

## Fertilizer Phosphorus Management Options for No-Till Dryland Winter Wheat

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Adoption of no-till (NT) wheat-fallow farming systems in the Central Great Plains raised the question of how to best manage fertilizer P to optimize yields when tillage would not be an option to incorporate added P. Research in the Northern Great Plains had shown that a one-time, high rate application of P would satisfy the P needs of dryland crops for several years under conventional tillage practices. Would a high rate of fertilizer P be effective in a NT wheat-fallow system in the Central Great Plains? This research was undertaken to determine effects of fertilizer P placement method and P rate on winter wheat yields in a wheat-fallow cropping system under NT management.

Four placement methods [broadcast incorporated (BCI), broadcast without incorporation (BC), deep band (DB), and seed placed (SP)] were initiated in part of a conventional-tilled wheat field that was converted to NT. Five fertilizer P rates (0, 69, 137, 206, and 275 lb P<sub>2</sub>O<sub>5</sub>/A) were applied as a one-time application in each of the BCI, BC, and DB placement treatments. The DB fertilizer P was placed about 3 in. below the soil surface in bands spaced 12 in. apart. Fertilizer P rates were reduced 75% for the SP treatment for rates of 0, 17, 34, 52, and 69 lb P<sub>2</sub>O<sub>5</sub>/A placed directly with the seed at

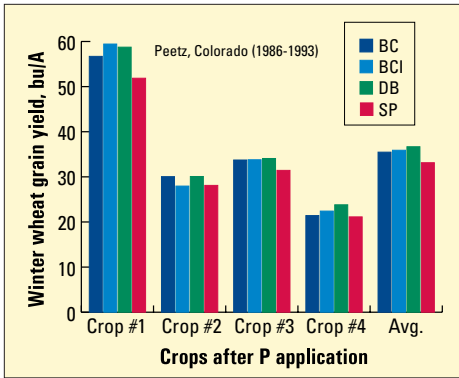
planting for each of four crop years. After four wheat crops, the SP had received the same amount of fertilizer P as the one time BCI, BC, and DB treatments. Each P treatment was further split into two nitrogen (N) treatments (with and without fertilizer N applied; see **Table 1** for N

rate). The study was located about 10 miles west of Peetz, Colorado, on a Rosebud-Escabosa loam soil with a medium sodium bicarbonate extractable soil test P level [10 parts per million (ppm)], soil pH of 7.8, and 2.4% soil organic matter. Duplicate sets of plots were established to have all phases of the crop rotation present each year. Data were averaged over the duplicate sets of plots so that treatment yields for each crop represents data collected for two crop years. A NT winter wheat-fallow cropping sequence was followed for eight years and

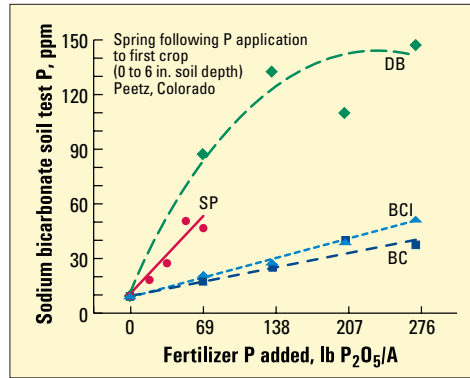
four replications of each treatment were used.

Grain yields did not vary significantly ( $p = 0.05$ ) among P placement methods when averaged over N and P rates (**Figure 1**) for any of the crops and when averaged over crops. When averaged across all four crops, P placement made no significant difference in winter wheat yields. This would indicate that the fertilizer P applied directly with the seed each year at 25% of the rate of

The effects of four phosphorus (P) fertilizer placement methods and five P rates on winter wheat yields were evaluated in a no-till wheat-fallow system in eastern Colorado. Winter wheat grain yields, averaged over four crops, were increased significantly with P fertilization. Additionally, differences in total wheat yields after four crops were observed among P placement methods. The results of this study have demonstrated the need for relatively high rates of fertilizer P to optimize winter wheat yields in the Central Great Plains.



**Figure 1.** Winter wheat grain yields as a function of P placement method for each crop after initial fertilizer P application, averaged over N and P rates.



**Figure 2.** Spring sodium bicarbonate soil test P levels following the fall application of P to the first crop.

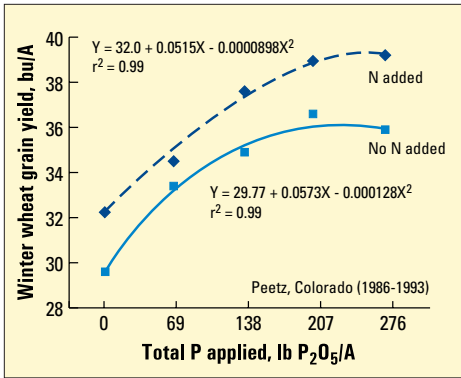
the one-time P applications was just as effective as the one-time high rate applications. Soil samples (0 to 6 in. depth) collected in the spring following the fall P fertilizer application to the first crop and analyzed for sodium bicarbonate extractable P may offer an explanation to the observed response. For the DB and SP treatments, soil cores were taken directly through the fertilizer P bands. For the BCI and BC treatments, soil cores were taken at random in the plot area. Levels in the 0 to 6 in. soil depth were

extremely high in the DB treatments (**Figure 2**), increasing curvilinearly with increasing fertilizer P rate. Soil test P levels in the SP bands were as high or higher than in the BCI and BC treatments at the higher P rates, increasing linearly with increasing rate of fertilizer P application. Levels increased linearly with increasing P rate for the BCI and BC treatments. Thus, estimates of available P to the crop were similar for the BC, BCI, and SP treatments.

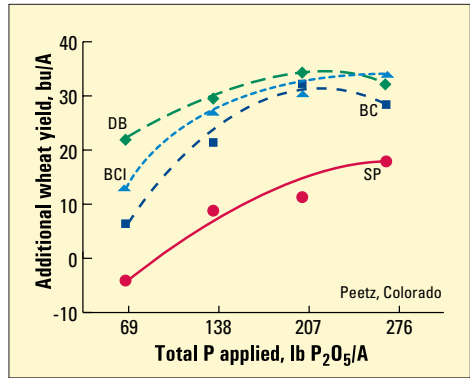
Winter wheat grain yields, averaged

**TABLE 1.** Years averaged for each crop, fertilizer N rate applied to N treatment, available soil N at planting (0 to 6 in. soil depth), growing season precipitation, soil water used by corn, estimated total crop water use, and environmental factors affecting grain yield each year.

| Crop   | Year | Fertilizer N rate, | Planting soil N, | Growing season precip., | Soil water used, | Crop water used, | Environmental factors                           |
|--------|------|--------------------|------------------|-------------------------|------------------|------------------|---|
|        |      | lb/A               | lb/A             | in.                     | in.              | in.              |   |
| Crop 1 | 1986 | 50                 | 148              | 9.6                     | 0.6              | 10.2             | No major limiting factors                       |
|        | 1987 | 50                 | 97               | 11.7                    | 3.2              | 14.9             | Russian wheat aphid                             |
| Crop 2 | 1988 | 80                 | 88               | 10.7                    | 6.2              | 16.9             | 6.5 in. precipitation in May                    |
|        | 1989 | 75                 | 88               | 5.7                     | 4.9              | 10.6             | Drought in June<br>Hail, drought                |
| Crop 3 | 1990 | 50                 | 195              | 1.1                     | 7.9              | 9.0              | Severe drought                                  |
|        | 1991 | 50                 | 195              | 6.7                     | 5.4              | 12.1             | Hail damage                                     |
| Crop 4 | 1992 | 50                 | 279              | 10.2                    | 2.7              | 13.5             | Dry April-May, frost,<br>hail damage            |
|        | 1993 | 50                 | 197              | 5.5                     | 5.2              | 10.8             | Dry planting to late May,<br>hail after heading |



**Figure 3.** Winter wheat grain yields, averaged over four crops, as a function of total fertilizer P applied.



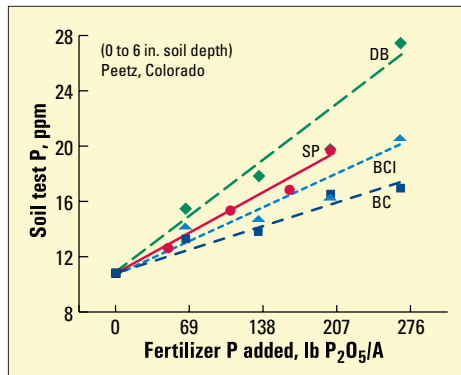
**Figure 4.** Total grain yield response of winter wheat to P fertilization after four crops for each P placement method.

over four crops, increased significantly with increasing rates of fertilizer P, with and without N (**Figure 3**). Average grain yields appeared to possibly start leveling out with the application of 275 lb P<sub>2</sub>O<sub>5</sub>/A. This indicates that a significant amount of fertilizer P is needed to optimize grain yields and eliminate P deficiency in dryland winter wheat in the Central Great Plains. Winter wheat responded to fertilizer P application rate similarly for each N rate and P placement treatment. Because of several dry years and hail damage, yield potential for crops 2, 3, and 4 were limited (**Table 1**). This may explain the reduced response to N fertilization.

Although the P placement by P rate interaction was not significant, a single degree of freedom F test contrasting SP total grain yield of four crops with N fertilization to the grain yields of the other placement methods indicated a significant ( $p = 0.10$ ) difference between SP and the other P placement methods. The cumulative additional

wheat yield due to P fertilization after four crops with N fertilization is shown in **Figure 4**. As P rate increased, cumulative wheat yields were slightly higher for the DB, BCI, and BC treatments than for the SP treatment. At the highest P rate (275 lb P<sub>2</sub>O<sub>5</sub>/A) and a cost of \$0.30/lb P<sub>2</sub>O<sub>5</sub>, about 24 bu of additional wheat per acre would be needed to pay for the fertilizer P at a wheat price of \$3.50/bu. The cumulative additional wheat yield above that without fertilizer P applied exceeded 24 bu/A in four crops at the highest P rate for the DB, BC, and BCI treatments, thus generating profit. Additionally,

the residual fertilizer P remaining after four crops will impact wheat yields for many more years, based on long-term P studies in the Northern Great Plains. Soil test P levels measured seven years after P application, but before the fourth crop was produced (**Figure 5**), show that soil test levels for the BCI and BC had declined for all fertilizer P rates. However, the soil



**Figure 5.** Sodium bicarbonate soil test P level seven years after initial fertilizer P application and before planting of the fourth wheat crop as a function of fertilizer P rate and P placement method.



**These photos compare** various treatments for wheat plots at Peetz, Colorado, in 1986. Shown from left to right are: no P added, 68 lb  $P_2O_5/A$  as SP, 68 lb  $P_2O_5$  as BCI, and 278 lb  $P_2O_5/A$  as BCI.

test level with no fertilizer P applied remained fairly constant over the seven-year period at about 10 ppm. These results support the concept put forward by Kastens et al. (*Better Crops with Plant Food*, 2000, Vol. 84, 2:8-10) that higher soil test P levels are needed to optimize economic yields in the Central Great Plains. The soil test P levels for the DB and SP treatments in **Figure 5** were determined by taking 10 soil cores across the space within and between fertilizer bands, analyzing each core separately, then averaging across the cores. The results show that soil test levels after seven years increased linearly with the DB placement as P rate increased, and the soil test P levels were greater than those observed for the other placement treatments (SP had received 75% of the total DB rate at this sampling). Soil test P levels for the SP treatment were slightly greater than for the BCI and BC treatment after three crops and nearly seven years after application. These soil test P levels show that yield potential was increased for several future crops.

The results from this study show the need for higher rates of fertilizer P application to optimize winter wheat yields in the Central Great Plains. If soil P is deficient in a NT production system, applying fertilizer P on the soil surface will help alleviate P deficiency even without incorporation. Applying fertilizer P on the soil surface without incorporation will, however, in-

crease the risk of P loss in surface runoff water.

Annual applications of SP fertilizer P at 25% of the one-time BCI rate were effective in increasing wheat yields. However, the total cumulative yield after four crops tended to be less than that of the other placement methods. Wheat yields increased with increasing rates of SP fertilizer P, but high P rates were required to maximize grain yields. Total yield response to P application may have been even greater if environmental conditions for crops 2, 3, and 4 had been more favorable. The results in **Figure 4** show that a high level of available P is needed to optimize wheat yields in the Central Great Plains regardless of P application method. [BC](#)

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