ilk down 6% vs. a year ago. Fortunately, forage supplies are good.

Ev Thomas

Phosphorus Soil Stratification

"Typical" as-produced dairy manure contains 7-10 lbs of phosphorus (17-22 lbs P_2O_5) per ton of dry manure. Liquid dairy manure applied at 4000 gallons per acre as is done here at Miner Institute is equivalent to 40 lbs P_2O_5 and 75-80 lbs of K_2O or the equivalent of 2 tons dry manure per acre. The liquid manure is typically 6.7 to 7.8% dry matter so 4000 gallons at 8.1 - 8.2 lbs per gallon equals approximately 2400 - 2500 lbs of dry manure as it is coming out of the pit. The nutrients going back onto the field from the manure pit are usually more than enough to supply all the phosphorus needs and most (but not all) of potassium needs of either corn, alfalfa or grass.

A good corn silage yield of 20 tons per acre at 30% DM is actually 6 tons of dry plant material that is being removed each year. Nutrients removed must either be supplied by the soil or added back as either fertilizer or manure. Corn silage contains 0.17 - 0.22% phosphorus and 0.8 - 1.0% potassium so 20-26 lbs P(45-60 lbs P_2O_5) and 96 - 120 lbs K (115 - 145 lbs K_2O) are being removed with each silage harvest.

A quick nutrient balance for phosphorus indicates that slightly more P is being added each year as fertilizer or manure than is being removed by the corn. P_2O_5 from starter fertilizer (32 lbs) and manure (40 lbs P_2O_5) totals 72 lbs. Crop removal is 45-60 lbs leaving a positive balance of 12-27 lbs per acre per year. Most of this excess P (5-12 lbs elemental P) gets adsorbed onto Calcium, Iron, and Aluminum minerals, slowly builds the soil test P levels, and is considered immobile. It usually takes 5-10 lbs P (varies by soil type and soil test level) to increase the soil test level by 1 lb so not all of this "excess" phosphorus is readily available for plant growth.

Phosphorus is immobile and does not usually move into the soil through leaching. Downward movement of phosphorus into the soil is usually dependent upon degree of tillage. Phosphorus movement from agricultural fields occurs during surface runoff events in sediment following soil erosion. The excess P in sediment, when applied over several years, can become a significant contributor to phosphorus loads in streams, rivers, and lakes. An unanswered question is whether phosphorus moves downward at high rates of manure application. Preferential flow of the soil solution through soil cracks, worm holes, and tile drainage may accelerate movement of anions like phosphate and nitrate. Work just completed here, however, indicated that both phosphate and nitrate were extremely low in tile outlet flow following manure application. Similar results have also just been reported from Massachusetts indicating that tile drainage may not contribute to enhanced phosphate and nitrate movement. In fact, plant nutrient uptake may be enhanced by tile drainage thereby reducing potential surface runoff of nutrients in soil sediment! Moderation is the key. Overloading of manure or fertilizer will cause problems that may be accentuated by tile drainage.

The question is how much is too much? Each soil will vary in terms of texture (clay, silt, sand) and landscape slope (topography) and these properties will determine how much manure a particular site can handle. Four fields at Miner with differing manure histories (0 to 175 tons liquid manure per acre over the past

14 years) were sampled down to 24 inches and tested for phosphorus. The objective was to determine if phosphorus was moving into the soil at various rates of manure application.

Soil was sampled at 0-1", 1-2", 2-4", 4-8", 8.16", and 16-24" at six sites within each field. At each site, several cores (6-8) were taken and composited. We are currently setting up to run phosphorus in the lab at Miner using several extractants. The amount of phosphorus extracted from a given soil varies considerably dependent upon the chemical extractant used and represents only a small fraction of the total phosphorus in soil. The phosphorus tightly bound to soil minerals is not easily dissolved even in strong chemical extractants and so it is easy to understand why phosphorus would not easily leach in the soil water solution.

Preliminary results were obtained by compositing soil from each site at each depth from each field and sending half of the sample to the Vermont soil testing lab. Results presented in Table 1 represent the extractable phosphorus that is considered available for plant growth.

Each field varied tremendously in its available P and there didn't appear to be any relationship between manure application rate and available P level. Field R-38, which received the highest manure rate (175 tons/Ac since 1981), had an available P level 5-6 times lower than R5-NT which received only 40 tons manure since 1981. Obviously, plant uptake and varying soil characteristics account for each field's available P levels. R-38 appears to be a soil that could handle high rates of manure application.

Movement of phosphorus downward in the soil was facilitated by tillage. Fields R-20 and R-38 had relatively equal P levels down to 8". These fields were conventionally tilled with a moldboard plow. Mixing of the soil incorporated P and other nutrients thereby reducing their concentration at the soil surface. R-5NT, (no-till field that has only been minimally disked) on the other hand, showed a sharp accumulation of P at the surface (0-1"). This accumulation of P at the soil surface is subject to runoff if soil erosion or seasonal flooding is a problem. Fortunately, R-5NT is not highly erodible nor is it subject to flooding so surface movement of P is not a problem on this field. More significantly, downward movement of P was not evidenced on R5-NT or on any of the fields sampled. Available P was greatly reduced to generally very low levels at 16-24". These results are preliminary and work will continue to determine if phosphorus movement is, in fact, not a problem as indicated thus far. This study was supported in part by the funds of USDA Agreement 91 COOP-1-6593.

David Lang and Ev Thomas

Table 1. Soil Phosphorus Stratification at Miner Institute

	Field			
Soil Depth	M-12	R5-NT	R-20	R-38
inches	---------- ppm P[1] ----------			
0-1	1.5	37.3	11.9	5.8
1-2	1.1	25.3	13.2	5.8
2-4	1.4	20.5	14.9	6.4
4-8	1.8	11.7	12.9	5.2
8-16	1.5	5.9	8.6	1.7
16-24	0.6	1.4	3.4	0.8

Manure and Tillage History:
M-12: No Manure Since 1981; Conventional Tillage
R5-NT: 40 Tons Manure/Ac Since 1981; Minimum Tillage
R-20: 110 Tons Manure/Ac Since 1981; Conventional Tillage
R-38: 175 Tons Manure/Ac Since 1981; Conventional Tillage

[1]Vermont Soil Test Available Phosphorus