POSITIONAL AVAILABILITY OF PHOSPHORUS FROM SURFACE FERTILIZER BANDS

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ABSTRACT

Our objective in this field study was to determine the relative distribution of P applied as a liquid starter fertilizer in a surface band during the early part of the corn growing season. Research was conducted during three years (2001-2003) at three locations in central Iowa. Exchange-resin membranes were used to characterize P movement. Treatments consisted of a control and 15-30-10 or 60-30-10 starter dribbled (30 gal./A) on the soil surface two inches to the side of the corn row at the time of planting. In 2001, the highest concentration of bioavailable P was found more than three inches below the soil surface 43 days after application of 60-30-10 starter. In 2002, the highest concentration of bioavailable P at 43 days after application in 2002 was found more than four inches below the surface for the 15-30-10 treatment, while application of 60-30-10 starter had little measurable effect. At 68 days after application, the highest P concentration was measured at a depth of less than two inches below the surface for the 15-30-10 starter treatment, and more than three inches below the surface for the 60-30-10 treatment. Similar results were found from measurements in 2003. Given that P diffusion in soil is a relatively slow process, the volume of material (30 gal./A) and the porosity of the soil probably played a role in P movement. In any case, the increased levels of bioavailable P in the root zone would potentially benefit the plant throughout the remainder of the growing season.

INTRODUCTION

In general, the effectiveness of starter fertilizer depends both on the ability of the added material to increase the soil supply of nutrients, especially P, and the ability of the corn seedling to respond to this increase. Changes in the soil supply characteristics of P, resulting from fertilizer addition, depend on soil type and inherent P levels. Moreover, the spatial distribution of fertilized soil relative to actively growing roots is important. Intuitively, it would seem that the most effective starter placement would be as close to the seed as possible. Research has shown, however, that surface applications of starter often are as effective as subsurface bands or in-furrow applications. For example, Gordon et al. (1997) reported that early growth and grain yield of corn grown in Kansas were significantly increased by surface dribble applications of fertilizer. These results suggest that the nutrients in the starter became positionally available for uptake. Our objective in this study was to determine the relative distribution of P applied as a N-P liquid starter fertilizer in a surface band during the early part of the growing season. This research was a part of a larger study initiated to evaluate the effectiveness of a N-P_2O_5-K_2O liquid material (7-21-7) in combination with urea ammonium nitrate liquid (UAN, 32-0-0) as a starter fertilizer for corn production in Iowa.

MATERIALS AND METHODS

Field Sites and Cultural Practices

Research was conducted during three growing seasons (2001-2003). The previous crop was soybean in all years. In 2001, field plots were established at the Iowa State University Agricultural Engineering Research Center. At this location, the soil is a Canisteo silty clay loam (fine-loamy, mixed, superactive, calcareous, mesic Typic Endoaquolls). Phosphorus movement was characterized after 60-30-10 starter was dribbled on the soil surface two inches to the side of the corn row at the time of planting. The material was a blended combination of 7-21-7 liquid and 32-0-0 UAN. To maintain a uniform application, the material was applied at 30 gal./A. For the 2002 field trials, plots again were established on a Canisteo silty clay loam. Phosphorus movement was characterized in three treatments that consisted of a control and 15-30-10 or 60-30-10 starter fertilizer dribbled (30 gal./A) on the soil surface two inches to the side of the row at the time of planting. The study was expanded to determine whether different N:P_2O_5 ratios would affect P mobility. The 2003 field trials were conducted at the Iowa State University Kelly Research Center. At this location, the soil is a Clarion silt loam (fine-loamy, mixed, superactive, mesic Typic Haplaquolls). As in 2002, P movement was characterized in three treatments, including a control and 15-30-10 or 60-30-10 starter fertilizers dribbled (30 gal./A) on the soil surface two inches to the side of the row at the time of planting.

In each of the three years, soil samples (0-6 in.) were collected with a hand probe before planting, and analyzed for available P, exchangeable K, Ca, and Mg, pH, and organic matter content (Table 1). Corn was planted each year in 30-inch rows at a seeding rate of 33,000 plants/A. Plots consisted of five rows. More detailed information discussing the effect of starter treatments can be found elsewhere (Kovar, 2003).

Table 1. Initial properties of soils used in the field trials. Soils were Canisteo silty clay loam in 2001 and 2002, and Clarion silt loam in 2003.

Year	Treatment	Bray P 1	Exch. K	Exch. Ca	Exch. Mg	pH	OM*
		------------------------	ppm	------------------------			%
2001	60-30-10	63	216	3395	570	5.8	5.4
2002	0-0-0	63	186	5047	449	7.7	7.8
	15-30-10	54	191	5937	417	7.9	7.6
	60-30-10	75	242	4700	415	7.3	8.0
2003	0-0-0	44	75	1950	271	6.4	4.9
	15-30-10	47	113	3017	385	6.8	5.3
	60-30-10	41	81	2400	370	6.7	5.1

*LOI method.

Measurements of P Movement

An evaluation of the movement of bioavailable P from the application band into the soil profile was conducted during the early part of the growing season in each year. At 43 days after application in 2001, a 6 in. x 6 in. sheet of bicarbonate-saturated anion exchange membrane was inserted vertically into the soil profile within and perpendicular to the row of two reps of the 60-30-10 (dribbled 2x0) treatment. One side of the membrane sheet was pressed firmly against soil profile to extract P. The other side of the membrane was covered with parafilm and then a 6 in. x

8 in. piece of styrofoam that held the membrane in place as the in-row trench was refilled with soil. The membranes remained in place for 24 h. At the end of this extraction period, the membranes were removed from the plots, and brought into the lab for analysis. Excess soil was gently washed from the membranes with deionized water. Each membrane sheet was then cut into 1 in. x 1 in. squares, and P desorbed by shaking each square in 50 mL of 1.0 M sodium chloride (NaCl) solution. The P concentration in the NaCl solution was determined colorimetrically. Contour plots of the P data were developed to assess relative differences in soil P bioavailability within the profile.

The same procedure was used to evaluate downward P movement from surface application of starter fertilizer in 2002 and 2003. Measurements were made 43 and 68 days after application in 2002 and 42 and 63 days after application in 2003. In 2002, membrane sheets were inserted into the soil profile of two reps of the three treatments. Measurements were made all three reps of the three treatments in 2003.

RESULTS AND DISCUSSION

Based on analysis of individual pieces of exchange resin membrane, movement of bioavailable fertilizer P into the profile was clearly evident in 2001 (Fig. 1). Although the starter material (60-30-10) was applied on the soil surface, the highest concentration of bioavailable P was found at a depth of more than three inches below the surface 43 days after application. Movement of P from fertilizer bands has been observed in other studies (Stecker et al., 2001), but the extent of the movement in this study was greater than expected. Given that P diffusion in soil is a relatively slow process, the volume of material applied (30 gal./A) and the porosity of the soil may have played a role. Regardless, the increased levels of bioavailable P would potentially benefit the plant through the remainder of the growing season.

The characterization of P movement from the application band into the soil profile was expanded during the 2002 growing season to include two $N:P_2O_5$ ratios, as well as measurements at both 43 and 68 days after application. Some movement of fertilizer P into the profile was evident 43 days after application (Fig. 2). The highest concentration of bioavailable P was found at a depth of more than four inches below the surface for the 15-30-10 starter treatment. In contrast to the 2001 results, however, application of the 60-30-10 starter had little measurable effect on bioavailable P concentrations 43 days after application. Because the data shown in Fig. 2 represent only two replications, movement of bioavailable P may have occurred, but was not measured.

At 68 days after application, the highest concentration of bioavailable P was measured at a depth of less than two inches below the surface for the 15-30-10 starter treatment (Fig. 2). For the 60-30-10 treatment, the highest concentration of bioavailable P was found at a depth of more than three inches below the surface. Unfortunately, these measurements may be an artifact of P in the corn root system, rather than the soil. At this point in the growing season, root proliferation in the surface soil was extensive. Although the membranes were placed no closer than 12 inches from a plant, roots could not be avoided.

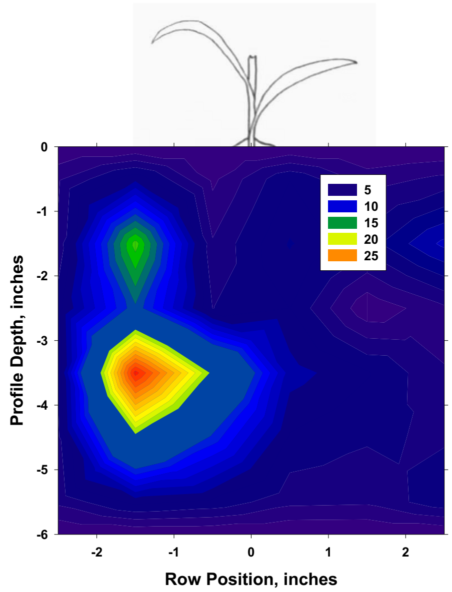

Fig. 1. Profile distribution of bioavailable P 43 days after dribble application of 60-30-10 starter fertilizer on the soil surface approximately two inches to the side of the corn row in 2001. Phosphorus concentrations are ($x10^{-8}$) lb. actual P/inch^2 and were determined by extraction with bicarbonate-saturated exchange resin membranes.

In 2003, P movement from starter bands was measured with membranes placed in an area of a row that was not planted, so that confounding of root P and soil P could be avoided. As in previous years, movement of fertilizer P into the profile was evident. The highest concentration of bioavailable P was found at a depth of one to two inches below the surface for the 15-30-10 starter treatment 43 days after application (Fig. 3). Similar increased levels resulted from application of 60-30-10 starter. At 63 days after application, the highest concentration of bioavailable P was measured at a depth of more than three inches below the surface for the 15-30-10 starter treatment (Fig. 3). In contrast, no measurable differences in bioavailable P concentrations were found in the 60-30-10 treatment 63 days after application. The reason for the difference between the two treatments is unclear. As pointed out by Stecker et al. (2001), there often is significant variation in measurable soil P in the direction of band application. Even with three replications and a relatively uniform fertilizer band, more measurements may be necessary to identify areas with more bioavailable P.

When the bioavailable P profiles for the 15-30-10 and 60-30-10 treatments are compared (Figs. 2 and 3), the effect of increasing the amount of N relative to P_2O_5 in the starter material on P movement into the profile cannot not be determined. To characterize this effect, more intensive sampling is needed. In this study, antecedent soil water content was not controlled, but certainly may affect measurements with the exchange-resin membranes.

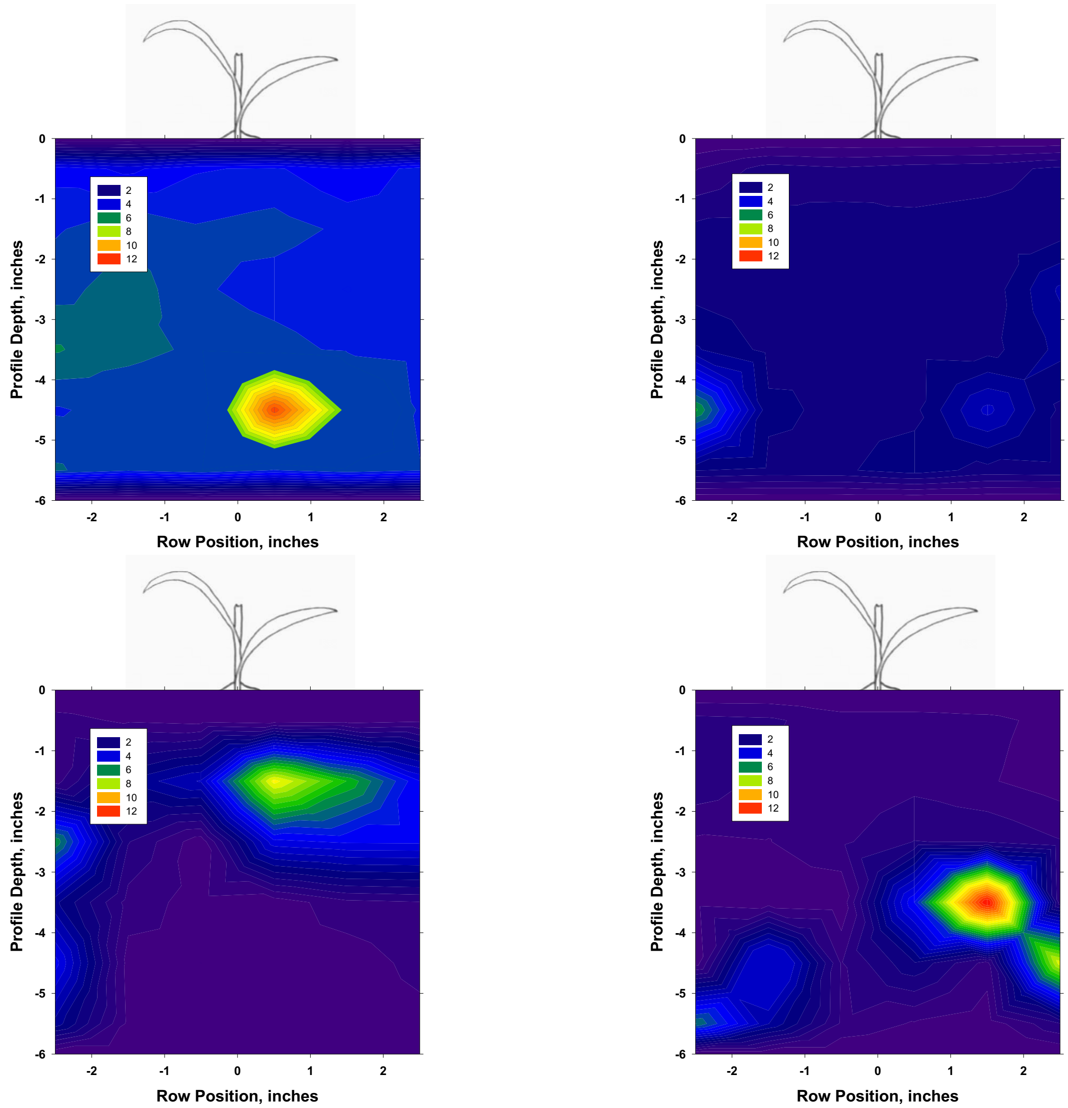

Fig. 2. Profile distribution of bioavailable P 43 days after dribble application of 15-30-10 (top left) and 60-30-10 (top right) starter fertilizer on the soil surface approximately two inches to the side of the corn row in 2002. Profile distribution of bioavailable P 68 days after dribble application of 15-30-10 (bottom left) and 60-30-10 (bottom right) also is shown. Phosphorus concentrations are ($x10^{-8}$) lb. actual P/inch^2 and were determined by extraction with bicarbonate-saturated exchange resin membranes.

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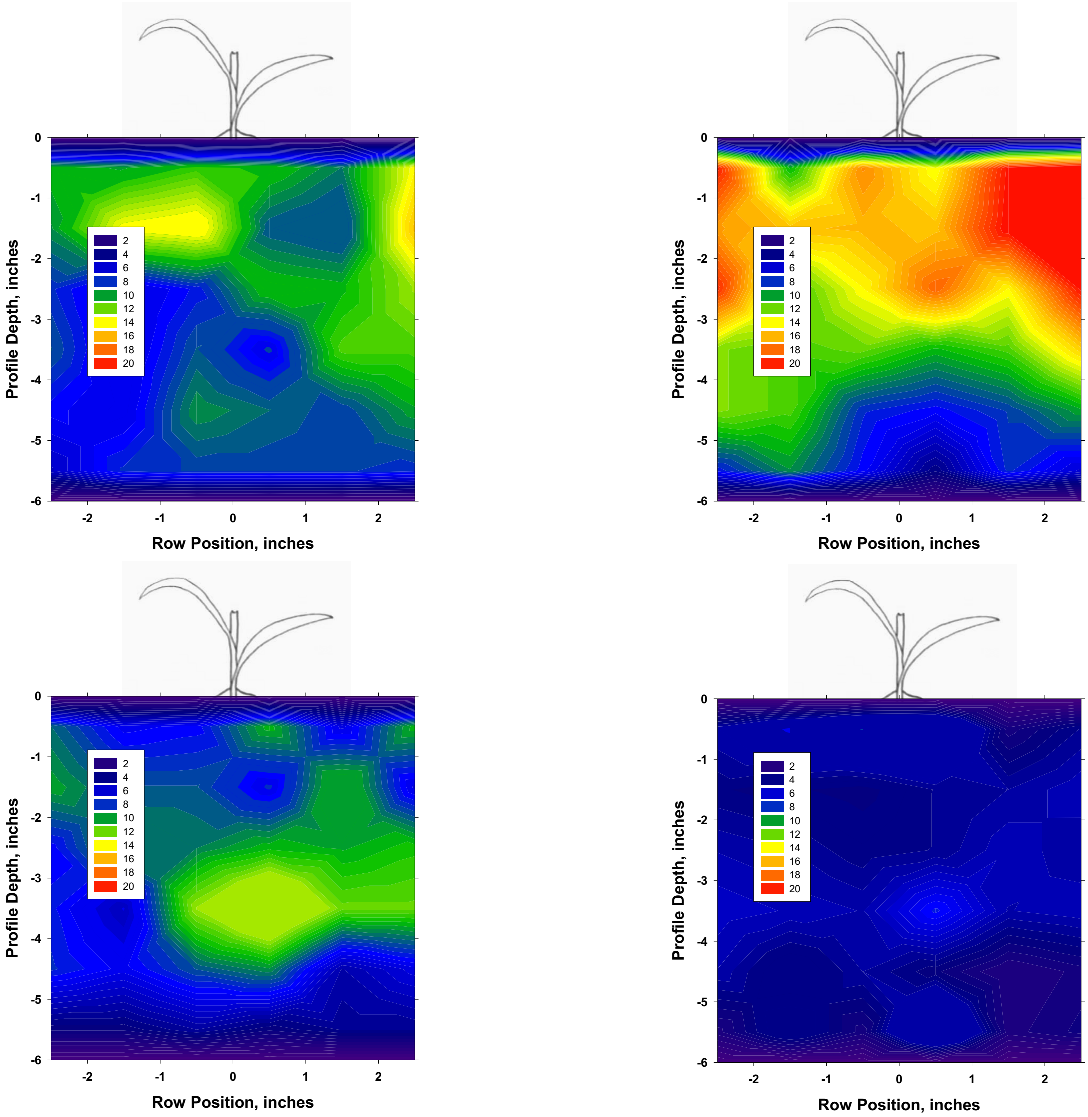

Fig. 3. Profile distribution of bioavailable P 42 days after dribble application of 15-30-10 (top left) and 60-30-10 (top right) starter fertilizer on the soil surface approximately two inches to the side of the corn row in 2002. Profile distribution of bioavailable P 63 days after dribble application of 15-30-10 (bottom left) and 60-30-10 (bottom right) also is shown. Phosphorus concentrations are ($x10^{-8}$) lb. actual P/inch^2.

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