Minimum phosphorus on turf

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Phosphorus fertilization practices and recommendations for turfgrass systems are currently based on arbitrary figures rather than any established minimum requirements. The reason is the scarcity of data on the phosphorus status of turf soils and the lack of information concerning critical phosphorus levels in turfgrass tissue. A common speculation is that turf soils have been overfertilized with phosphate fertilizers, leading to such problems as weediness and high maintenance costs.

Our two-part investigation had two goals: first, the establishment of a data base on phosphorus in California turf soils and, second, a determination of critical tissue phosphorus levels for Kentucky bluegrass, *Poa pratensis* L. In addition, we assessed the contribution of mycorrhizal fungi to the phosphorus nutrition of Kentucky bluegrass. This information may aid in establishing realistic recommendations for the phosphorus fertilization of turfgrass.

In the investigation of turf soil phosphorus, soil samples were collected from 42 sites throughout California, including city and county parks, municipal and industrial grounds, golf course fairways, athletic fields, and home lawns. Soil cores from each site were divided into three subsamples according to depth: 0 to 2.5 cm, 2.5 to 10 cm, and 10 to 30 cm, as measured from the soil surface. Available (sodium bicarbonate extractable) phosphorus was determined for each subsample and the values expressed as ppm phosphorus on an air-dry soil basis. In addition to soil samples, cultural information and observations were recorded for as many sites as possible, including fertilization practices, clippings removal, weediness, and turf quality.

Many soils deficient

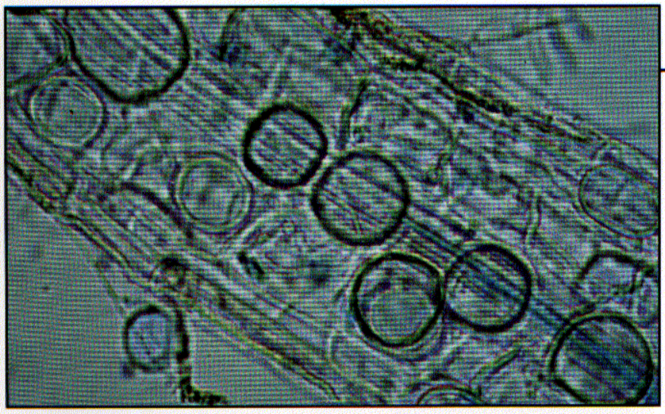
Soil phosphorus levels varied considerably among the turf sites sampled. Combined values for the first two subsamples, representing the 0- to 10-cm depth of the soil profile containing 60 to 90 percent of turfgrass roots, ranged from as low as 1.5 ppm to as high as 48.1 ppm phosphorus. Previous research has established that soils with less than 5 ppm sodium bicarbonate extractable phosphorus are deficient for several turfgrass species, while 8 ppm phosphorus or more is adequate for growth. Using these criteria and considering the 0- to 10-cm depth for each site, 24 percent of the soils sampled were deficient in available phosphorus (less than 5 ppm phosphorus), 19 percent were marginal (between 5 and 8 ppm), and 57 percent were adequate (above 8 ppm). In addition, 5 percent of the sites tested contained greater than optimal soil phosphorus levels (above 35 ppm) at 0 to 10 cm. When the depth considered was 0 to 2.5 cm, 17 percent of the sites were excessively high in available phosphorus.

Of the seven soils containing less than 5 ppm phosphorus in the 0- to 2.5-cm subsamples, five were from home lawns. This finding can be attributed to the removal of grass clippings, causing phosphorus depletion in the upper portion of the soil profile. No clippings were removed from any of the other sites sampled in this study.

For most of the sites, phosphorus levels were noticeably higher in the top 0 to 2.5 cm, as compared with those in the 2.5- to 10-cm and 10- to 30-cm layers. Phosphorus appeared to accumulate in the surface 0 to 2.5 cm, possibly because of fertilization and the practice of returning clippings (except as noted for home lawns). Being relatively immobile in the soil, phosphorus tends to remain close to the surface when positioned there either by plant residues or fertilizers.

Weediness

In this study, weediness increased with decreasing soil phosphorus. An average of 6.8 ppm available phosphorus in the top 10 cm (marginally deficient) was found for the sites indicated to be high in weediness. Perhaps at the low phosphorus levels in these soils, weeds were able to compete more successfully and were not as limited by phosphorus as the turfgrass species. This relationship may also, however,



Mycorrhizal hyphae and vesicles infecting bluegrass root cortex cells. Through symbiotic association with the grass roots, these organisms are responsible for improved phosphorus nutrition of the grass plant growing in phosphorus-deficient soil.

reflect a lower level or quality of management.

Visual assessment of turf quality as "good," "fair," or "poor" showed a trend toward better quality with increasing phosphorus levels in the top 10 cm of soil for the various sites. Sites evaluated as poor in turf quality averaged 7 ppm phosphorus in the 0- to 10-cm depth.

As previously noted, 17 percent of the sites sampled contained excessively high levels of phosphorus (above 35 ppm phosphorus) in the top 2.5 cm of soil. Frequent fertilization accounted for these results at some of the sites, but at those not receiving supplemental phosphorus, it is speculated that animal manure (especially that of dogs) contributed to the surface accumulation of soil phosphorus.

In the second part of this investigation was a controlled field study to determine critical tissue levels of phosphorus for Kentucky bluegrass and to evaluate the effects of soil phosphorus levels on turf establishment and growth. The experiment included three soils: Auburn clay loam, a phosphorus-fixing soil very low in available phosphorus; Yolo loam subsoil, marginally deficient in phosphorus; and Tidewater sand, moderately phosphorus-deficient. The soils were placed in 45-liter lysimeter containers, and ammonium phosphate was applied at the rates of 0, 1, 2.5, 5, and 10 grams phosphorus per square meter to each soil. Additional nitrogen was added as ammonium nitrate to bring all treatments to 5 grams nitrogen per square meter, and the fertilizers were incorporated into the upper two inches of soil. There were four replications for each phosphorus level, and thus a total of 20 containers for each soil. Seed of Kentucky bluegrass 'Columbia' was sown at the rate of 2 pounds per 100 square feet in late May and clippings were taken periodically. Yields were recorded and the clippings were analyzed colorimetrically for phosphorus levels.

Early seedling growth in the Auburn clay loam was markedly influenced by phosphorus level. No clipping yields were obtained for the 0 phosphorus plot until October. At the first harvest, the dry weight yield from the plot receiving 10 grams phosphorus per square meter was 13 times greater than that of the plot receiving 1 gram phosphorus per square meter. Seedling growth was excellent in the Yolo loam; growth in the 0 phosphorus treatment was slower than in the others, but emergence was uniform. The first clipping harvest showed a response to phosphorus, but later yields were similar in all treatments. Seedling establishment was difficult in the Tidewater sand, and reseeding was necessary on several occasions.

Phosphorus levels in the tissue for each harvest of clippings were determined by an extraction procedure with 2 percent acetic acid followed by colorimetric analysis. When these results were plotted against dry weight yields, the critical concentration, at which the yield was 90 percent of maximum, could be determined. For all three soils, this critical level was found to be approximately 1100 ppm phosphorus in the tissue.

Mycorrhizal fungi

Once established, turf growth in the Auburn soil was remarkably lush and uniform, despite the gradient in applied phosphorus. A contribution by mycorrhizal fungi was suspected; therefore, soil cores were taken from each lysimeter container and subjected to a washing procedure to retrieve the roots. After clearing and staining with a fungus-specific dye, the roots were examined microscopically and assessed quantitatively for the presence of mycorrhizal fungi. The percentage of root length colonized by these symbiotic organisms was highest for the 0 phosphorus treatment (67 percent) and showed a definite downward trend, reaching a minimum of 25 percent for the 10-gram phosphorus treatment.

Soil phosphorus is seen to be necessary for turfgrass establishment, and a critical tissue concentration of 1100 ppm phosphorus can be used as a guide for fertilization. Growth of established turf proceeds satisfactorily over a wide range of soil phosphorus levels, varying from deficiencies due to removal of clippings to excesses resulting from use by pets. Mycorrhizal fungi contribute substantially to phosphorus nutrition under deficient conditions. Taking these factors into account, it can be seen that fertilization recommendations for established turf are in need of revision. Under some conditions, phosphorus fertilizer may even be unnecessary.

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