UNDERSTANDING TURF MANAGEMENT
The ninth in a series by
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PHOSPHORUS

During the past century more effort in research time and money has been expended on the study of the chemistry of phosphorus in the soil than any other element. The importance assigned to this plant nutrient reflects the generally low concentration that is normally found in the soil solution and the importance of the element in the nutrition of plants.

Why does grass need phosphorus?

Even though the concentration of phosphorus in the grass blade is generally in the range of 0.3 to 0.5 percent, one-eight that of nitrogen or potassium, it is still considered an essential major nutrient. It is essential for the transfer of energy derived from the sun by photosynthesis in the cells in the leaf to all other parts of the plant. The most actively growing portions of the plant, the meristematic region at the base of the leaf and the growing tip of the root, therefore contain the highest levels of phosphorus. Thus one realizes the importance of phosphorus in root development.

Phosphorus also tends to concentrate in seeds and on maturation of a plant the phosphorus will move from other parts of the plant to the seed as it is formed. Nevertheless the amount of phosphorus that can be stored in the small seed of bluegrass never meets the requirement of the rapid growth which occurs immediately following germination of the seed; thus the essential need for a relatively high level of phosphorus in the soil when a new stand is being established.

Phosphorus seldom influences the colour of turf unless there is extreme deficiency when a purplish tinge may be seen. Slow development of a newly seeded sports field or slow growth of a turf receiving adequate nitrogen may be a warning that phosphorus is deficient. Any suspicion of low phosphorus nutrition should be confirmed by soil or plant analysis.

Why the great concern?

Most soils generally contain less than **one ppm** of phosphorus in the soil solution at any time of measurement. If the rate at which this low level in the soil solution is replaced is too slow you have a deficiency problem and it becomes a rate limiting factor in turf growth. The low level is caused by the extremely low solubility of most phosphorus compounds in water - that is - how much phosphorus is dissolved in the soil solution.

The original mineral from which all phosphate fertilizers are manufacture - fluorapatite (tricalcium phosphate or rock phosphate) - is extremely insoluble (Table 1). The insolubility is further increased by a low level of fluoride in the rock phosphate, a similar concept to the use of fluoride to increase the strength of your tooth enamel. When very finely ground, rock phosphate can be considered a slow release phosphate source, but it is only effective in supplying phosphorus to turf on acid soils; soils of less than pH 5.0.

In the 1880's, two soil scientist, Lawes and Gilbert, at the Rothamstead experiment Station in England discovered that treating the rock phosphate with sulphuric acid greatly increased the solubility of the material (Table 1). The increase was due to the formation of monocalcium phosphate, the basic phosphate compound in ordinary (0-20-0) and triple (0-46-0) phosphates. Further manufacturing processes can produce calcium metaphoshate and ammonium phosphates which are essentially water soluble.

Regardless of the form of phosphate fertilizer added to the soil, the phosphate will slowly revert to an insoluble form through a process often referred to as phosphate fixation. The overriding factor controlling the process is the pH of the soil.

In the last article in this series it was mentioned that phosphorus was most soluble between pH 6.5 and pH 7.2. At a pH value more acid than 6.5 the concentration of aluminum, iron and manganese in the soil solution increases, all of which form insoluble compounds with phosphorus. At pH values greater than 7.2 there is an increase in the amount of calcium and magnesium in the soil solution; ions which also form insoluble compounds with phosphorus. Hence phosphorus added as a fertilizer tends to remain in a form which can recharge the soil solution most readily in this relatively narrow pH range between 6.5 and 7.2.

Table 1: The solubility of several phosphorus compounds.

Compound	Formula	Solubility in Water
		(ppm)
Monocalcium phosphate	$Ca(H_2PO_4)_2$	50,000
Dicalcium phosphate	$CaHPO_4$	60
Tricalcium phosphate	$Ca_3(PO_4)_2$	1
Fluor-apatite	$[Ca_3(PO_4)_2]_3CaF_2$	0.003

It should be understood, however, that the reversion to a completely insoluble form such as tricalcium phosphate is a multi-step chemical process which may take years for completion. In the first few months the initial compounds produced may be only slightly less soluble than the material added as a fertilizer. The greater the amount of these initial forms in the soil, the more rapidly the concentration of phosphorus in the soil solution can be recharged and the greater the fertility of the soil for grass.

Researchers have attempted to increase the efficiency of phosphate fertilizer use by cultivated crops by placing the fertilizer in band, proving a localized zone of higher phosphorus concentration. To a degree this practice is copied for turf managers in the suggestion that a high phosphate fertilizer should be surface-applied and worked into the top 2 cm. just prior to seeding a new stand.

Phosphorus and pollution

The chemistry of phosphate in soil, which is based on the formation of compounds of relatively low solubility, results in a very low concentration of phosphorus in the soil solution. Furthermore the formation of these compounds prevents any significant downward movement of phosphorus in the soil. Research at the Univ. of Guelph, using radioactive phosphate fertilizer applied in May, demonstrated that the phosphate had not migrated downward more than one cm by the end of the season (Table 2). Pollution by phosphorus in percolating ground water, therefore, seldom occurs.

Water pollution by phosphorus from land surfaces is primarily from the erosion of phosphorus-enriched soil particles into water systems. The number one system for the prevention of soil erosion is a bluegrass sod. Hence phosphorus pollution by surface flow from turf areas is also as close to zero as is feasibly possible.

Efficient phosphate use

A turf manager should be concerned most about the phosphorus levels in his soils at the time of establishment of a new stand. At that time phosphate applied at least at the rate recommended by a soil test is one of the best insurance moves he can make for the rapid establishment of a vigorous sod. This phosphorus should be worked into the top inch of soil during the final seed bed preparations.

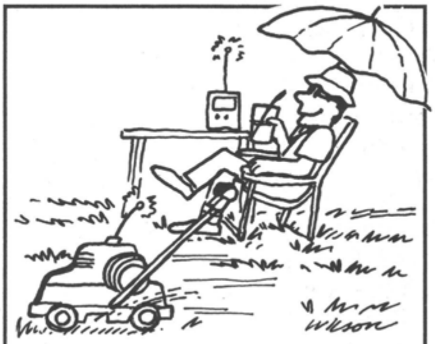
Subsequent phosphorus applications, of necessity, are applied to the soil surface. Furthermore clippings continually returned to the surface tend to concentrate the phosphorus at the surface. This is not a problem. Research using radioactive phosphorus to identify the source of the phosphorus found in the grass has shown that in one growing season up to 30% of a surface application of fertilizer phosphorus may be utilized by the grass plants. This percentage utilization is as high as that recorded for band applications for cultivated crops.

While phosphorus only needs to be applied once each season most turf fertilizers contain some phosphorus. The amount required for a full season may be estimated from a soil test. Since the fertilizer rates used are generally set by the amount of nitrogen required at any one application, a knowledge of the number of nitrogen applications planned for the year and the rate of material application should allow the calculation of the concentration of phosphorus required in the complete fertilizer.

Remember for established turf it is not necessary to include phosphorus every time you make a fertilizer application.

Table 2: The downward movement of fertilizer phosphorus in one season from a surface application on grass.

Depth of sampling (cm)	Concentration of applied fertilizer phosphorus (ppm)
0 - 1.5	275
1.5 - 3.0	41
3.0 - 4.5	11
4.5 - 6.0	3
6.0 - 7.5	1



Space Age Mowing

Thomas Noonan and partners John Fisher and Barry Bryant have won a U.S. patent for an automatic, self-propelled lawn mower that stores a map of terrain and a cutting route in its microprocessor.

"Basically, it can memorize a lawn and then reroute itself," Mr. Noonan, a salesman for Minnesota Mining & Manufacturing Co. in Havertown, PA., said of the mowing robot he and his partners call MOBOT.

The gas-powered mower relies on three navigation systems. First, the computer map tells it where to turn or slow down for a hill. Because mechanical problems, such as wheel slippage, can still knock it off its route, it adjusts its position by using sensors to detect metal markers or guide paths buried at intervals in the lawn.

If the mower cannot find its way, it shuts itself off. Ultrasonic sensors also tell the mower to shut down if there is an obstacle in its path. An alarm would alert the mower's owner to put down the ice tea and check out the problem.

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