The Long-Term Effect of a Single Application of Horse Manure on Soil pH

Donald H. Bickelhaupt

Research assistant, Faculty of Forestry, State University of New York, College of Environmental Science and Forestry, Syracuse, NY

The application of 6 inches of composted lime-treated horse manure resulted in an undesirable increase in soil pH. The soil pH has remained high (7.0 or above) for at least 12 years.
Tree Planters' Notes 40(1):31-33; 1989.

The presence of organic matter in forest tree nursery soils has long been recognized as essential for high productivity. The amount of organic matter present in soils directly affects moisture-holding capacity, aeration, structure, drainage, buffering capacity, and availability of nutrients. Organic materials commonly incorporated into nursery soils include sawdust, bark, straw, leaves, peat, and green manure from cover crops (5). Many industries burn wood waste to reduce their energy costs thereby reducing the availability of this source of organic matter *(7).* New, inexpensive sources of organic material, suitable for application to nursery soils, should constantly be investigated.

The Saratoga Tree Nursery, Saratoga Springs, NY, is located within a few miles of a major horse racing facility offering a readily available, inexpensive source of organic material in the form of horse manure. A study was undertaken to evaluate the possibility of utilizing this horse manure, including barn sweepings, as a major source of organic matter. The long-term effect of the addition of composted horse manure on soil pH is reported in this paper.

Methods

The Saratoga Tree Nursery produces four to five million conifer seedlings annually (10). The nursery is located on deep loamy sand soil that requires periodic addition of organic matter to maintain productivity. A single 6-inch application of composted horse manure was applied to various blocks in one section of the nursery between 1973 and 1975. This resulted in some blocks in the study area being untreated in 1974. Soil samples have been collected periodically since 1974 and analyzed for pH, organic matter, total nitrogen, available phosphorus and exchangeable potassium, calcium, and magnesium according to standard methods (4) as part of an ongoing soil analysis program.

Results

The composted horse manure, including barn sweepings, was highly alkaline (pH 8.4) because hydrated lime, sprinkled on the floor of the stables to control odor, was mixed into the material (table 1). The application of lime to horse stalls is common practice.

Table 1—*Analysis of composted lime-treated horse manure applied to the Saratoga Tree Nursery*

pH	8.4
% N	0.78
% P	0.20
% K	0.67
% Ca	3.67
% Mg	1.74
% Mn	0.025
% Na	0.11

Soil pH of areas that had not received composted horse manure was 5.7 in 1974 (table 2); that of areas that had received composted horse manure during 1973 was 6.7 in 1974. Soil pH has varied between 7.0 and 7.3 since composted lime-treated horse manure was applied, with no significant downward trend indicated.

The application of manure increased soil organic matter from 5.0% in untreated areas to over 8.0% in areas where manure had been applied (table 2). The soil organic matter content has decreased since 1977 and is currently being maintained at approximately 3.5%. The concentration of exchangeable calcium increased from 450 ppm to 2,950 ppm as a result of applying the manure and the concentration of exchangeable magnesium increased from 50 ppm to 750 ppm (table 2). The concentration of exchangeable calcium and magnesium appears to have stabilized at approximately 1,200 ppm and 200 ppm, respectively. The recommended

Table 2—*Chemical properties of soil at the Saratoga Tree Nursery before and after application of composted lime-treated horse manure*

Year	pH	% OM	% N	Composition (ppm) P	K	Ca	Mg
Before compost							
1974	5.7	5.0	0.08	136	69	454	50
After compost							
1974	6.7	8.0	0.12	138	119	1,321	156
1977	7.2	8.1	0.19	196	246	2,947	756
1982	7.3	4.5	0.14	182	131	1,326	227
1983	7.0	3.4	0.11	170	138	1,250	200
1986	7.0	3.5	0.11	152	81	1,136	194

OM = organic matter.

concentration of exchangeable calcium and magnesium for conifer seedling production is 500 ppm and 150 ppm, respectively (13).

Discussion

The single application of 6 inches of composted limetreated horse manure was equivalent to applying 3.5 tons per acre of lime. A guideline for the application of lime to sandy nursery soils is that 1 ton per acre of lime should increase soil pH by 0.5 units (13).

The initial increase in soil pH was not as large as the guideline suggested. There are several possible reasons for this. First, the soil organic matter content before the application of composted horse manure was higher than normally found in sandy soil. Soil organic matter and clay serve as a buffer, thus preventing large changes in soil pH. Second, some of the calcium and magnesium present in the material applied was contained within the organic matter itself. The organic matter had to decompose before the calcium and magnesium could react with the soil. Third, the particle size of the lime used in the horse stalls may have been larger than the particle size of lime normally applied to soil, thus increasing the length of time required for the lime to completely react with the soil (6). The initial change in soil pH, as a result of adding organic matter, was not an indication of the total change in soil pH or the duration of the change.

The soil pH has not decreased with time. Calcium and magnesium are lost from soils in three ways: (a) erosion, (b) crop removal, and (c) leaching (6). The loss of nutrients by erosion in this nursery is minimal. The amount of calcium removed in seedling crops is insignificant in comparison to the amount of exchangeable calcium present in the soil to which the composted horse manure was applied. Harvesting 2 + 0 white pine (*Pinus strobus* L.) seedlings grown in an area treated with horse manure removed 23 pounds per acre of calcium (3).

The nutrients taken up by cover crops are returned to the soil during decomposition and thus are not removed from the site. Another possible reason that soil pH in the treatment area has not decreased is because the irrigation water contains 30 ppm of calcium. Twelve inches of irrigation water per year contributes 80 pounds per acre per year of calcium. This is equivalent to applying 150 pounds per acre of lime per year.

Problems with poor seed germination, early survival, and poor seedling growth have been experienced in areas where the composted lime-treated horse manure was applied. High soil pH is believed to be the main cause of these problems (3, 9). Poor early seedling survival may be attributed to damping-off, which is favored in cool and wet, neutral to basic soils containing large amounts of organic matter (8). The problems with poor seedling growth may be attributed to soil nutrient imbalance. Phosphorus availability to plants is greatest when soil pH is between 6.0 and 7.0. Potassium and ammonium become fixed and therefore

unavailable to plants when soil pH is too high. Solubility of micronutrients such as zinc, copper, manganese, and iron decreases as soil pH increases, thus decreasing the availability of these nutrients to plants. Plants may exhibit nutrient deficiencies when soil pH is too high (11).

Reports in the literature indicate that some conifer species are intolerant to soil pH above 6.0. Dry weight of red pine (*Pinus resinosa* Ait.), and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings were found to be greatest when soil pH was 5.5 (1, 12). The tallest Norway spruce (*Picea abies* (L.) Karst.) seedlings were produced when soil pH was 4.5 (2).

Conclusions

It can be concluded that an undesirable increase in soil pH occurred after a single 6-inch application of composted lime-treated horse manure. The effect of applying this material on soil pH and chemical properties has persisted for at least 12 years. There are indications that the high soil pH is responsible for poor early survival and growth of conifer seedlings.

Organic materials having a pH above 7.0 and containing large amounts of calcium and magnesium should not be applied to soils in conifer nurseries where moderately acid soil conditions are desirable. It must be stressed that there is a need to test new sources of organic matter and application rates in small areas of the nursery before applying the material to the entire nursery. This testing program should be designed to include several tree species with a duration of at least two rotations of seedlings.

Literature Cited

1. Armson, K.A.; Sadreika, V. 1979. Forest tree nursery soil management and related practices. Toronto: Ontario Ministry of Natural Resources. 179 p.
2. Benzian, B. 1965. Experiments on nutrition in forest nurseries. For. Comm. Bull. 37. London: Her Majesty's Stationery Office.
3. Bickelhaupt, D.H.; Ulzen-Appian, A.; White, E.H. 1987. Effect of horse manure on white pine seed ling production in a forest tree nursery. Fac. For. Misc. Pub. 14 (ESF 87 003). Syracuse, NY: State University of New York, College of Environmental Science and Forestry.
4. Bickelhaupt, D.H.; Davey, C.B.; White, E.H. 1983. Laboratory methods for forest tree nursery soil analysis. Sch. For. Misc. Pub. 2 (ESF 83-004). Syracuse, NY: State University of New York, College of Environmental Science and Forestry.
5. Blumenthal, S.G.; Boyer, D.E. 1982. Organic amendments in forest nursery management in the Pacific Northwest. Admin. Rep. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.
6. Brady, N.C. 1984. The nature and properties of soils, 9th ed. New York: Macmillan. 750 p.
7. Davey, C.B.; Krause, H.H. 1980. Functions and maintenance of organic matter in forest nursery soils. In: Proceedings, North American Forest Tree Nursery Soils Workshop. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 130165.
8. Manion, P.D. 1931. Tree disease concepts. Englewood Cliffs, NJ: Prentice-Hall. 399 p.
9. Plumley, K.A. 1986. Fusarium as a cause of seedling mortality at the Saratoga Tree Nursery, Saratoga Springs, New York. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 57 p. M.S. thesis.
10. Scholtes, J.R. 1985. Northeast area state owned nursery production. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Area.
11. Tinus, R.W. 1980. Nature and management of soil pH and salinity. In: Proceedings, North American Forest Tree Nursery Soils Workshop. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 72-86.
12. van den Driessche, R. 1979. Soil management in Douglas-fir nurseries. In: Heilman, P.E.; Anderson, H.W.; Baumgartner, D.M., eds. Forest soils of the Douglas-fir region. Pullman, WA: Washington State University: 278-292.
13. White, E.H.; Comerford, N.B.; Bickelhaupt, D.H.1980. Interpretation of nursery soil and seedling analysis to benefit nursery soil management. In: Proceedings, North American Forest Tree Nursery Soils Workshop. Syracuse, NY: State University of New York, College of Environmental Science and Forestry: 269-287.