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RESPONSE OF DRYLAND WINTER WHEAT TO RESIDUAL P

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ABSTRACT

Phosphorus studies were conducted in Kansas and Nebraska to determine the effects of P fertilizer placement method on the availability of residual P fertilizer in a reduced tillage winter wheat-fallow rotation and in a continuously cropped winter wheat system under dryland conditions. The results of these studies indicate that on soils testing very low in available P, band applications of P fertilizer at low rates (< 50 lb P_2O_5/a) are more effective than broadcast P fertilizer during the first year of application. As P rates increase, differences in yield potential between band and broadcast application methods decrease. Winter wheat responded equally to banded or broadcast residual P fertilizer when the broadcast P was initially incorporated. Residual P needs to be considered when making P fertilizer recommendations.

INTRODUCTION

The frequency of band application of fertilizer phosphorus (P) has increased in the last decade. Banding of low rates of P fertilizer near the seed on soils testing low in available P has been more effective than broadcast applications of P fertilizer at the same rate during the year of application in the Central Great Plains. The residual availability of fertilizer P in these bands to successive crops will depend on many factors such as the rate applied, row spacing, soil test P level, time between application and P uptake of the successive crop, and extent of band disturbance by tillage. As soil test P levels increase, yield differences between banding and broadcast applications are expected to decrease (Peterson, et al., 1981). On a long-term basis, a broadcast application of P fertilizer may be equally as effective as a band application at equal rates for wheat production (Wagar et al., 1986). Long-term P studies conducted in the northern Great Plains indicate that benefits from a single P fertilizer application may last as long as 16 years, depending on initial rate of P application and cropping history (Black, 1982; Halvorson and Black, 1985; Roberts and Stewart, 1987; Wager et al., 1986). Halvorson (1989) showed positive yield responses of irrigated winter wheat to residual P at Akron, CO. Halvorson and Black (1985) suggested that a one time, high rate application of P fertilizer may be one way to satisfy the P needs of crops grown with reduced tillage and no tillage systems for several years. The studies reported here evaluate this suggestion in addition to comparing the effects of P placement method on the long-term effectiveness of residual P fertilizer with reduced tillage systems. The specific objectives of

the studies reported here were to determine the effects of P fertilizer placement on residual P fertilizer effectiveness within a reduced tillage winter wheat-fallow production system and a no-till continuous winter wheat cropping system.

MATERIALS AND METHODS

The research was located at two sites, one site located in Butler County, Kansas and one site near Morrill, Nebraska. Both sites involved dryland cropping systems and were seeded with hoe type drills (12 inch row spacing) equipped to band fertilizer with the seed, below the seed, or over the seed row. Winter wheat was planted at both sites from mid- to late-September each year. Herbicides were used to control weeds during non-crop periods and within the growing crop. Approximately 900,000 seeds/a or 60 lb/a were planted at both sites. Grain yields were determined by harvesting each plot with a plot combine. Specific details of each site are presented below.

Morrill, NE Site: A split-split plot, randomized block design was used with P placement method as main plots, P fertilizer rate as sub-plots, and N fertilizer rate as sub-sub plots with four replications. Fertilizer P placement methods were: BCI (broadcast with shallow incorporation, 3 inch depth); BS (band below seed about 2 inches or 3 inch soil depth); and SD (placed directly with seed at 50% of established P rates for 2 crop years). The fertilizer P (0-45-0) rates were 0, 23, 46, and 92 lb P_2O_5/acre and the N (34-0-0) rates were 0 and 40 lb N/acre for crop-1 and 50 lb N/a for crop-2 and 3. The study was initiated in September 1984 on a Mitchell silt loam soil with a 4 ppm Olsen P soil test level (0 to 6 inch depth) and a pH of 7.3. A no-till system was maintained for crop-1 and 2, but converted to a reduced tillage system (residual herbicide over winter and then sweep tillage during summer of fallow period) for crop-3. Nitrogen was broadcast applied without incorporation at the specified rates just prior to planting. The study included duplicate sets of treatments and plots to allow a crop to be present each year from 1985 to 1990. Therefore, one set of treatments was established in September 1984 and the other set in September 1985. The yield data reported here represent two years of data for each crop or eight replications of each treatment.

Butler County Kansas Site: No-till winter wheat was established in 1988 on a Woodson silt loam soil that had been in grain sorghum in 1987 (P treatments were initially applied to sorghum in spring 1987). The soil had a pH of 5.6 and a 3 ppm Bray-1 P level (0 to 6 inch depth). These plots were chemical fallowed during summer 1988, and were no-till planted to wheat in the fall 1988, 1989, and 1990. Phosphorus was applied at 15, 30, and 45 lb P_2O_5/a as ammonium polyphosphate (10-34-0). Method of application included broadcast with no incorporation (BCNI); band (dribble) over the seed row (DR); band 2 inches below the seed (BS); and directly with

the seed (SD). A check treatment was included with each placement method. Treatments were replicated four times in a randomized complete block design. Duplicate sets of SD treatments were established when sorghum was planted in 1987 (24 inch row spacing). One set received no additional P during the winter wheat phase of the study [SD(87)], therefore, yield responses are to residual P. The other SD treatments received a 2nd application of P in the fall of 1988 and then no further P applied. The DR treatments received P in 1987, 1988, and 1989 at the specified rates and no additional P in fall 1990. The BS and BCNI treatments received the specified P rates each crop year (1987-1990). Therefore, winter wheat responses to P were the result of both residual and newly applied P fertilizer. Nitrogen (UAN) was broadcast after planting at 80 lb N/a.

RESULTS AND DISCUSSION

Morrill, NE Site: Grain yields were significantly increased with increasing P rate for all P placement methods for crop-1 (1985 & 1986). Yields were not significantly affected by P placement method, indicating that the SD P was as effective at the 50% P rate as the BS and BCI treatments at full P rate. The tendency was for the band treatments (BS and SD) to be more effective at the 23 and 46 lb P_2O_5/a rates. The yield response (P treatment-check plot) to P fertilizer rate for each P placement method is shown in Fig. 1 for those treatments receiving 40 lb N/a. Because of limited space, only data from the treatments receiving N will be reported here. In general, P responses with N were greater than P responses without N most years. Based on the data presented in Fig. 1, grain yields were not maximized at this site by the highest P rate.

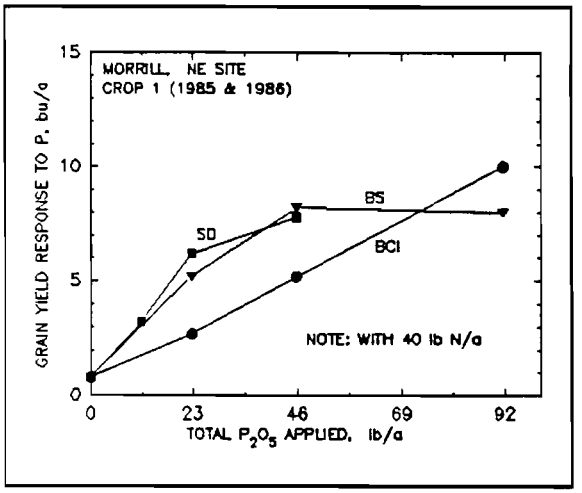

Figure 1. Crop-1 yield response to P fertilization.

Winter wheat grain yields for crop-2 (1987 & 1988) responded positively to residual P from the BCI and BS treatments, increasing as initial P rate increased. Without P fertilization, N application resulted in a decrease in grain yield. The yields from the BCI and SD (2nd P application) treatments were similar at the highest P rate, with the SD yields tending to be higher at the lower P rates. The grain yield response (P treatment-check plot) to increasing P levels is shown for each P placement method in Fig. 2 for crop-2.

Grain yields for crop-3 (1989 & 1990) increased significantly with increasing residual P levels (Fig. 3) with no significant difference in grain yield between P placement methods. Total cumulative grain yield response (crop 1+2+3) to P fertilization and

P placement methods are shown in Fig. 4. Cumulative grain yields were very similar for all P placement methods at all P rates. The data indicate that the highest P rate (92 lb P_2O_5/a) was not sufficient to maximize grain yields at this site when N was also applied.

Assuming a wheat price of \$3.75/bu, P_2O_5 cost of \$.284/lb, and a N cost of \$.18/lb, a simple economic analysis was conducted to estimate the return to P and N fertilization. A net loss of \$25/a was estimated when N was applied without P over three crops. When P was added, estimated returns to P rates of 23, 46, and 92 lb P_2O_5/a were \$13, \$17, and \$59 for BCI; \$10, \$26, and \$27 for BS; and \$12, \$27, and \$51 for SD treatments, respectively, for three crops. The SD P rates tended to show a higher level of profitability for crop-1 than the higher, one-time P applications of the BCI and BS treatments. However, this difference in profitability disappeared with each additional crop year.

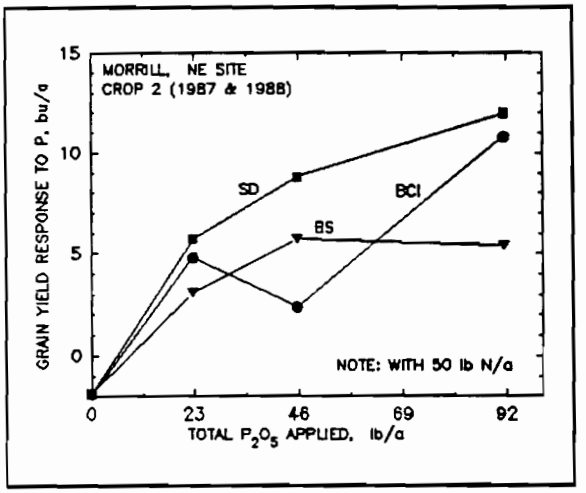

Figure 2. Crop-2 grain yield response to P fertilization.

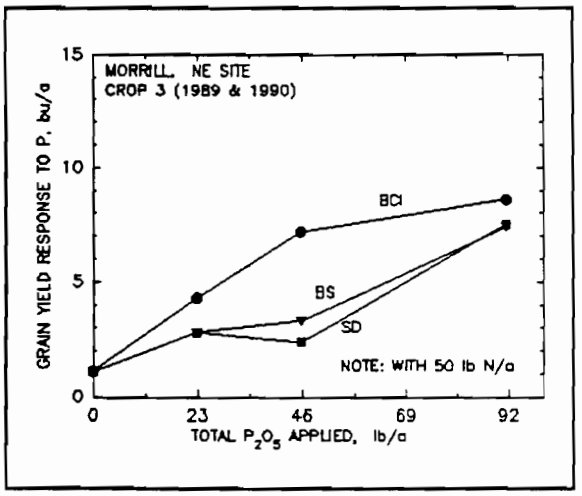

Figure 3. Crop-3 grain yield response to P fertilization.

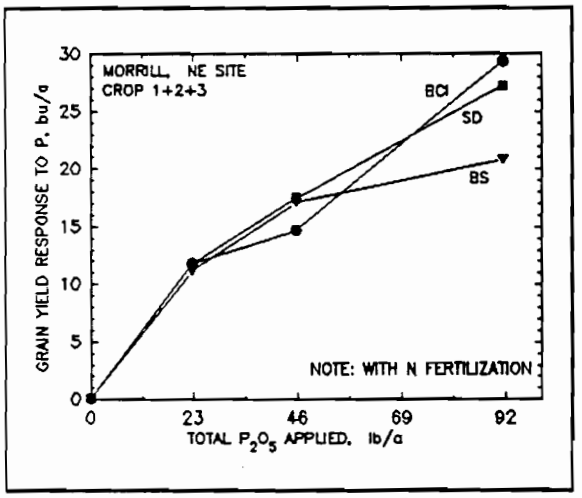

Figure 4. Total grain yield response to P fertilization in 3 crops.

Kansas Site: The extreme drought stress experienced in 1989 reduced regional wheat grain yields severely as well as those at the study site (Fig. 5). The highest yields were obtained only with the BS and SD treatments at the highest P rate. The extreme dry surface soil conditions that occurred during tillering (fall and early spring) reduced P availability with the DR and BCNI treatments, resulting in a

significantly lower yield. Winter wheat responded positively to the residual P applied SD('87) in 24 inch rows with the grain sorghum in 1987 (Fig. 5). This 24 inch row spacing was to wide to provide adequate P to all rows of wheat in 1989. Visual symptoms of P deficiency were obvious in alternate wheat rows in 1989. These data do, however, indicate a yield response to residual SD P similar to that of the DR treatments when compared on an equal P rate basis.

In 1990 the rainfall quantity and distribution were near normal. Wheat yield responses to P with all methods of application were observed; however, BS P increased wheat yield about 20 bu/ac more than BCNI applied P (Fig. 6). Wheat yields of the DR treatments were similar to the BS treatments at the higher P rates. Wheat response in 1990 to residual P of the SD treatments showed a significant increase in grain yield with increasing level of P application. Yields of the SD(87, 88) treatments were similar or equal to those of the DR treatments when expressed on an equivalent P rate basis. Phosphorus application with the SD method did not provide sufficient P for optimum yield in 1990. These data indicate that on a low P soil, band P applications will provide residual available P for successive crops. Additional P was required to optimize yield for all P placement methods in 1990.

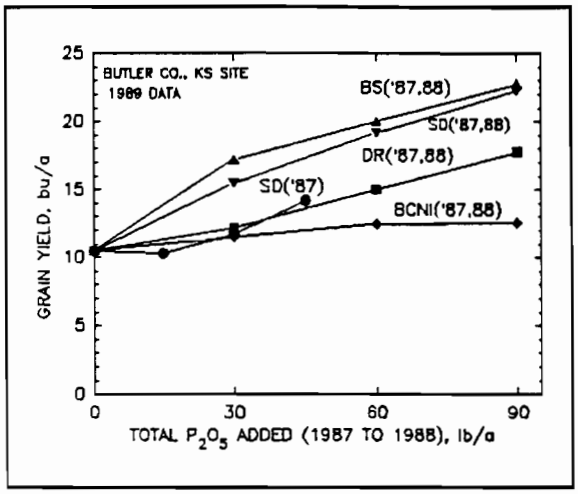

Figure 5. Winter wheat response to P fertilizer placement and rate.

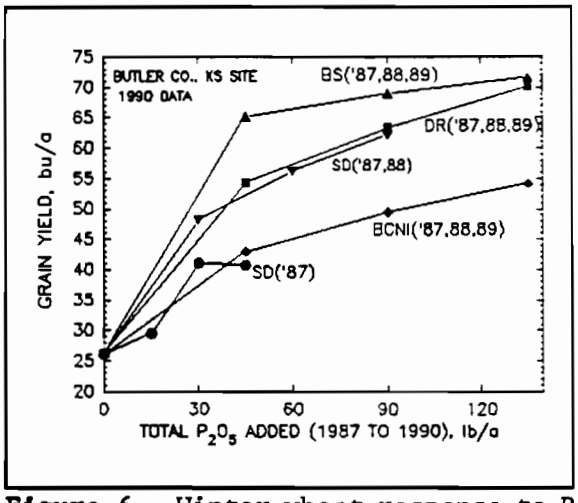

Figure 6. Winter wheat response to P fertilizer placement and rate.

In 1991, wheat yields were again reduced because of drought (Fig. 7), although not as much as in 1989. Grain yield were significantly increased with increasing rates of P application for all P placement methods. Responses to residual P fertilizer were similar to those of the BS and BCNI treatments. Broadcast application of 75 lb P_2O_5/a to previously unfertilized plots resulted in similar grain yields as continuous application of 30 lb BCNI P_2O_5/a (total 120 lb P_2O_5/a). Sufficient P was not available from any of the placement methods to maximize grain yields in 1991.

The cumulative winter wheat yield response to P fertilization

(3 crops) is shown in Fig. 8 as a function of P placement method. Total response to P fertilizer rates was similar for all band application methods, even when the yield response resulted from residual P. The BCNI treatment showed the lowest total response in three crops, possibly because of the drought conditions in 1989 and no incorporation of the P which caused the P to be positionally unavailable. The 1991 data would indicate that the residual P from the BCNI treatments may be becoming more available with time, as the P gets incorporated with each successive seeding operation.

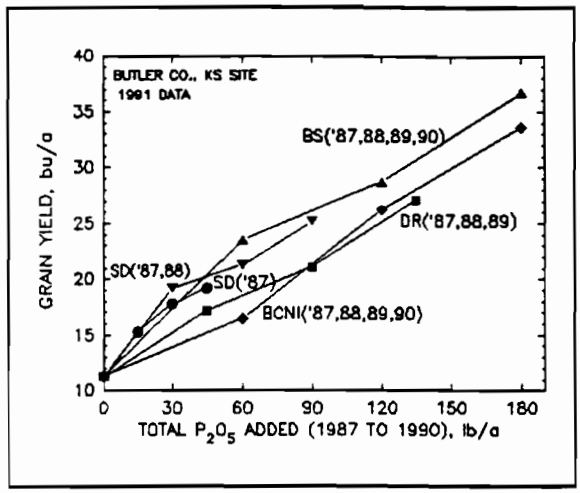

Figure 7. Winter wheat response to P fertilizer placement and rate.

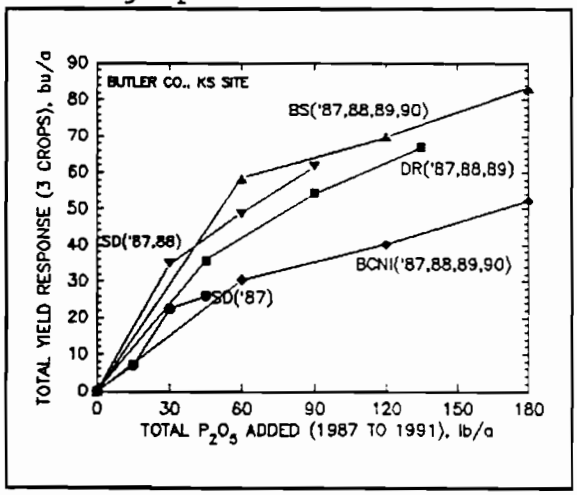

Figure 8. Total yield response to P fertilization (3 crops)

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