



# NRI Research Highlights

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## Phosphorus (P) Feeding Programs For Dairy Cows: Impacts On Manure Composition, P Runoff, and Farm Sustainability

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*Research-derived technology reduced the impact of land-applied dairy manure on soil and water resources. In addition, the Phosphorus Indices (P Index) adopted results from this study are producing the first significant reduction in non-point phosphorus inputs and degradation of surface water quality.*



Figure 1. A typical south central Pennsylvanian dairy farm where the research was conducted. Courtesy of Sharpley.

**T**he application of dairy manure to agricultural soils can result in an increase in the transport of phosphorus (P) in water runoff, which is a major cause of accelerated eutrophication of lakes and other freshwater bodies. The potential for this to occur has increased due to an imbalance of P inputs to a farm in feed and fertilizer and outputs from the farm in grain and animal produce. The situation is further complicated by the land application of manure to meet crop nitrogen (N) needs. The applied manure, however, supplies more P than the crops need and results in excess P in the soil. One way to address this problem is to adjust the P content of feed to match the needs of the cow as closely as possible. Unfortunately, little information is available on feeding program and cow

performance, amount and form of P excreted, P loss in runoff, and overall farm profitability.

### The Phosphorus Study

In an effort to address these unknown variables, scientists crafted a P study to examine the impact of feed programs on manure composition, runoff P concentration, and farm sustainability.

Controlled feeding studies, using dietary P and forage source as variables, were conducted by ARS and University researchers at Penn State's Dairy Cattle Research and Education Center. Dietary treatments included low P (0.3% of dry matter) using alfalfa hay, low P using soybean hulls, high P (0.42%) using alfalfa hay and high P using soybean hulls. The diets were fed to 32 mid-lactation

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Figure 2. Rainfall - runoff equipment used to evaluate the effect of land applying manure from the feeding trials on nutrient transport in surface runoff. Courtesy of Sharpley.

Holsteins for a 14-week period. The researchers discovered the dietary P content did not affect dry matter intake, milk yield, or milk composition. However, the dietary P content did impact the manure P content. The low P feeds resulted in approximately 35% less P in excreted manure. A direct comparison of the two forage sources showed that cows fed alfalfa hay excreted about 10% more P than cows fed soybean hulls.

Runoff studies showed that P loss was greater after applying feeding trial manure from high P and high fiber diets than from low P and low fiber diets. The Integrated Farming Systems Model was used to compare P loss from dairy farms in southeastern New York using various cropping, grazing, and feeding strategies. Model simulations showed implementation of feed management strategies to better utilize P could reduce annual

P losses by about 25% and minimize long-term accumulation of soil P on the farm while improving farm profitability.

### The Phosphorus Index

The P Index is widely regarded as a critical tool in protecting water quality, particularly with regard to land application of manure. To increase the power of this tool, the P Index must differentiate between different sources of land-applied P, e.g. manures, fertilizers, or sewage sludge, given the different potentials of these sources to contaminate runoff.

### Impacts

The research findings from this study helped refine recommended manure extraction protocols for P indices and models. Project scientists conducted a series of experiments that resulted in a novel ranking system for different

sources of land applied P. A protocol for water-based extraction was developed to estimate the availability of manure P to water runoff. A commercial test applying P Indices was created to minimize the potential of P runoff from applied manures.

This system has been adopted by all states in the mid-Atlantic region, as well as 49 states in the United States as a component of the required Comprehensive Nutrient Management Planning Strategy. It also serves as a template for other states seeking to improve manure management recommendations for water quality protection. Wide spread adoption and use of the P Index is resulting in the first significant reduction in the threat of non-point P pollution to water systems and improving water quality.



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