Nutrient Stratification in Four Crop Production Fields

David Lang, Dept. of Plant and Soil Sciences, Mississippi State University
Everett D. Thomas, William H. Miner Agricultural Research Institute

Materials and methods

Four crop production fields at the William H. Miner Agricultural Research Institute in Chazy, NY were sampled during July, 1994 and analyzed for pH, phosphorus, and potassium at six depths: 0-1", 1-2", 2-4", 4-8", 8-16", and 16-24". A standard soil probe was used for soil depths up to 8", and a screw auger used for soil depths to 24". In Field 1 excessive stoniness throughout the sampling zone made use of a screw auger impossible and pits were dug with soil sampled from the sides of the pits at the various sampling depths. Six to eight composite samples were taken from six locations across uniform sections of each field.

Soil pH and potassium were analyzed by the University of Vermont Agricultural and Environmental Testing Laboratory in Burlington, Vermont. Three soil extractants were used to determine phosphorus: Modified Morgan's Solution, pH 4.8 (the standard soil extractant used at the University of Vermont); the University of Vermont Reserve P Test; and distilled water. Only the 0-1" and 16-24" soil depths were tested with distilled water, which was designed to evaluate the potential phosphorus movement from surface runoff (0-1") or through tile drainage (16-24").

The four fields used varied widely in cropping history, soil type, tillage practices and soil fertility, with much of the variability in soil fertility due to past manure application practices.

Field 1

- Continuous zero or minimum tillage since conversion from permanent pasture in 1987.
- Hogansburg loam, very stony, moderately well drained.
- Very high soil test P due to prior heavy manure applications combined with very low nutrient removal when the field was in pasture.
- Fourth year of alfalfa-grass.

Field 2

- Conventional tillage since 1970.
- Adjidaumo clay, poorly drained with drainage improvement by subsurface pattern tile drainage at 50-foot spacing.
- High soil test P due to past manure applications.
- Fourth year of corn harvested as silage.

Field 3

- Conventional tillage since 1970.
- Primarily Hogansburg loam with several other soil types, generally loams and sandy loams, moderate drainage with drainage improvement by subsurface tile drainage.
- High soil test P due to past manure applications.
- Recently seeded to alfalfa-grass.

Field 4

- Conventional tillage since 1984 (Rented land, prior to 1984 continuous low-input grass pasture for many years).
- Hogansburg loam, moderately well drained.
- Medium soil test P. No manure since 1981.
- Second year of alfalfa-grass.

•

Soil pH

Table 1. Soil pH in water

Soil depth, inches	Field 1	Field 2	Field 3	Field 4
0-1	7.7	6.5	7.0	6.0
1-2	7.7	6.7	7.0	6.1
2-4	7.6	6.7	7.0	6.2
4-8	7.8	6.8	7.0	6.3
8-16	8.1	6.9	7.3	6.4
16-24	8.1	7.4	7.4	6.5

Discussion

Note that pH increased at soil depths greater than 8”(average depth of plowing 6-8”) for Fields 2, 3, and 4, and increased in Field 1 even though it was never tilled deeper than 1-2”. Since soils with pH levels over 7.0 have the ability to greatly reduce the solubility and movement of phosphorus, it would be expected that P movement in several of these fields, but especially Field 1, would be quite limited.

Potassium

Table 2. Potassium, ppm

Soil depth, inches	Field 1	Field 2	Field 3	Field 4
0-1	169	103	90	105
1-2	115	105	80	62
2-4	122	111	87	43
4-8	171	99	76	36
8-16	86	112	61	44
16-24	69	86	51	43

Discussion

The potassium from past manure applications apparently leached at least 8” deep in Field 1 in spite of minimal, shallow tillage, but did not appear to leach appreciably deeper than that. The coarse soil texture combined with moderately good internal drainage would facilitate the downward movement of potassium. There were few differences in soil test K by sampling depth for the other fields except for higher soil test K in the 0-1” depth for Field 4, most likely due to a surface application of potassium fertilizer.

Available Phosphorus

Table 3. Available phosphorus, ppm

Soil depth, inches	Field 1	Field 2	Field 3	Field 4
0-1	37.3	11.9	5.8	1.5
1-2	25.3	13.2	5.8	1.1
2-4	20.5	14.9	6.4	1.4
4-8	11.7	12.9	5.2	1.8
8-16	5.9	8.6	1.7	1.5
16-24	1.4	3.4	0.8	0.6

Discussion

While there was distinct stratification of available P in Field 1, where there had been minimal tillage, P was relatively uniformly distributed throughout the plow 0-8" plow layer in the other three fields. Note that Available P decreased significantly at depths greater than 8" except in Field 4, where available P levels were very low at all depths. Also, note that even though both soil texture and internal drainage would facilitate downward movement of nutrients, available P at the 16-24" depth was very low, most likely due to the high soil pH at this depth.

Reserve Phosphorus, ppm

Table 4. Reserve phosphorus, ppm

Soil depth, inches	Field 1	Field 2	Field 3	Field 4
0-1	90	78	65	31
1-2	68	92	60	34
2-4	63	91	64	32
4-8	44	80	64	32
8-16	29	64	63	27
16-24	9	34	23	23

Discussion

Similar trends were observed for reserve P as for available P. Except for considerable P stratification in Field 1, reserve P was relatively uniformly distributed throughout the 0-8" plow layer in the other fields. Not surprisingly, reserve P was lowest at 16-24" for all four fields.

Phosphorus movement potential from surface runoff or tile drainage

Table 5. Extractable and dissolved P, ppm

Analysis	Field 1	Field 2	Field 3	Field 4
Extractable P, * 0-1"	36.5	10.0	5.5	1.1
Dissolved P, ** 0-1"	0.79	0.41	0.07	0.11
Extractable P, * 16-24"	0.9	2.8	0.7	0.4
Dissolved P, ** 16-24"	0.06	0.11	0.07	0.08

* University of Vermont Soil Test P.

** Soil saturated and extracted with water.

Discussion

Dissolved P at the 0-1" soil depth for each of the four fields generally agreed with extractable P at 0-1"; dissolved P was highest in the very fertile Field 1, and quite low on Fields 3 and 4, which had considerably lower extractable P. This would suggest that even with the high surface pH in Field 1, more P was subject to surface runoff than in the less fertile fields. However, at the 16-24" soil depth, not only were extractable P concentrations quite low, but dissolved P was so low as to pose little significant risk of P leaching into tile drainage systems. Note that dissolved P at 16-24" was higher in the low fertility Field 4 than in the very high fertility Field 1. It should be noted that this does not suggest that there is no risk of the P from fertilizer and manure applications reaching tile drainage water, but that the risks are probably much greater from preferential flow (from worm tunnels and cracking of clay soils during dry weather) than from high plow layer P levels.

Summary and conclusions

Tillage and soil pH have significant influences on soil stratification and potential loss of P to surface and ground water. Reduced tillage results in a stratification of nutrients (but especially P) in the top several inches of soil, decreasing the chances of loss through tile drainage systems but increasing the potential of losses through surface runoff. High subsoil pH levels may contribute to the resulting very low dissolved P concentrations. Unfortunately, most Phosphorus Index calculations fail to account for the influence of subsoil pH on P leaching.