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Ethanol Distiller By-product Phosphorus Concentration as Influenced by Corn Hybrid

Bahman Eghball¹

Summary

Analysis of commercial corn hybrids indicated grain phosphorus concentrations ranged from 0.19% to 0.39%. This range of P concentration provides an opportunity to reduce P in the distiller's by-products. Based on 90% starch conversion efficiency, the estimated P concentrations of ethanol by-product were 0.52% and 1.04% when using grain with P concentrations of 0.19% and 0.39%, respectively. This is a reduction of 50% when using low P instead of high P corn hybrids.

Introduction

Ethanol production plants are using a significant amount of corn produced in the United States each year. In 2002, about 800 million bushels of corn were used to produce ethanol (Agricultural Statistics, 2002). In the ethanol production system, the starch is converted to ethanol and CO₂ and the remaining grain material is called distiller by-product (wet distiller grain plus soluble or dry distiller grain plus soluble). This by-product is high in energy, protein and P content and is usually fed to feedlot cattle in Nebraska. Removing starch from grain concentrates P in the by-product. When this high P material is added to a ration, it increases P concentration

of the ration and subsequently increases manure P concentration.

Corn hybrids have different concentrations of P in grain. Results of a two-year field study conducted by the author in 1999 and 2000 indicated grain P concentration ranged from 0.21% to 0.33% among 12 commercial corn hybrids. Analysis of other commercial hybrids in 2003 indicated that high P hybrids have P concentrations that can be more than double those for low P hybrids. These low P grain hybrids can be used in rations to reduce P content or used in ethanol production to reduce P content of the by-product and hence make it a more environmentally friendly feedstuff. The starch conversion efficiency is usually greater than 90% with either dry or wet milling. Some of the starch is associated with phytate (P compound in the grain) and that would prevent the associated starch from being converted to ethanol (H. Noureddini, personal communication). The low P corn would have the advantage of containing less starch associated with P in grain and hence may increase starch conversion efficiency. The objective of this study was to determine the effects of corn hybrids with different grain P concentrations on the P content of ethanol by-products. By reducing P concentration of the by-product, the P concentration of manure also will be reduced, addressing concerns about soil P accumulation in the soil.

Procedure

Commercial corn hybrids (Pioneer Hi-Bred and NC+ brands) grown in Nebraska and Iowa in 2003 and the B73 X Mo17 hybrid were tested for grain P concentration differences. The grain samples (at least two replications except the NC+ samples) were tested for total P using the X-ray method at the University of Nebraska Soil Testing Laboratory. The grain P concentration of each hybrid was used to estimate the P concentrations of the ethanol production by-products.

Ethanol distiller by-product P concentrations were estimated based on grain starch content and starch conversion efficiency. Starch recovery for the low temperature dried, elevator, and export corn during five years of milling ranged from 89 to 94% (average 92% + 0.5) (U.S. Grain Council, 2001). When calculating the expected P concentrations of the ethanol by-product, an assumption of 90% starch conversion efficiency was used. Corn grain total starch concentration was determined using the chemical solubilization method.

Results

There was a wide range of grain P concentrations among the corn hybrids (Table 1). Grain P concentration ranged from 0.19% to 0.39%, indicating that P concentrations varied more than 100% across the

(Continued on next page)

range of hybrids included in the study. The average grain P concentration for the hybrids was 0.27% and that was 42% higher than Pioneer 33B50, which had the lowest grain P concentration.

When grain from these hybrids is used for ethanol production, the P concentrations of the byproduct would be expected to range from 0.52% to 1.04%. Using Pioneer 33B50 instead of NC⁺ 3709 (the hybrids with the least and greatest P concentrations in the study; Table 1) for ethanol production would reduce the by-product P concentration by 50%. The low P content by-product should reduce the amount of P excreted in manure when it is fed to cattle.

In ethanol production facilities, corn from a number of farms and likely a mixture of hybrids with different P concentrations are used. The average P concentration of the hybrids reported in Table 1 was 0.27%, which may be similar to the mix used by ethanol plants. Using Pioneer 33B50 hybrid as compared with the average concentration can result in 27% reduction in the by-product P concentration. Phosphorus concentrations of by-products in eight new ethanol plants in Minnesota and South Dakota (118 samples) ranged from 0.70% to 0.99% (average 0.89% and CV=11.7%) (Spiehs et al., 2002, *Journal of Animal Science* 80:2639-2645). The P concentration of the by-product from the low P corn hybrid (0.19% P) was expected to be

Table 1. Grain phosphorus and starch concentrations (dry weight basis) of selected commercial corn hybrids and the estimated ethanol by-product P concentrations assuming 90% starch conversion efficiency.

Hybrid	Grain P Concentration	Grain Starch Concentration	Estimated Ethanol By-product P Content
	----- % -----		
Pioneer 33B50	0.190	70.8	0.52
Pioneer 34M94	0.197	69.6	0.53
Pioneer 35Y65	0.211	70.6	0.58
Pioneer 33R77	0.212	68.7	0.56
Pioneer 34N43	0.212	70.0	0.57
Pioneer 34B97	0.227	68.7	0.59
B73 X Mo 17	0.235	68.7	0.62
Pioneer 31N27	0.248	69.7	0.67
Pioneer 33P66	0.260	69.6	0.70
Pioneer 34H31	0.266	70.4	0.73
NC ⁺ 3672	0.285	69.5	0.76
Pioneer 34G82 ^a	0.295	69.6	0.79
Pioneer 33R87 ^a	0.315	69.6	0.84
Pioneer 34D34 ^a	0.322	69.6	0.86
NC ⁺ 4771	0.386	69.5	1.03
NC ⁺ 3709	0.394	68.8	1.04
Average	0.266	69.6	0.71

^aGrain P concentrations taken from Eghball et al. (2003) and starch concentrations are the average of the other 13 hybrids reported in the table (the mean starch concentration of 69.6% had a standard error of 0.2).

42% less than the average of those from these eight plants.

Corn hybrids have a wide range of grain P concentrations. Using those with low P concentrations provides a great opportunity to reduce the P content in ethanol distiller byproducts. Using the low P hybrid can result in as much as a 50% reduction in the P concentration of the by-product. Additional research is needed to confirm the effects of P concentration in corn grain on ethanol quality and quantity and distiller by-product. In addition, other commercial corn hybrids need to be tested for grain P

concentration differences and whether the P concentration trait is stable under various soil P levels or environmental conditions. Low grain P concentration corn removes less P from soil at the same grain yield level as high grain P corn, resulting in longer period when corn production is used to lower soil P level.

¹Dr. Bahman Eghball passed away July 26, 2004. He was a soil scientist with the USDA-ARS and adjunct associate professor in the Department of Agronomy and Horticulture, Lincoln.