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A. Schlegel  
*Kansas State University*, [schlegel@ksu.edu](mailto:schlegel@ksu.edu)

H. D. Bond  
*Kansas State University*, [dbond@ksu.edu](mailto:dbond@ksu.edu)

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## Long-Term Nitrogen and Phosphorus Fertilization of Irrigated Grain Sorghum

*A. Schlegel and H.D. Bond*

### 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 2014, N applied alone increased yields 49 bu/a, whereas N and P applied together increased yields up to 81 bu/a. Averaged across the past 10 years, N and P fertilization increased sorghum yields up to 73 bu/a. Application of 40 lb/a N (with P) was sufficient to produce more than 80% of maximum yield in 2014, which almost equals the 10-year average. Application of potassium (K) has had no effect on sorghum yield throughout the study period.

### 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 is 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

This field study is conducted at the Tribune Unit of the Southwest Research-Extension Center. Fertilizer treatments initiated in 1961 are N rates of 0, 40, 80, 120, 160, and 200 lb/a N without P and K; with 40 lb/a  $P_2O_5$  and zero K; and with 40 lb/a  $P_2O_5$  and 40 lb/a  $K_2O$ . All fertilizers are broadcast by hand in the spring and incorporated before planting. The soil is a Ulysses silt loam. Sorghum (Pioneer 8500/8505 from 2003–2007, Pioneer 85G46 in 2008–2011, and Pioneer 84G62 in 2012–2014) was planted in late May or early June. Irrigation is used to minimize water stress. Sprinkler irrigation has been used since 2001. The center two rows of each plot are machine harvested after physiological maturity. Grain yields are adjusted to 12.5% moisture.

### Results

Grain sorghum yields in 2014 were 18% greater than the 10-year average (Table 1). Nitrogen alone increased yields 49 bu/a, whereas P alone increased yields only 4 bu/a. However, N and P applied together increased yields up to 81 bu/a. Averaged across the past 10 years, N and P applied together increased yields up to 73 bu/a. In 2014, 40 lb/a N (with P) produced about 82% of maximum yield, which almost equals the 10-year average of 83%; 120 lb/a N (with P) and 160 lb/a N (with P) produced 92% and 97% of

maximum yield, respectively. Sorghum yields were not affected by K fertilization, which has been the case throughout the study period.

**Table 1. Effects of nitrogen, phosphorus, and potassium fertilizers on irrigated grain sorghum yields, Tribune, KS, 2005–2014**

| Fertilizer       |                               |                  | Grain sorghum yield |       |       |       |       |       |       |       |       |       |       |
|------------------|-------------------------------|------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| N                | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | 2005 <sup>1</sup>   | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | Mean  |
| ----- lb/a ----- |                               |                  | ----- bu/a -----    |       |       |       |       |       |       |       |       |       |       |
| 0                | 0                             | 0                | 58                  | 84    | 80    | 66    | 64    | 51    | 75    | 78    | 62    | 90    | 71    |
| 0                | 40                            | 0                | 53                  | 102   | 97    | 60    | 70    | 51    | 83    | 90    | 77    | 94    | 79    |
| 0                | 40                            | 40               | 54                  | 95    | 94    | 65    | 76    | 55    | 88    | 93    | 72    | 96    | 80    |
| 40               | 0                             | 0                | 63                  | 102   | 123   | 92    | 84    | 66    | 106   | 115   | 94    | 115   | 97    |
| 40               | 40                            | 0                | 84                  | 133   | 146   | 111   | 118   | 77    | 121   | 140   | 114   | 144   | 120   |
| 40               | 40                            | 40               | 84                  | 130   | 145   | 105   | 109   | 73    | 125   | 132   | 110   | 142   | 117   |
| 80               | 0                             | 0                | 76                  | 111   | 138   | 114   | 115   | 73    | 117   | 132   | 102   | 120   | 111   |
| 80               | 40                            | 0                | 81                  | 132   | 159   | 128   | 136   | 86    | 140   | 163   | 136   | 151   | 133   |
| 80               | 40                            | 40               | 92                  | 142   | 166   | 126   | 108   | 84    | 138   | 161   | 133   | 164   | 133   |
| 120              | 0                             | 0                | 77                  | 101   | 138   | 106   | 113   | 70    | 116   | 130   | 100   | 116   | 108   |
| 120              | 40                            | 0                | 95                  | 136   | 164   | 131   | 130   | 88    | 145   | 172   | 137   | 162   | 138   |
| 120              | 40                            | 40               | 98                  | 139   | 165   | 136   | 136   | 90    | 147   | 175   | 142   | 170   | 141   |
| 160              | 0                             | 0                | 77                  | 123   | 146   | 105   | 108   | 74    | 124   | 149   | 117   | 139   | 118   |
| 160              | 40                            | 0                | 106                 | 145   | 170   | 138   | 128   | 92    | 152   | 178   | 146   | 171   | 144   |
| 160              | 40                            | 40               | 91                  | 128   | 167   | 133   | 140   | 88    | 151   | 174   | 143   | 176   | 141   |
| 200              | 0                             | 0                | 86                  | 134   | 154   | 120   | 110   | 78    | 128   | 147   | 119   | 139   | 123   |
| 200              | 40                            | 0                | 108                 | 143   | 168   | 137   | 139   | 84    | 141   | 171   | 136   | 165   | 141   |
| 200              | 40                            | 40               | 101                 | 143   | 170   | 135   | 129   | 87    | 152   | 175   | 138   | 170   | 142   |
| ANOVA (P > F)    |                               |                  |                     |       |       |       |       |       |       |       |       |       |       |
| Nitrogen         |                               |                  | 0.001               | 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 | 0.001 |
| Quadratic        |                               |                  | 0.005               | 0.004 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 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        |                               |                  | 0.803               | 0.578 | 0.992 | 0.745 | 0.324 | 0.892 | 0.278 | 0.826 | 0.644 | 0.117 | 0.967 |
| N × P-K          |                               |                  | 0.195               | 0.210 | 0.965 | 0.005 | 0.053 | 0.229 | 0.542 | 0.186 | 0.079 | 0.012 | 0.077 |

*continued*

**Table 1. Effects of nitrogen, phosphorus, and potassium fertilizers on irrigated grain sorghum yields, Tribune, KS, 2005–2014**

| Fertilizer  |                               |                  | Grain sorghum yield |      |      |      |      |      |      |      |      |      |      |
|---|-------------------------------|------------------|---------------------|------|------|------|------|------|------|------|------|------|------|
| N   | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | 2005 <sup>1</sup>   | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Mean |
| ----- lb/a -----                                      |                               |                  | ----- bu/a -----    |      |      |      |      |      |      |      |      |      |      |
| <b>MEANS</b>  |                               |                  |                     |      |      |      |      |      |      |      |      |      |      |
| Nitrogen, lb/a  |                               |                  |                     |      |      |      |      |      |      |      |      |      |      |
| 0   |                               |                  | 55                  | 93   | 91   | 64   | 70   | 52   | 82   | 87   | 70   | 94   | 77   |
| 40  |                               |                  | 77                  | 121  | 138  | 103  | 104  | 72   | 117  | 129  | 106  | 134  | 112  |
| 80  |                               |                  | 83                  | 128  | 155  | 123  | 120  | 81   | 132  | 152  | 124  | 145  | 126  |
| 120   |                               |                  | 90                  | 125  | 156  | 124  | 126  | 82   | 136  | 159  | 126  | 149  | 129  |
| 160   |                               |                  | 92                  | 132  | 161  | 125  | 125  | 83   | 142  | 167  | 135  | 162  | 134  |
| 200   |                               |                  | 98                  | 140  | 164  | 131  | 126  | 84   | 141  | 165  | 131  | 158  | 135  |
| LSD <sub>(0.05)</sub>                                 |                               |                  | 10                  | 11   | 9    | 7    | 11   | 5    | 8    | 9    | 8    | 9    | 6    |
| P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O, lb/a |                               |                  |                     |      |      |      |      |      |      |      |      |      |      |
| 0 - 0   |                               |                  | 73                  | 109  | 130  | 101  | 99   | 68   | 111  | 125  | 99   | 120  | 105  |
| 40 - 0  |                               |                  | 88                  | 132  | 151  | 117  | 120  | 80   | 130  | 152  | 124  | 148  | 126  |
| 40 - 40   |                               |                  | 87                  | 130  | 151  | 117  | 116  | 79   | 133  | 152  | 123  | 153  | 126  |
| LSD <sub>(0.05)</sub>                                 |                               |                  | 7                   | 7    | 6    | 5    | 7    | 4    | 6    | 6    | 5    | 6    | 4    |

<sup>1</sup> 2005 yields used only blocks 3, 4, and 5.