SOIL FERTILITY RESEARCH
EAST CENTRAL KANSAS EXPERIMENT FIELD

RESIDUAL EFFECTS FROM PHOSPHORUS
FERTILIZER APPLICATIONS IN TWO TILLAGE SYSTEMS

K.A. Janssen

Summary

Residual phosphorus (P) from 4 years of P fertilizer applications was evaluated for grain sorghum in chisel-disc and no-till systems in east-central KS. Responses to residual P were similar in both tillage systems. The highest rates of original P produced the greatest residual P yield responses. The methods of P application had little influence on residual P yield. Residual P from the 10 lb/a P$_2$O$_5$ treatments produced marginally higher yield in the first year, but no response the following years. Statistically higher residual yields were produced by the 30 lb/a P$_2$O$_5$ rate in the first 2 years and by the 60 lb/a P$_2$O$_5$ rate in all 4 years of the study. Residual yield responses were less than those with fresh P in all instances, except for the first 2 residual-P years with the 60 lb/a P$_2$O$_5$ rate. Total grain production for all years (application and residual P years) showed that banded P applications were more efficient than broadcast P.

Introduction

Carryover of phosphorus (P) from fertilizer applications can provide P for succeeding crops. Some agronomists speculate that, with the use of reduced tillage (especially no-till), increased residual P could be available because of reduced soil mixing and soil tie-up of P. If this is the case, less fertilizer P or less frequent P applications should be required. The purposes of this study were to measure the residual P effects from 4 years (1987-1990) of P fertilizer applications in two tillage systems (chisel-disc and no-till), which included different P fertilizer rates and placement methods for grain sorghum and to compare these residual P responses with those from selected fresh P fertilizer applications.

Procedure

The study was conducted at the East Central Kansas Experiment Field near Ottawa, KS on an initially low P-test (12 lbs/a Bray #1 P-test) Woodson silt loam soil (fine, montmorillonitic, thermic, Abruptic Argiaquolls). The experiment was designed as a randomized complete block, split plot with the chisel-disc and no-till systems as whole plots and the P fertilizer rates and placement methods as subplots. There were three replications of each treatment.

The original P applications began in 1987 and continued on the same plots for 4 years. Treatments in each tillage system included five P fertilizer rates (0, 10, 20, 30, and 60 lbs P$_2$O$_5$/a) and four placement methods (seed-furrow, 2”x2” row banded, broadcast, and knifed) plus some combination application methods. Grain sorghum was grown in all years. However, only three crops were harvested during the P application years. In the first year, the grain sorghum crop was lost because of hail. Starting in 1991, the 5th year of the study, most P treatments were stopped and were left as residual treatments except for a select few that received annual, fresh P fertilizer of either 10, 20, or 30 lb/a P$_2$O$_5$, 2”x2” row banded. These are identified in Table 1 as “F” (fresh applications) compared to “R” for residual. The source of P fertilizer used in all treatments was liquid 7-21-7 except for some initial seed-furrow P applications, which were 9-18-9, 6-24-6, and 10-34-0 P materials. All of the broadcast P fertilizer in this study was sprayed on the soil surface and was incorporated in the chisel-disc.
systems. The knifed P fertilizer was knifed 5-7 inches deep on 15-inch centers through anhydrous ammonia fertilizer knives. The row-banded P was banded 2 inches to the side and 2 inches below the seed at planting. The P fertilizer applied in the seed-furrow was dribbled with the seed ahead of the seed-covering discs at planting.

Nitrogen (N) and potassium (K) fertilizers were applied as needed. The N fertilizer was knifed 5-7 inch deep on 15-inch centers, and the K fertilizer was broadcast on the soil surface. Planting dates for evaluating the residual P treatments were June 7, 1991; June 24, 1992; June 21, 1993; and June 16, 1994. Weeds were controlled each year by using a combination of early preplant and preemergence herbicides, plus hand weeding to assure no affect from weeds. All plots, including the no-till plots, were row-crop cultivated one time during the growing season.

Whole, aboveground, plant samples were collected at the 5- to 7-leaf growth stage to determine early-season, dry matter production, P content in the plant tissue, and P uptake. The center two rows of each plot were harvested for yield. All grain yields were adjusted to 12.5% moisture.

**Results**

Residual P responses in both tillage systems were similar except for 1994, when yield was slightly higher in the chisel-disc system than in the no-till system (Table 1). Also, a statistically significant interaction (p < 0.05) occurred between the tillage systems and the P fertilizer treatments for P uptake in 1994 and for residual yield when totaled for the 4-yr residual period. These effects indicate a possible increase in residual P availability with no-till.

Averaged across tillage systems, yield responses for the P treatments varied depending on the rates of original P application, from 6.0 to 14.6 bu/a in 1991, from 3.3 to 22.0 bu/a in 1992, from 0.3 to 12.9 bu/a in 1993, and from -1.5 to 14.3 bu/a in 1994. The highest rates of original P produced the greatest residual P yield responses. Residual P responses with the 10 lb/a P$_2$O$_5$ treatments were marginal in the first year and were statistically not significant in the remaining residual P years. The 30 lb/a P$_2$O$_5$ residual P treatments increased residual P yield in the first 2 years but not the second 2 years. The 60 lb/a P$_2$O$_5$ residual P treatments significantly increased residual P yield in all 4 years. All residual P responses were less compared to fresh P responses, except the first 2 residual P years with the 60 lb/a P$_2$O$_5$ residual P treatments. This suggests that residual P availability was insufficient past the first 2 residual P years, even with the highest P applications.

The methods of P application had little effect on residual P response. This differs compared to the placement effects on yield during the years of P application. This could be partially because of more efficient P use in the years of P application.

Total yield response for all study years (application and residual P years) is shown in the far right-hand column of Table 1. These figures show that the amount of P applied originally had a significant effect on initial and residual P yield responses. The data also show that, at equivalent P rates, the banded P applications were more efficient than broadcast P. Broadcast P in this study performed poorly, unless some P was concentrated near the seed.
Table 1. Grain sorghum response to residual and residual plus freshly applied P in two tillage systems (Woodson silt loam soil).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>1994 Whole Plant</th>
<th>Grain Yield</th>
<th>1994 Total Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7-Leaf</td>
<td>Dry Mass</td>
<td>P Uptake</td>
<td>1991 1st Yr Residual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gms/plant</td>
<td>%</td>
<td>mg/plant</td>
</tr>
</tbody>
</table>

**Tillage System:**

- **No-till**
  - Residual 6.1 0.27 17 67.8 65.1 20.6 71.8 225 395
- **Chisel-disc**
  - Residual 5.3 0.25 14 58.5 60.2 22.6 74.3 216 386

**L.S.D. 0.05**
- NS NS 2 NS NS NS 2.2 NS NS

**P Treatment:** /P/O<sub>5</sub> Rate, 1 lb/a

- **Check - NO P**
  - 4.2 0.23 10 (54.1) (49.9) (12.1) (65.4) (182) (308)
- **R-10S, F-10RB**
  - 6.5 0.27 17 +7.1 +14.9 +14.1 +3.5 +40 +77
- **R-10S, F-20RB**
  - 7.9 0.28 22 +8.0 +21.3 +20.4 +17.2 +67 +109
- **R-10S, F-30RB**
  - 8.0 0.30 24 +4.5 +22.4 +24.7 +22.0 +74 +104
- **R-10S**
  - 4.1 0.23 10 +6.2 +3.3 +0.3 +0.2 +10 +40
- **R-10KN**
  - 5.0 0.24 13 +6.0 +6.9 +3.8 +3.6 +20 +47
- **R-20KN**
  - 4.7 0.24 11 +6.3 +7.0 +0.9 +2.0 +16 +62
- **R-30KN**
  - 5.3 0.25 14 +10.3 +7.2 +4.0 +5.5 +27 +89
- **R-30BC**
  - 4.7 0.25 12 +8.8 +10.1 +5.3 +2.1 +26 +50
- **R-30RB**
  - 5.8 0.25 15 +12.2 +6.6 +3.3 -1.5 +21 +64
- **R-20KN+10S**
  - 4.6 0.26 12 +6.7 +9.1 +1.2 -1.4 +15 +83
- **R-60KN**
  - 6.4 0.28 19 +14.6 +17.5 +12.9 +14.3 +59 +136
- **R-60BC**
  - 5.5 0.28 15 +12.8 +22.0 +14.8 +10.8 +60 +93
- **R-50BC+10S**
  - 5.3 0.27 14 +14.5 +19.7 +11.1 +13.5 +59 +123
- **R-50BC+10S, F-10RB**
  - 7.7 0.30 23 +16.9 +23.1 +24.9 +23.7 +89 +155
- **L.S.D. 0.05**
  - 1.0 0.02 3 6.2 8.0 8.3 11 17 27

**Tillage x P Interaction:**
- NS NS * NS NS NS NS NS * NS

**CV/S:**
- 15 8 18 8 11 12 7 6

S = Placed with the seed in the seed furrow.
RB = Row-banded, 2” side and 2” below the seed at planting.
BC = Broadcast pre-plant surface and then incorporated 3-5” depth by discing in chisel-disc system.
KN = Knifed 5-7” deep on 15” centers, pre-plant.

2 Shaded residual P yield responses are not statistically better than the P control at the 0.05 level of probability.
REPORT OF PROGRESS 719

KANSAS FERTILIZER RESEARCH
1994

AGRICULTURAL EXPERIMENT STATION.
Kansas State University, Manhattan
Marc A. Johnson, Director