AGRONOMIC NUTRIENT APPLICATION RATES

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There is considerable current interest in the term "agronomic rates" because it figures prominently in new manure waste management rules being drafted by the Florida Department of Environmental Protection (FDEP). The definition of that term and the values that will be associated with it will directly impact Florida dairies. The two nutrients of concern are nitrogen (N) and phosphorus (P). This paper will give a brief overview of the issues associated with defining an agronomic rate and its application to manure nutrient management.

Nitrogen and Phosphorus – The Nutrients of Concern

Nitrogen is of interest because there is a national standard for nitrate in *drinking water*. We are thus concerned with preventing excessive nitrates from entering the aquifers. In many cases the path from manure application on land to a drinking water aquifer is long and it takes years for the nitrate to travel from the source to the aquifer. In other cases (e.g., a farmstead with shallow supply wells), it may not take very long to see nitrate contamination of the well water. Getting nitrate *out* of water is expensive (e.g., by distillation, reverse osmosis, or ion exchange), but dilution is a simple means of lowering the concentration to non-problematic levels. Commercial fertilizer and manure (animal and human) are major sources of N in the environment and are thus the subject of efforts to curb excessive applications.

Phosphorus is not a health concern. It is an *environmental concern* because its addition to P-deficient surface waters causes accelerated eutrophication of lakes and other water bodies. Since P is often deficient in surface water, enrichment (fertilization) from P associated with suspended soil and organic materials in runoff water increases growth of some plants and allows species that couldn't survive on low P levels to grow and flourish. This includes small plants (microphytes) such as algae and large plants (macrophytes) such as cattails. These changes in the plant communities and the increased biomass production can have the undesirable consequence of clogging up water bodies and changing their character and use (e.g., Lake Okeechobee, Lake Apopka, and water conservation areas in the Everglades). Decreasing soil erosion and movement of particulate matter off-site is a major means of controlling the P problem.

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Agronomic Rates In Perspective

FDEP is charged with protecting the surface and ground waters from pollution. Since manure is a major source of nutrients which could pollute, considerable attention has been given to avoiding excessive manure application rates. However, the complex system of soils, crops, climate, and management complicates definition of what rates are excessive. As the issues are debated, it is important to keep plant nutrients in the perspective of crop production. There is no doubt that nutrients must be added to soil to maintain the levels of food and fiber production needed for the world's population. Those nutrients can be recycled from manure or they can come from commercial fertilizer. The plants can't tell the difference. N and P from manure are no more problematic than those from fertilizer.

Agronomic rates of fertilization in crop production have always included fertilizer management recommendations (e.g. banding of P, splitting N applications). They have also included compensation for losses such as volatilization, denitrification, leaching, and immobilization of N, and immobilization and fixation of P under common commercial fertilization application practices. In many instances, recommendations for fertilization have also included economic considerations such as return on investment and hauling and application costs. These economic considerations are often unstated by those making the recommendations and are thus difficult to document. However, this factor is important to remember when using recommendations designed for commercial fertilizers to decide how much of a waste product to apply to crop land. The need to dispose of large amounts of waste must be balanced against the environmental danger of applying excess nutrients. A reasonable recommendation might permit higher amounts of nutrients than would be the case if the cost of purchasing a commercial product were being figured into the recommendation.

Some Approaches to Environmentally Sound Manure Disposal

One approach to manure management would have farmers apply no more of any plant nutrient than is taken up by the crop (e.g., "nutrient application rate shall not exceed uptake and removal"). However, this seemingly straight.forward approach leaves no room for well-documented biological and chemical processes which result in nutrients becoming inaccessible to growing plants. For example, it is well known that denitrification and volatilization of N occur, and soluble P reverts to insoluble forms under many field conditions. If application rates do not allow for such losses, the amounts of N and P available for crop production will be less than adequate. It would be comparable to giving a carpenter who is building a house only the exact number of board feet of lumber that is calculated to be in the finished house. It is not possible to build with no allowance for ends of boards and scraps resulting from fitting the pieces into a final product.

A different approach to manure management would allow the farmer to apply as much N and P to the land as the soil can handle *without causing nitrate contamination of drinking water aquifers or eutrophication of surface waters from increased P*. Non-polluting losses such as volatilization and denitrification of N and sorption of P would be accounted for along with crop removal. Thus, we address directly the objectives we are trying to accomplish. This approach takes into consideration various site-specific factors.

Major Site-Specific Considerations

Characteristics of a manure application site would determine the amount of waste to be applied. For example, a fluctuating shallow water table enhances denitrification and blocks the path to the deeper drinking water aquifer. During periods of saturated soil conditions, anaerobic bacteria in the surface few feet of soil convert nitrate to nitrogen gases which then dissipate into the atmosphere. That nitrate is thus removed from the system. Additionally, the presence of a high water table is a barrier between the shallow ground water and deeper, drinking-water aquifers.

The geology of an area is another major site-specific consideration. Nitrates from manure or fertilizer application cannot enter an aquifer in a region of confined aquifers with artesian wells. Conversely, a karst region with sinkholes and solution pipes has potential for accelerated access of surface-applied materials reaching the aquifers.

The very slight solubility of P in soils makes its management as a potential pollutant very different from that of N. Phosphorus reacts readily with soil components such as clay, iron, aluminum, manganese, and calcium to form compounds of low solubility. That means that there is very little P in soil *solution*. Thus, when P moves off-site it is almost entirely in association with particulate matter such as suspended soil and organic matter. Proximity to lakes and streams, presence of drainage ditches and canals, and sediment basins all influence the ease with which P-laden sediments reach surface waters. Measures which keep particulate matter from reaching waters of concern are major site-specific considerations.

Some soil materials (e.g., stripped white sands) have essentially no P-holding capacity. When those materials predominate in a soil, P will move with the water until it contacts material with which it *can* react (e.g., a soil horizon which does have P-holding capacity). If water with soluble P in it drains from the soil into surface water, it will be available for plant uptake — and thus has pollution potential.

On the other hand, there are soils that hold P so tightly that extra P fertilizer is needed in order to supply the needs of growing plants. Some soils (as are common in the FL Panhandle) have particularly high P-fixing capacity due to the type of clay minerals they contain. Calcareous soils or soils whose pH has been raised above 7.0 by liming also fix P, removing it from solution. It follows that such soils can be managed to receive loadings of P far beyond that removed by harvested crops and still not release P to non-target plants.

Examples of Normal Crop Nitrogen Requirements

Table 1 gives some examples of typical crop requirements for N. These rates of plant available N are generally considered sufficient to produce the crop in most years under conditions of good management. They are the result of experience with producing crops under many Florida field conditions. They can serve as the basis for determining N agronomic rates but will need to be adjusted to account for conditions which significantly increase or decrease the amount of N needed (e.g., denitrification in the root zone, volatilization from the soil surface, and leaching due to excessive rainfall). Under conditions of mobile P, that nutrient may have to be treated the same as N.

Summary

Agronomic rates of nutrients from dairy manure will need to take into consideration site-specific conditions such as soil, topography, underlying geology, water tables, ground and surface water flow patterns, and proximity of streams and lakes. By utilizing this information, we will be able to wisely manage this milk production by product as a non-polluting resource in crop production and soil enrichment.