CHANGES IN EXTRACTABLE P AND MINERAL N FROM SOIL RECEIVING FERTILIZER OR MANURE FROM SWINE FED TRADITIONAL OR HIGHLY AVAILABLE PHOSPHORUS CORN DIETS

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Abstract

We compared extractable P and mineral N from soils receiving inorganic fertilizer or manure from swine fed either traditional (TC) or Highly Available Phosphorus (HAP) corn diets. The study was conducted at two sites, one with conventionally tilled irrigated corn and the other with no-tillage dryland sorghum. Manure application to a no-tillage site resulted in volatilization losses of N and greater variation in nutrient availability when compared to incorporated manure. When expressed as a percentage of applied N and P the amount of inorganic N and extractable P was similar between the two manure types. The HAP technology has potential for reducing the amount of P applied to manured soils while still meeting the nutritional needs of the crop. Reducing the amount of applied P also reduces the potential for environmental contamination caused by runoff from manured fields.

Introduction

Swine manure contains essential plant nutrients such as N, P, and K, and can be an excellent fertilizer source. Swine manure typically has a N:P ratio lower than that need by the crop resulting in excess P being added to the soil when manure is applied to meet the N requirements of the crop. A gene has recently been isolated in corn that alters the way P is stored in the grain. Highly Available Phosphorus corn stores a majority of its P in the inorganic form while having a similar total P concentration in the grain (Ertl et al., 1998). For monogastric animals such as swine the bioavailability of P in HAP corn is higher reducing the need for P feed supplements and reducing the P excreted by the animals. Nutrient management practices for manure produced by swine fed HAP corn diets have not been developed. The objective of the current study is to compare N and P mineralization in soils under irrigated corn and dryland sorghum receiving manure from swine fed a HAP corn diet, manure from swine fed a traditional corn diet, or as inorganic fertilizer.

Materials and Methods

Swine Diets and Manure Collection

To provide the feed sources for this study, a stand of HAP corn (X1127PP) and a stand of the same variety (Alicia) without the HAP gene were grown from seed provided by Pioneer Hybrid International[1]. Corn was grown under irrigation near Shelton, NE using recommended practices for fertilization and pest control. The two stands were harvested and stored separately. Standard swine diets for each growth phase were prepared and adjusted to account for the increase in P bioavailability

[1] Trade and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product by the authors or USDA.

for the HAP corn. Diets were fed to swine in two locations. Finishing phase swine were divided into two groups with one group receiving the HAP diet and the other the TC diet at the University of Nebraska Animal Science Department in Lincoln, NE. Nursery phase swine were divided into two groups with one group receiving the HAP diet and the other the TC diet on a private farm near Grand Island, NE. At both sites, manure from swine fed the HAP corn diet and manure from swine fed the TC diet were collected and stored separately until needed for the field studies. Manure nutrient content was determined by a certified commercial laboratory.

Field Sites and Treatments

Two sites were used in this study. The first site was located at the University of Nebraska South Central Research and Extension Center near Clay Center, NE. Soils at this site were Hastings-Butler-Crete complex with a silt loam texture. The site has a slope of 0 to 2% and was uniformly cropped with corn the previous year. Four treatments were applied in a randomized block design with five replications. Treatment plot size was 15 by 22 ft. with a 5 ft. border between blocks. The study had a 5 ft. border surrounding it to minimize edge effects. The four treatments were: manure from swine fed a TC diet, manure from swine fed a HAP corn diet, inorganic N (as NH_4NO_3) and P (as triple superphosphate) fertilizer (IF), and an unfertilized control. Manure and fertilizer (Table 1) was surface applied on May 13, 1999 and incorporated with a tandom disk within 2 hours of application. Nitrogen was applied at a rate needed to meet the needs of a 140 bu ac^{-1} corn crop. Corn (Pioneer 33A14) was planted on May 13, 1999 in 36 in. rows resulting in a stand density of 28 000 plants ac^{-1}.

The second site was located at the Roger's Memorial Research Farm located 10 miles east of Lincoln, NE. Soil at this site is a Sharpsburg clay loam on a 3 to 5% slope. The site was cropped to sorghum the previous year. Treatment plot size was 17 by 35 ft. The study had a 15 ft. border around it to minimize edge effects. Sorghum (NC$^+$ 7R37E) was no-till seeded on May 13, 1999 in 36 in. rows resulting in a plant density of 48000 plants ac^{-1} at harvest. The same four treatments used at Clay Center were applied in a completely randomized design with three replications. Manure and inorganic fertilizer (Table 2) were surface applied on June 15, 1999.

Mineralization Technique and Laboratory Analysis

Mineralization of N and P was determined using a resin bag technique in three of the five replications at Clay Center and in all 12 plots at the Roger's Farm. Aluminum tubes were pushed into the soil to a depth of 6 in. The tubes and the intact soil core were removed and a nylon bag containing 0.35 oz. of resin was placed in contact with the soil at the base of the core. The resin bags were held in place by nylon cloth covering the bottom of the cylinder. The tubes were placed back in the soil. Four tubes were collected from each treatment five times during the growing season. After collection the resin bag and soil were removed from the tubes and air-dried. Mineral N was extracted from soil and resin using 2 M KCl. Inorganic N concentrations of extracts were determined colorimetrically using a Lachat flow injection ion analyzer (Zellweger Analytics, Lachat Instruments Div., Milwaukee, WI). Extractable P was determined using the method of Bray and Kurtz (1945) for soil and dilute (0.5 M HCl) for resin (Sibbeson, 1977). Phosphorus concentration was determined colorimetrically.

Results and Discussion

Delays in getting manure nutrient concentration data from the commercial laboratory resulted in variation in N and P rates among the treatments (Table 1 and 2). The amount of inorganic N and extractable P is presented as lbs ac^{-1} but will also be discussed as a percentage of that applied.

At Clay Center the amount of inorganic N mineralized increased linearly during the growing season in all treatments (Fig. 1). In control plots the amount of inorganic N present increased from 9 lbs ac^{-1} at planting to 35 lbs ac^{-1} at harvest (Fig. 1). At the first sampling date, inorganic N was lower in the HAP manure treatment than in the TC manure or fertilizer treatments reflecting the lower application rate in this treatment (Table 1). The amount of inorganic N present during the remainder of the growing season was similar among treatments receiving manure or fertilizer with 73 lbs ac^{-1} being present at harvest. Assuming that a similar amount of inorganic N was derived from soil organic matter in soils receiving manure or fertilizer as in the control, the amount of inorganic N derived from manure or fertilizer as a percentage of that applied was 26% for inorganic fertilizer and HAP manure and was 29% for TC manure.

At Clay Center the amount of extractable P in the control treatment doubled during the growing season increasing from 8 to 15 lbs ac^{-1} (Fig. 2). At the first sampling date, the amount of extractable P increased as application rate increased (Table 1) being lowest in the HAP manure treatment and highest in the TC manure treatment (Fig. 2). In the inorganic fertilizer treatment the amount of extractable P declined slightly during the second and third sampling periods and increased towards the end of the growing season (Fig. 2). Extractable P from the HAP manure treatment increased from 10 lbs ac^{-1} early in the growing season to an asymptotic level of 20 lbs ac^{-1} at the end of the growing season (Fig. 2). The TC manure treatment exhibited the greatest increase in extractable P increasing from 20 lbs ac^{-1} early in the growing season to 36 lbs ac^{-1} at harvest. Assuming that a similar amount of extractable P originated with soil organic matter in the fertilizer and manure treatment as was observed in the control treatment, the amount of extractable P derived from manure or fertilizer as a percentage of that applied was 10% for inorganic fertilizer, 19% for HAP manure, and 38% for TC manure.

At the Roger's Farm the amount of inorganic N present in the control treatment increased linearly from 8 to 27 lbs ac^{-1} (Fig. 3). The amount of inorganic N present in the fertilizer or manure treatments was similar to that in the control treatment at the time of fertilizer addition. In the inorganic fertilizer treatment the amount of inorganic N increased to 50 lbs ac^{-1} by day 60, remained at that level until day 120, and increased to 85 lbs ac^{-1} at harvest (Fig. 3). Inorganic N in the HAP manure treatment increased linearly to 58 lbs ac^{-1} at harvest (Fig. 3). Inorganic N in the TC manure treatment increased rapidly to 78 lbs ac^{-1} on day 88 and then declined to 58 lbs ac^{-1} at harvest (Fig. 3). At the Roger's Farm the amount of inorganic N derived from fertilizer or manure was 52% for inorganic fertilizer, 11% for TC manure, and 12% for HAP manure.

Extractable P at the Roger's Farm double in the control treatment increasing from 8 lbs ac^{-1} shortly after planting to 15 lbs ac^{-1} at harvest (Fig. 4). The amount of extractable P in the fertilizer and manure treatments were similar to that of the control shortly after planting and increased during the growing season to 34 lbs ac^{-1} in the inorganic fertilizer treatment, 49 lbs ac^{-1} in the HAP manure treatment, and 77 lbs ac^{-1} in the TC treatment (Fig. 4). The amount of extractable P found in soils at harvest represents 70% of that applied in the inorganic fertilizer treatment, nearly the same amount of that applied in the HAP manure treatment, and exceeds that applied in the TC manure treatment. The rate of accumulation and the amount of inorganic N present in soils receiving TC and HAP manure was similar suggesting that the HAP technology does not alter the availability of N present in manure produced by swine fed a HAP diet. When expressed as a percentage of that applied, the amount of inorganic N present in soils at the Roger's Farm were lower than those at Clay Center. Manure at Clay Center was incorporated while that at the Roger's Farm was not and volatilization losses of N at the Roger's Farm were likely much higher than at Clay Center. The much higher variability in the data from the Roger's Farm also results from the surface application. Tillage not only incorporates the manure but also mixes it with the soil helping to more evenly distribute nutrients throughout the tillage layer.

In this study manure was applied to meet the N needs of the crop. The higher bioavailability of P in the HAP diet results in lower P excretion by swine fed this diet. When HAP manure is applied to soil less P will be applied when compared to TC manure. While the amount of extractable P in soils receiving HAP manure is lower it is similar to that in soils receiving inorganic P fertilizer and the nutritional needs of the crop are still met.

First year results suggest that HAP technology has the potential for reducing the P content of manure. Reducing the P content of manure will reduce the potential for environmental contamination of surface water resulting from runoff from manured fields. Our results also suggest that the amount of extractable P from soils receiving HAP manure is adequate to meet the nutritional needs of the crop.

References

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Table 1. Nutrients added as manure or inorganic fertilizer to the treatment plots at the Clay Center, NE site.

Treatment	Total N	Total P
	lbs ac^{-1}	
HAP manure	115	39
TC manure	148	55
Inorganic Fertilizer	160	45
Control	0	0

Table 2. Nutrients added as manure or inorganic fertilizer to the treatment plots at the Roger's Farm site near Lincoln, NE.

Treatment	Total N	Total P
	lbs ac^{-1}	
HAP manure	245	38
TC manure	263	47
Inorganic Fertilizer	110	27
Control	0	0

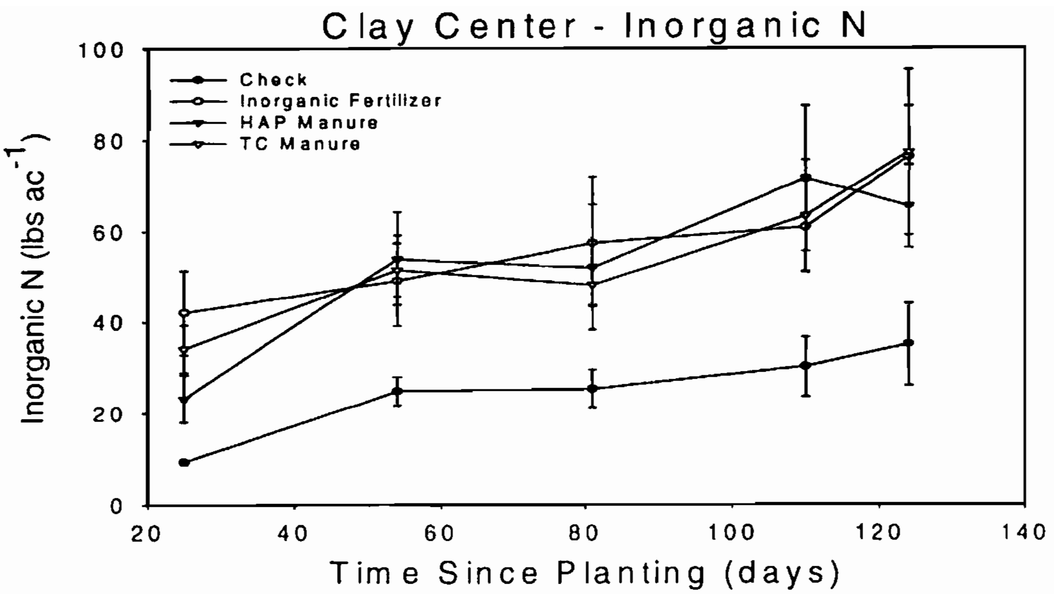

Figure 1. Inorganic N as a function of time since planting for soil under irrigated corn at Clay Center, Ne.

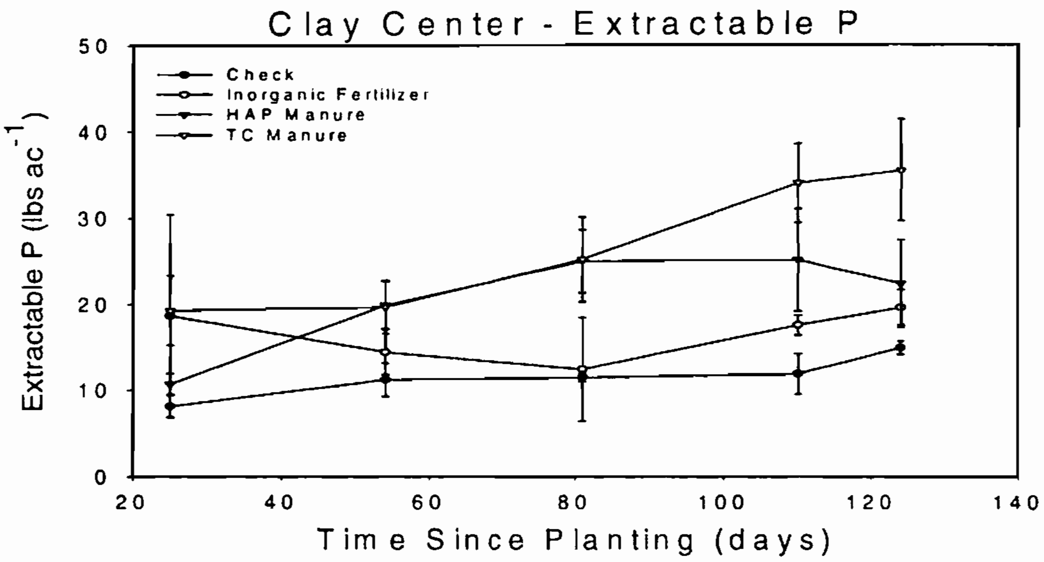

Figure 2. Extractable P as a function of time since planting for soil under irrigation at Clay Center, NE.

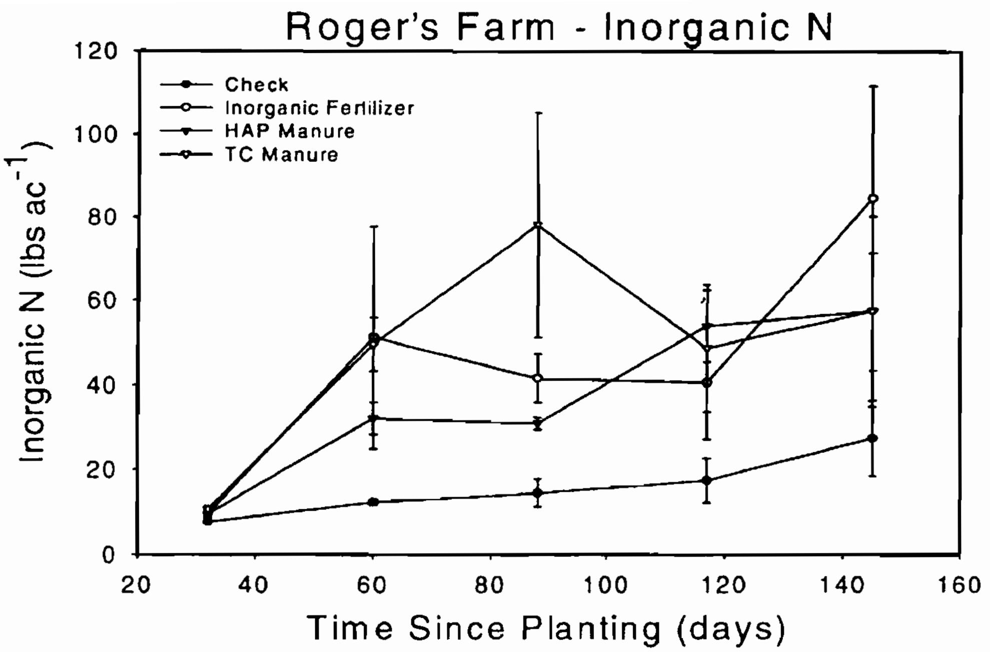

Figure 3. Inorganic N as a function of time since planting in soil from no-tillage dryland sorghum near Lincoln, NE.

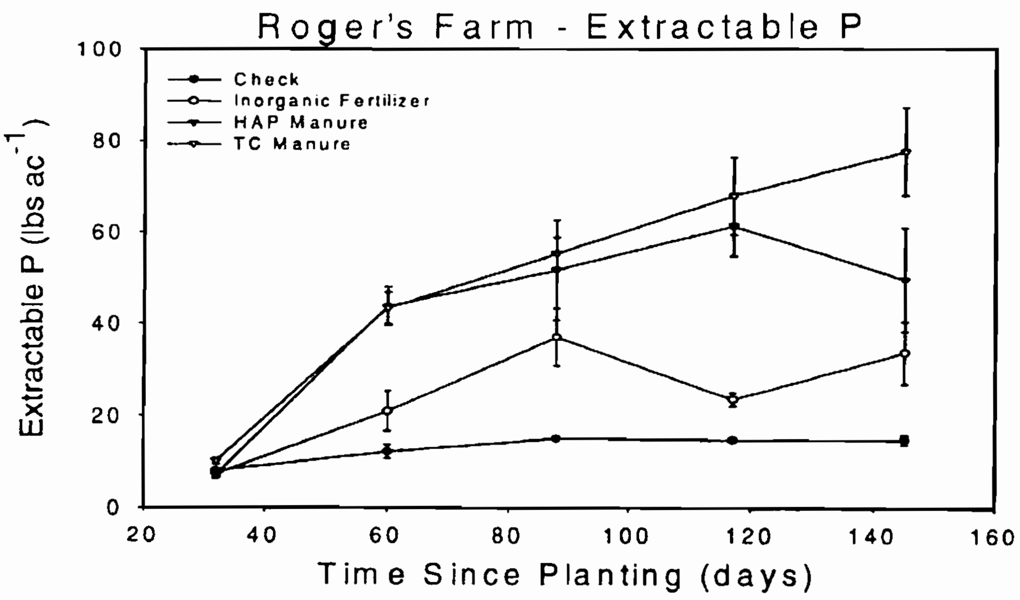

Figure 4. Extractable P as a function of time since planting in soil from no-tillage sorghum near Lincoln, NE.

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