights increased slightly with Cl fertilizer.

Table 1. Effects of chloride fertilization on no-till continuous winter wheat, Hesston, Kansas, 2005†.

| Cl‡ | Grain Yield†† | Bushel Wt | Leaf‡‡ | | | |
|---|---|---|---|---|---|---|
| | | | N | P | K | Cl |
| lb/a | bu/a | lb | % | | | |
| 0 | 29.9 | 55.1 | 3.09 | 0.190 | 1.40 | 0.057 |
| 10 | 32.5 | 54.5 | 3.17 | 0.199 | 1.59 | 0.138 |
| 20 | 37.5 | 55.3 | 3.20 | 0.192 | 1.56 | 0.166 |
| 30 | 33.1 | 55.1 | 3.13 | 0.199 | 1.59 | 0.259 |
| LSD (.05) | 3.9 | NS | NS | NS | 0.15 | 0.031 |

† All data are the means of four replications.
‡ Broadcast as ammonium chloride (6-0-0-16.5) on 4- to 6- inch wheat, March 16 .
†† Yields adjusted to 12.5% moisture.
‡‡ Flag leaf and flag leaf minus one at late boot to early heading, May 7.

Table 2. Effects of chloride fertilization on no-till continuous grain sorghum, Hesston, Kansas, 2005†.

| Cl‡ | Grain Yield†† | Bushel Wt | Half Bloom | Lodg-ing | Leaf‡‡ | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | N | P | K | Cl |
| lb/a | bu/a | lb | DAP | % | % | | | |
| 0 | 101.9 | 57.3 | 63 | 0 | 2.68 | 0.258 | 2.47 | 0.090 |
| 10 | 104.3 | 56.7 | 64 | 0 | 2.66 | 0.244 | 2.41 | 0.351 |
| 20 | 106.6 | 56.8 | 64 | 0 | 2.71 | 0.243 | 2.33 | 0.611 |
| 30 | 105.3 | 56.9 | 64 | 0 | 2.82 | 0.253 | 2.26 | 0.774 |
| LSD (0.10) | 2.9 | 0.4 | 0.4 | NS | NS | NS | 0.15 | 0.059 |

† All data are the means of eight replications.
‡ Broadcast as ammonium chloride (6-0-0-16.5) preemergence to sorghum, June 2.
†† Yields adjusted to 12.5% moisture.
‡‡ Uppermost expanded leaf at 6- to 8-leaf stage, June 29.

# CORN, SORGHUM, AND SOYBEAN FERTILIZATION STUDIES KANSAS STATE UNIVERSITY, DEPARTMENT OF AGRONOMY

## EFFECTS OF POTASSIUM ON IRRIGATED CORN YIELD IN WESTERN KANSAS

D. Leikam

### Introduction

Relatively low potassium (K) soil test values can be found on coarse-textured soils in much of south-central and southwestern Kansas, but these soils do not seem to be as responsive to applied fertilizer K as medium-fine textured soils in the eastern part of Kansas. Also, the number of fields exhibiting K deficiency of corn in the eastern part of the state, on soils testing greater than commonly accepted critical values, are increasing. As a result, there is increasing interest in determining if the commonly used K soil test and critical values are useful in western Kansas.

With this in mind, a simple fertilizer study, with and without fertilizer K application, was conducted on irrigated sandy ridges in Stevens county that tested low in soil K.

### Procedures

Soil samples from the 0- to 6-inch soil depth were collected from two fields and were analyzed for exchangeable soil test potassium.

Potassium application rates of 0 and 120 lb $K_2O$/a were broadcast applied to these sprinkler-irrigated fields; plots were replicated nine times. Corn grain was hand harvested from 20 feet of row in the center of each plot.

### Results

Corn growth was somewhat erratic on the ridges chosen and, as a result, variability was high. In addition, field varmints destroyed two replications.

It was interesting that overall grain yields were higher in the plots receiving 120 lb $K_2O$/a than in the control plots, but with the large amount of variability, the difference was not statistically significant.

Grain test weights decreased slightly with potassium application, moisture content significantly increased, and grain K content decreased with K application. These results were completely unexpected. It is possible that they are a result of slightly higher grain yields associated with K application. Potassium content of the grain was far less than commonly expected norms.

No conclusions can be drawn from these efforts, but it seems that these coarse-textured soils are much less responsive to fertilizer K than eastern Kansas soils. Also, it seems that 0- to 6-inch soil samples do not provide as low K soil test results as samples collected to a greater depth, inasmuch as none of the samples collected tested as low as was expected in these fields.

Table 1. Effect of potassium application to corn, Stevens Co., Kansas, 2005.

| | Corn Grain | | | |
|---|---|---|---|---|
| $K_2O$ Rate | Yield | Test Weight | Moisture | K Content |
| - lb/a - | bu/a | lb/bu | % | lb $K_2O$/bu |
| 0 | 125 | 61.2 | 15.2 | 0.17 |
| 120 | 132 | 60.1 | 17.1 | 0.16 |
| Sig. Level | NS | 0.11 | 0.04 | 0.05 |

Exch. K Soil Test – Range of 91-192 ppm; Average of 141 ppm.

# EFFECTS OF PHOSPHORUS APPLICATION ON CORN YIELD AND NUTRIENT CONTENT OF THE GRAIN

**D. Leikam, A. Schlegel, and G. Sohm**

## Summary

A series of corn and grain sorghum studies have been initiated across the state over the past two years to help refine the information needed for crop nutrient recommendations. This particular study was conducted on corn and included phosphorus (P) rates of 0, 20, 40, 80, and 120 lb $P_2O_5$/a. The study was conducted at two locations. All fertilizer was broadcast applied. Significant, large yield responses were obtained at one of the locations; smaller yield responses were measured at the other location. In addition, increasing P rates reduced grain moisture content and increased grain test weight.

## Introduction

Several corn and grain sorghum studies have been initiated across the state to improve crop nutrient P and potassium (K) recommendations. To meet this objective, the following information is being gathered from various studies conducted across the state of Kansas: 1) crop response to various rates of P and/or K application at various soil test values, 2) percentage sufficiency (for maximum yield) at various soil test values, 3) amounts of P and K nutrient application/crop removal to change soil test values, and 4) amounts of P and K removed in the harvested grain.

This project was initiated for the 2003 crop and continued for the 2005 crop year.

## Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots at some locations and from individual replications at others. Bray P1, Mehlich 3 colorimetric, and Mehlich 3 ICP soil test procedures were run on individual samples. For this report, only the Bray P1 results will be presented.

The Greeley County study was located on the K-State Research Station; the Stevens County study was located in a farmer/cooperator field. Both locations were sprinkler irrigated.

Phosphorus rates of 0, 20, 40, 80, and 120 lb $P_2O_5$/a were preplant broadcast applied in late winter. Applied P was incorporated at both sites. The treatments were replicated six times in Greeley County and five times at the Stevens County site. Grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

## Results

A significant, large yield response was obtained at the Greeley County location again in 2005 (Table 1). The response was even greater than at this same location in 2004. Grain yields were still increasing at the highest application rate. Grain moisture was significantly reduced with P application, whereas grain test weight was significantly increased.

A major weed problem developed at the Stevens County location, and yields were severely reduced (Table 2). Even so, yields trended upward with increasing P application rates. In general, corn test weights trended up and grain moisture trended down with increasing P rates at both locations.

Table 1. Effect of phosphorus application to corn, Stevens Co., Kansas, 2005.

| | Corn Grain | | | |
|---|---|---|---|---|
| $P_2O_5$ Rate | Yield | Test Weight | Moisture | P Content |
| - lb/a - | bu/a | lb/bu | % | lb $P_2O_5$/bu |
| 0 | 47 | 50.2 | 27.2 | 0.35 |
| 20 | 46 | 50.1 | 27.3 | 0.37 |
| 40 | 52 | 51.7 | 24.5 | 0.35 |
| 80 | 49 | 50.9 | 26.9 | 0.36 |
| 120 | 61 | 54.8 | 21.7 | 0.33 |
| Sig. Level | 0.32 | 0.21 | 0.18 | 0.02 |

Bray P1 Soil Test – Range of 8-29 ppm; Average of 17 ppm.

Table 2. Effect of phosphorus application to corn, Greeley Co., Kansas, 2004 and 2005.

| | Corn Grain | | | |
|---|---|---|---|---|
| $P_2O_5$ Rate | 2004 Yield | 2005 Yield | 2005 Moisture | Test Weight |
| - lb/a - | - - - - bu/a | - - - - - | % | lb /bu |
| 0 | 180 | 118 | 31.5 | 49.2 |
| 20 | 191 | 145 | 29.4 | 50.8 |
| 40 | 206 | 154 | 27.1 | 51.5 |
| 80 | 222 | 163 | 26.3 | 51.6 |
| 120 | 222 | 170 | 26.5 | 51.7 |
| Sig. Level | < 0.01 | 0.09 | < 0.01 | < 0.01 |

Bray P1 Soil Test – Range of 7-9 ppm; Average of 8 ppm.

# EFFECTS OF PHOSPHORUS APPLICATION ON GRAIN SORGHUM YIELD AND NUTRIENT CONTENT OF THE GRAIN

**D. Leikam, A. Schlegel G. Sohm, J. Siemens, and J. Naysmith**

## Summary

A series of corn and grain sorghum studies have been conducted across the state over the past several years to help refine the information needed for crop nutrient recommendations. Grain sorghum studies include phosphorus (P) and potassium (K) application rates, and were conducted in 2005 in Stevens, Ford, Greeley, and Butler counties. Considerable variability exists in the data obtained from these studies due to droughty conditions in the parts of western half of Kansas during the past several summers, but grain yields did trend higher with increasing P application rates.

## Introduction

Several corn and grain sorghum studies have been initiated across the state to improve crop nutrient P and K recommendations. To meet this objective, the following information is being gathered from various studies conducted across the state of Kansas: 1) crop response to various rates of P and/or K application at various soil test values, 2) percentage sufficiency (for maximum yield) at various soil test values, 3) amounts of P and K nutrient application/crop removal to change soil test values, and 4) amounts of P and K removed in the harvested grain.

This project was initiated for the 2003 crop and continued through the 2005 crop year.

## Procedures

Soil samples from the 0- to 6-inch depth were collected from individual plots at some locations and from individual replications at others. For phosphorus, Bray P1, Mehlich 3 colorimetric, and Mehlich 3 ICP soil test procedures were run on individual samples. For this report, only the Bray P1 results will be presented. Soil test values were determined for potassium exchangeable K.

Reported studies were located at the K-State Research Station in Greeley County and in farmer fields in Butler, Stevens, and Ford counties. Phosphorus rates of 0, 20, 40, 80, and 120 lb $P_2O_5$/a were preplant broadcast applied in late winter. Applied P was incorporated at Greeley and Ford county sites. Stevens and Butler county sites were in a no-till production system. The treatments were replicated six times in Greeley County and five times at the other locations.

For the K study in Butler County, K application rates of 0, 40, 80, and 120 lb $K_2O$/a were preplant broadcast applied to five replications.

All grain yields were obtained by hand harvesting 20 feet of row from the center of each plot.

## Results

Droughty conditions at the Ford County location resulted in a total loss of the study. A herbicide application problem on the circle, resulting in very high weed pressure, caused the Stevens County location to be lost as well.

Soil test values at the Butler County location averaged about 20 ppm Bray P1, and a yield response to applied P was not obtained (Table 1). Although test weight trended up with increasing P application rates, the increase was not significant.

A highly significant grain yield response to applied P was obtained in both 2004 and 2005 at the Greeley County location (Table 2). At a soil test value of about 7 ppm Bray P1, about 70 to 75% of maximum yield was obtained in the check plots.

Grain P contents were lower than the 0.40 lb/bu $P_2O_5$ estimated for current Kansas State University recommendations, but increased from 0.27 to 0.35 lb/bu $P_2O_5$ as the P application rate increased from zero to 120 lb $P_2O_5$/a – and were still increasing at the highest rates of applied P. Analysis of grain P content was not yet completed for the 2005 crop in late fall.

Grain yields were not significantly impacted by potassium (K) application in Butler County. Grain moisture trended down with increasing K application rates; test weights were unaffected.

Table 1. Effect of phosphorus application to grain sorghum, Butler Co., Kansas, 2005.

| | Grain Sorghum Grain | | |
|---|---|---|---|
| $P_2O_5$ Rate | Yield | Test Weight | Grain Moisture |
| - lb/a - | bu/a | lb/bu | % |
| 0 | 107 | 55.0 | 11.1 |
| 20 | 104 | 57.6 | 11.0 |
| 40 | 107 | 56.2 | 11.7 |
| 80 | 109 | 59.3 | 10.6 |
| 120 | 103 | 57.9 | 11.6 |
| Sig. Level | NS | NS | 0.09 |

Bray P1 Soil Test – Average of 20 ppm.

Table 2. Effect of phosphorus application to grain sorghum, Greeley Co., Kansas, 2004-05.

| | Grain Sorghum Grain | | | |
|---|---|---|---|---|
| $P_2O_5$ Rate | 2004 Yield | 2004 Grain P Content | 2005 Yield | 2005 Test Weight |
| - lb/a - | bu/a | lb $P_2O_5$/bu | bu/a | lb/bu |
| 0 | 92 | 0.27 | 77 | 60.2 |
| 20 | 108 | 0.29 | 108 | 60.1 |
| 40 | 108 | 0.30 | 93 | 60.6 |
| 80 | 117 | 0.32 | 102 | 60.6 |
| 120 | 120 | 0.35 | 100 | 60.7 |
| Sig. Level | 0.01 | < 0.01 | 0.04 | 0.06 |

Bray P1 Soil Test – Average of 7 ppm.

Table 3. Effect of potassium application to grain sorghum, Butler Co., Kansas, 2005.

| | Grain Sorghum Grain | | |
|---|---|---|---|
| $K_2O$ Rate | Yield | Moisture | Test Weight |
| - lb/a - | bu/a | % | lb/bu |
| 0 | 105 | 11.9 | 57.2 |
| 40 | 120 | 11.4 | 59.0 |
| 80 | 109 | 10.6 | 59.3 |
| 120 | 104 | 11.2 | 57.4 |
| Sig. Level | NS | 0.14 | NS |

Exchangeable K Soil Test – Average of 201 ppm.

# EFFECTS OF ZINC FERTILIZER PRODUCTS ON DTPA ZINC SOIL TESTS

**D. Leikam and D. Seymore**

## Summary

Zinc fertilizer products of differing water solubility increased zinc soil test values in proportion to the water solubility of the products. The greater the water solubility, the more DTPA Zn soil tests increased at all Zn application rates. About 5 pounds of water-soluble Zn or 15 pounds of non-water-soluble Zn was required to increase DTPA Zn soil test values 1 ppm.

## Introduction

There are many zinc fertilizer products on the market and these products often differ considerably in their water solubility. Although questions about the efficacy of these products to increase soil test values are often raised, there is little information on which to base an answer. Presented are preliminary results of a study initiated early in 2003.

## Procedures

Locations of these zinc studies are distributed across a broad section of western Kansas. Dryland locations included Thomas County, Ness County, and Ford County (near Dodge City). In addition, an irrigated site was established in Ford County (near Ford). Soil samples (0-6 inches) were collected from each individual plot before fertilizer application. All products were broadcast applied.

Because of drought conditions in 2004, it was not possible to resample the Ness and Thomas County locations until 18 months after initial zinc product application. The two Ford County locations were sampled about 12 months after initial zinc application. All locations were again sampled in late winter of 2005, and will be sampled in late winter of 2006. About 10 to 12 individual soil cores were collected from each plot and combined into a composite sample; the sample was then submitted to the laboratory for analysis.

Zinc products used included a zinc sulfate product (96% water-soluble Zn), an oxysulfate product (50% Zn water solubility) and an older oxysulfate zinc product with limited zinc water solubility (15% Zn water solubility).

## Results

It seems that the efficacy of zinc fertilizer products in effecting DTPA Zn soil test change is directly related to amount of water-soluble zinc in the product (Tables 2-6). Highly significant differences due to the specific zinc product used and the rate at which it was applied were measured. Although some differences among locations were noted, there was not a location-zinc product interaction noted. In general, DTPA Zn soil tests changed the most at the Thomas County location and least at the irrigated Ford County location. It is interesting that no tillage has occurred at the Thomas County location, whereas the irrigated Ford County location has undergone the deepest and most frequent tillage of all the sites. It is likely that much of the differences among locations can be explained by the amount of soil affected (soil depth) by the initial zinc application.

Averaged across locations, it is clear that the greater the zinc product water solubility, the greater the effect on resulting DTPA Zn soil test values. Further analysis reveals that the change in DTPA Zn soil test value is highly correlated to the amount of water-soluble and water-insoluble zinc applied (Figure 1). It seems that about 5 pounds of water-soluble zinc is required to increase DTPA soil tests 1 ppm, whereas about 15 pounds of non-water-soluble zinc is required to increase DTPA soil test values 1 ppm.

Table 1. Characteristics of study locations.

| Location | | Tillage System | Soil Acidity | Free Lime |
|---|---|---|---|---|
| Thomas Co. | Dryland | No-Till | 5.4 – 6.5 | None |
| Ness Co. | Dryland | Minimum Till | 6.1 – 6.6 | None |
| Ford Co. (Dodge) | Dryland | Minimum Till | 6.3 – 8.0 | None |
| Ford Co. (Ford) | Irrigated | Reduced Till | 7.9 – 8.3 | Slight - Moderate |

Table 2. Effect of zinc fertilizer water solubility on DTPA Zn soil test change, Ness Co., Kansas, 2004 and 2005.

| | Total | | DTPA Zn Soil Test Change | |
|---|---|---|---|---|
| Zn Product | Zn Rate | Water-Soluble Zn | 2004 | 2005 |
| | lb/a | % | relative to check (ppm) | |
| Product A | 5 | 15 | 0.28 | 0.20 |
| Product A | 15 | 15 | 1.62 | 1.40 |
| Product B | 5 | 50 | 0.52 | 0.45 |
| Product B | 15 | 50 | 1.98 | 2.20 |
| Product C | 5 | 96 | 0.80 | 0.72 |
| Product C | 15 | 96 | 2.92 | 2.78 |
| Significance Level | | | < 0.01 | < 0.01 |

Table 3. Effect of zinc fertilizer water solubility on DTPA Zn soil test change, Thomas Co., Kansas, 2004 and 2005.

| | Total | | DTPA Zn Soil Test Change | |
|---|---|---|---|---|
| Zn Product | Zn Rate | Water-Soluble Zn | 2004 | 2005 |
| | lb/a | % | relative to check (ppm) | |
| Product A | 5 | 15 | 0.08 | 0.22 |
| Product A | 15 | 15 | 2.25 | 1.48 |
| Product B | 5 | 50 | 1.00 | 0.32 |
| Product B | 15 | 50 | 2.72 | 2.18 |
| Product C | 5 | 96 | 1.12 | 0.62 |
| Product C | 15 | 96 | 3.38 | 3.95 |
| Significance Level | | | 0.08 | 0.02 |

Table 4. Effect of zinc fertilizer water solubility on DTPA Zn soil test change, Dodge City, Kansas, 2004 and 2005.

| | Total | | DTPA Zn Soil Test Change | |
|---|---|---|---|---|
| Zn Product | Zn Rate | Water-Soluble Zn | 2004 | 2005 |
| | lb/a | % | relative to check (ppm) | |
| Product A | 5 | 15 | 0.70 | 0.18 |
| Product A | 15 | 15 | 1.02 | 1.04 |
| Product B | 5 | 50 | 1.28 | 0.54 |
| Product B | 15 | 50 | 2.50 | 1.58 |
| Product C | 5 | 96 | 1.12 | 0.76 |
| Product C | 15 | 96 | 3.52 | 2.34 |
| Significance Level | | | < 0.01 | < 0.01 |

Table 5. Effect of zinc fertilizer water solubility on DTPA Zn soil test change, Ford Co., Kansas, 2004 and 2005.

| | Total | | DTPA Zn Soil Test Change | |
|---|---|---|---|---|
| Zn Product | Zn Rate | Water-Soluble Zn | 2004 | 2005 |
| | lb/a | % | relative to check (ppm) | |
| Product A | 5 | 15 | 0.35 | 0.22 |
| Product A | 15 | 15 | 1.00 | 0.98 |
| Product B | 5 | 50 | 0.48 | 0.25 |
| Product B | 15 | 50 | 2.02 | 1.30 |
| Product C | 5 | 96 | 1.98 | 0.72 |
| Product C | 15 | 96 | 2.56 | 1.52 |
| Significance Level | | | 0.05 | < 0.01 |

Table 6. Effect of zinc fertilizer water solubility on DTPA Zn soil test change, all locations combined, 2004 and 2005.

| | Total | | DTPA Zn Soil Test Change | |
|---|---|---|---|---|
| Zn Product | Zn Rate | Water-Soluble Zn | 2004 | 2005 |
| | lb/a | % | relative to check (ppm) | |
| Product A | 5 | 15 | 0.38 | 0.17 |
| Product A | 15 | 15 | 1.28 | 1.42 |
| Product B | 5 | 50 | 0.65 | 0.56 |
| Product B | 15 | 50 | 2.17 | 1.95 |
| Product C | 5 | 96 | 1.13 | 0.83 |
| | 15 | 96 | 3.24 | 2.50 |
| Product C | | | | |
| Significance Level | | | < 0.01 | < 0.01 |

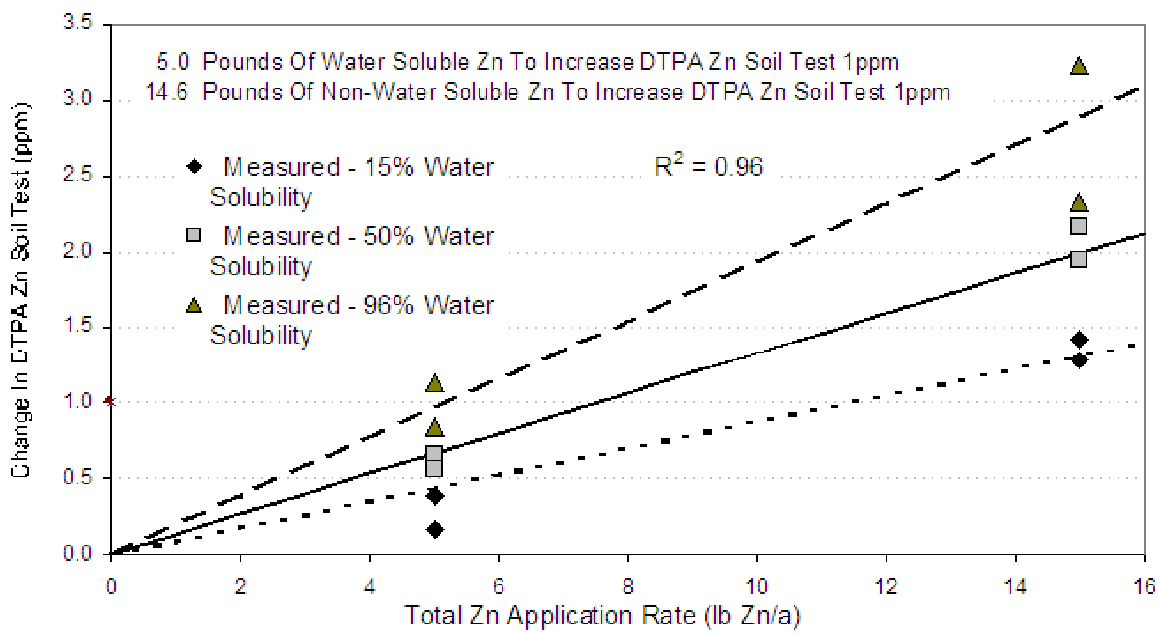


**Figure 1.** Effect of various zinc sources on DTPA Zn soil test, 2003 to 2005.

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