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Reducing Phosphorus Concentration of Ethanol Distiller Byproducts by Using Low Grain Phosphorus Corn

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Dr. Bahman Eghball, Soil Scientist with the Soil and Water Conservation Research Unit (SWCRU), Lincoln, NE, died in a swimming accident at Lake McConaughy, near Ogallala, NE, during a family vacation on Monday, July 26, 2004. Though Dr. Eghball's career was short, he achieved much. His areas of expertise included nutrients cycling in manure, the process of composting, P and N environmental issues, and soil-plant-N-P interactions. He studied and developed management practices that effectively used C, N, and P in manure while limiting the negative environmental effects of manure application. As a part of the effort to understand nutrient (N) availability from manure, Dr. Eghball developed an in situ resin-based method to access N mineralization in field studies. He statistically evaluated factors in the P Risk Assessment Index demonstrating the importance of erosion in the loss of P from cropland. Dr. Eghball was a regular newsletter contributor to Manure Matters and his energy and expertise will be greatly missed. While this may be his last newsletter, his contributions will last for some time to come.

Overview of the Problem

Ethanol production plants are using about 800 million bu of corn each year to produce ethanol. In the ethanol production system, the starch is converted to ethanol and CO₂ and the remaining grain material is called distiller byproduct (wet distiller grain plus soluble or dry distiller grain plus soluble). This byproduct is high in energy, protein, and P contents and is usually fed to feedlot cattle and other livestock. Removal of starch from grain concentrates P in the byproduct and when this high P material is added to 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 to 2000 indicated grain P concentration range of 0.21% to 0.33% among 12 commercial corn hybrids. Analysis of some other commercial hybrids in 2003 indicated that high P hybrids have P concentrations that can be more than double of those for low P hybrids. These low grain P

hybrids can be used in rations to reduce its P content or can be used in ethanol production to reduce P content of the byproduct and hence make it a more environmentally friendly feedstuff. By reducing P concentration of the byproduct, the P concentration of manure will also reduce and that lessen the concern about soil P accumulation in the soil.

Procedure and Findings

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 were tested for total P and starch concentrations. Ethanol distiller byproduct P concentrations were estimated based on grain starch content and starch conversion efficiency of 90%.

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 range of hybrids included in the study. The

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

Hybrid	Grain P Concentration	Grain starch concentration	Estimated ethanol byproduct 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 [†]	0.295	69.6	0.79
Pioneer 33R87 [†]	0.315	69.6	0.84
Pioneer 34D34 [†]	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

[†]Grain P concentrations taken from Eghball et al. (Agron. J. 2003, 95:1233-1239) 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).

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% (Table 1). 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 byproduct P concentration by 50%. The low P content byproduct should reduce the amount of P excreted in manure when it is fed to cattle or other livestock.

In ethanol production facilities, corn from a number of farms is used for ethanol production. Corn from each farm is perhaps from a different hybrid so that mixes of hybrids with different P concentrations are used in these facilities. 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 byproduct P concentration. Phosphorus concentrations of byproducts 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 byproduct from the low P corn hybrid (0.19% P) was

expected to be 42% less than the average of those from these eight ethanol plants.

Conclusions

Corn hybrids have a wide range of grain P concentrations and that provides a great opportunity to reduce the P content in ethanol distiller byproducts. Using the low P hybrid can result in as much as 50% reduction in the P concentration of the byproduct. Additional research is needed to confirm the effects of P concentration in corn grain on ethanol quality and quantity and distiller byproduct. 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 and that can result in longer period when corn production is used to lower soil P level. Previous research indicates that up to ten years of corn production may be required to reduce soil P level from 265 ppm to 70 ppm

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UNL's Livestock Environmental Issues Committee includes representation from UNL, Nebraska Department of Environmental Quality, Natural Resources Conservation Service, Natural Resources Districts, Center for Rural Affairs, Nebraska Cattlemen, USDA Ag Research Services, and Nebraska Pork Producers Association.

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