# Phosphorus In Sand Putting Greens

*By Paul G. Drugan*

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Indications are that there is a discrepancy between what many soil testing laboratories perceive to be the optimum soil test P level in sand putting greens and the actual requirement. Christiams, Martin and Karnok (1981) did not find a response to P applications made to a calcareous sand green containing 24 lb P/acre nor did Calclough and Canaway (1989) on a sand green containing approximately 18 lb P/acre. These seemingly optimum soil P levels are but 1/8 to 1/4 those deemed optimum by several U.S. soil testing laboratories (Miller, 1971; Turner and Waddington, 1978).

The most likely reason for this major difference is that soil testing laboratory interpretations of soil tests are based upon research conducted with native soils rather than USGA specification rootzone mixes. When soluble fertilizer P is applied to soil, the bulk of the P is adsorbed on surfaces of hydrous aluminum and iron oxides, on alumino-silicate clay minerals, and if present, on carbonates. Only a very small portions of the P remains in solution in equilibrium with the surface adsorbed P. As the amount of surface adsorbed P is increased through fertilization, the solution concentration of P increases, eventually reaching the level where plants are supplied with all of the P they can use. The soil is then at its optimum soil test P level (Sample, Soper and Racz, 1981). Soil P tests associated with the optimum solution P concentrations.

In comparison to native soil, sand rootzone mixes likely have very low P adsorption capacities because of the lack of clay minerals and hydrous iron and aluminum oxides. This being the case, then the amount of surface adsorbed P needed to provide adequate solution concentrations of P will be correspondingly low. It follows that optimum soil test P levels will be considerably lower in sand greens than in native soil.

Phosphate ions are relatively immobile in soil due to their low solution concentrations and constant adsorption-desorption as they migrate through soil. This has led to the recommendation that phosphate be incorporated into rootzone mixes prior to green construction (Hummel, 1993). But if current soil test recommendations are followed, the P application rate may well be 4 to 8 times higher than the optimum level for sand greens. In this case, solution concentrations of P will be high enough to allow for substantial downward migration of P into the turfgrass rootzone. The practice of blending fertilizer P into the rootzone mix may then be unnecessary.

The objectives of the present study were to determine the optimum soil test P level for bentgrass establishment in a USGA specification rootzone mix and to observe the mobility of fertilizer P in the mix.

## METHODS

The rootzone mix used was a 90:10 (v/v) blend of Greensmix 2340 sand and Dakota reed sedge peat. Lots of the mix were equilibrated with P to provide soil test P (Bray-1) levels of 2, 10, 16, 37, and 72 ppm P (approximately 5,25,40,92, and 180 lb P/acre). Four pots were filled with 2.65 kg (oven-dry basis) of each mix. Two of the four pots were fertilized with a 19-26-5 starter fertilizer at the rate of 1.0 lb N/M. The other two pots were fertilized with Nutralene (40-0-0) and potassium sulfate to provide the same rates of N and K as in the starter fertilizer. The pots were seeded with 'Penncross' creeping bentgrass at the rate of 5.0 lb/M and watered to their pre-determined water holding capacity of 12.1 % by weight. All pots were daily adjusted to this moisture level for the duration of the study.

To observe the mobility of P in this rootzone mix, miniature USGA greens were established in 6-inch diameter PVC pipe. In two of the greens the top inch of mix was that containing 72 ppm P. Two other greens had mix containing 16 ppm P to a 4-inch depth. The last two greens had 10 ppm P to an 8-inch depth. All columns received starter fertilizer prior to seeding.

Starting 14 days after seeding, all experimental units were clipped every 3 to 4 days at a height of 0.5 inch. After 5 mowings (28 days after seeding), tillers / cm2 were determined and a 1.5-inch diameter plug removed from the P rate study pots. Maximum rooting depth was noted and the weight of roots in the plug determined.

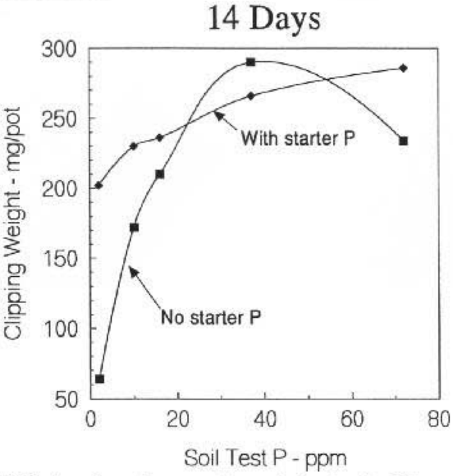
Thirty days after seeding of the miniature greens, soil cores were removed from the 6 columns and cut into 1-inch segments for P analysis. Clipping weights were recorded for a single 4-day growth period just prior to dismantling of the columns.

## RESULTS

### Optimum Soil Test P

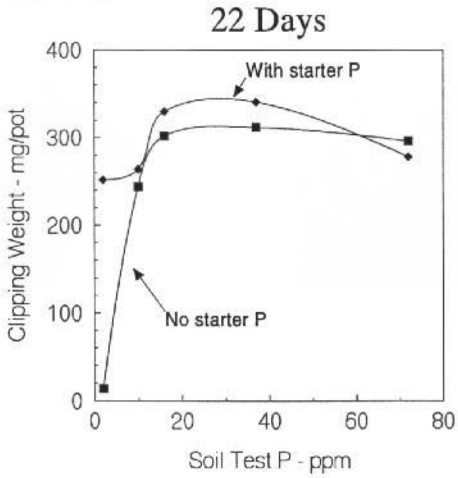
The first clipping weights recorded indicated that the optimum soil test P early in the establishment phase was about 37 ppm (Fig. 1) and at this soil test level there was no advantage to applying additional P in the form of

FIGURE 1.



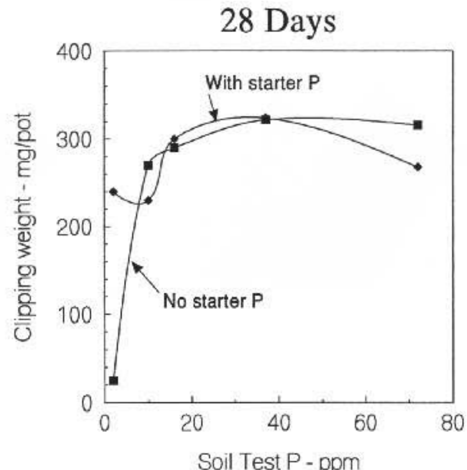

**Effects of rootzone mix and starter fertilizer P on the shoot growth of creeping bentgrass the first 14 days after seeding.**

FIGURE 2.




**Effects of rootzone mix and starter fertilizer P on the shoot growth of creeping bentgrass at 22 days after seeding.**

FIGURE 3.




**Effects of rootzone mix and starter fertilizer P on the shoot growth of creeping bentgrass at 28 days after seeding.**

started fertilizer. During the following week, the optimum soil test P level declined to 16 ppm (Fig. 2). Turner and Waddington (1983) have noted similar declines in the optimum soil P level once turfgrass has become established. Thus, the decline in the optimum soil test P was anticipated, but not as soon as 22 days after seeding.

Between 22 and 28 days after seeding, there were no further changes in the relationship between clipping weight and soil test P level (Fig. 3). The optimum soil test P remained in the range of 16 ppm or about 40 lb P/acre and there was no response to starter P at this soil test P level.

Between 14 and 17 days after seeding, the bentgrass growing in the pots to which no P had been added began to exhibit typical P deficiency symptoms. The grass was unusually dark green, the leaf blades narrow, and the grass virtually stopped growing. By 22 days after seeding, more severe deficiency symptoms in the form of yellowish-orange leaf tips began to appear. Application of 10 ppm P to the greens mix or starter fertilizer prevented development of P deficiency symptoms. There were no discernible color differences among any of the pots where P had been applied.

Clippings collected during the study were combined to provide sufficient tissue for analysis for P. When no P was applied and visual P deficiency symptoms were evident, the tissue P concentration was 0.16 % (Fig.4). Increasing the rootzone mix P level from 2 to 10 ppm resulted in a tissue P concentration of 0.4 %. This is well above the concentration of 0.3% often considered to be satisfactory for turfgrass growth. However, it was not until the clippings contained 0.57 % that dry matter yield was optimized.

Even when the rootzone mix contained only 2 ppm P, application of starter fertilizer elevated tissue P concentrations above 0.6 % (Fig. 4). However, clipping weights were no greater than when the tissue contained 0.57 % P. This suggests that an adequate or sufficient level of P in bentgrass clippings is approximately 0.6 %. Applying starter P to the rootzone mix containing 37 ppm P resulted in a tissue P concentration of 0.88%. Given that there was a tendency for clipping weights to decline when starter P was applied at soil P levels above 37 ppm, it seems reasonable to suggest that clipping P concentrations above 0.9 % should be considered to be excessive.

There were no differences among the P treatments with regard to tiller density. The pots receiving P appeared to have higher turf density, but this apparently was solely the result of wider leaf blades.

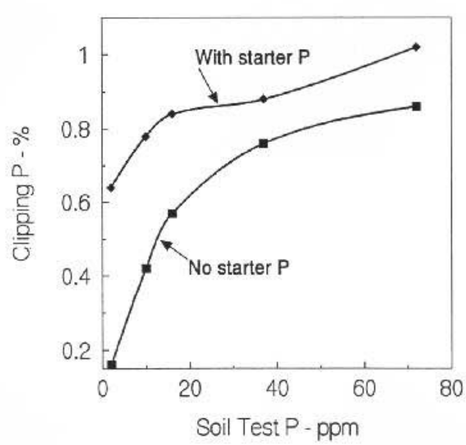
The bentgrass root weights did not support the common belief that application of P to a P-deficient soil stimulates root growth (Fig. 5). There did appear to be some stimulation of root growth when starter P was applied to rootzone mix containing 16 ppm soil test P, but not at any other level of soil test P. If inverted, the root weight responses (Fig. 5) appear to correspond quite well to the clipping responses observed after 22 days into the study (Fig. 2 and 3). This prompted examination of the relationship between total clipping weights and root weights. The relationship calculated clearly showed an inverse relationship and indicated that clipping weight accounted for 98% of the variation in root weights. Thus, shoot growth rate and its influence on carbon partitioning between roots and shoots seemed to be the dominant factor as far as root growth was concerned.

Bentgrass rooting depth responses (Fig. 6) displayed some of the same features as the root weight responses (Fig. 5). With the sole exception of starter P applied at 10 ppm soil test P, increasing the P supply reduced rooting depth in all instances where increasing the P supply increased clipping weights.

### Phosphorous Mobility

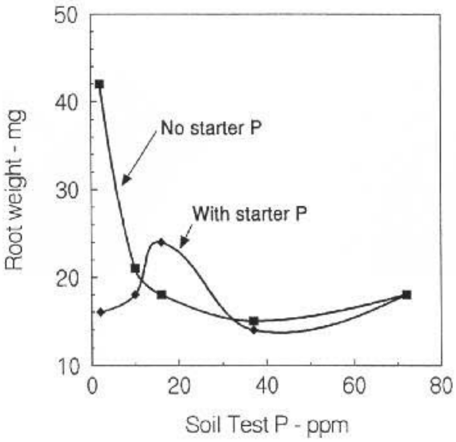
Clippings were collected from the miniature putting greens on just one occasion. The clipping weights tended to decline as the depth to which P was

FIGURE 4.



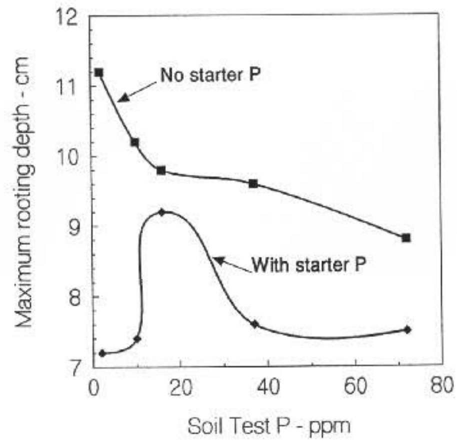

**Effects of rootzone mix and starter fertilizer P on the average P concentration in creeping bentgrass clippings.**

**FIGURE 5.**



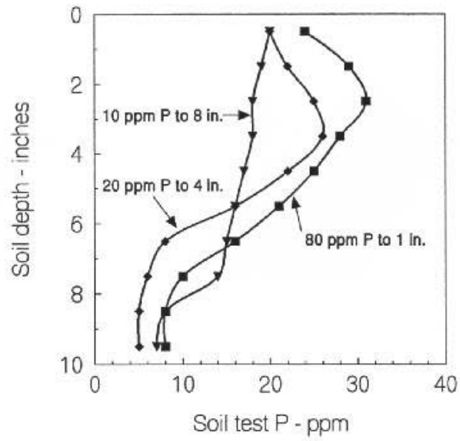

**Effects of rootzone mix and starter fertilizer P on the root growth of creeping bentgrass at 28 days after seeding.**

**FIGURE 6.**




**Effects of rootzone mix and starter fertilizer P on the maximum depth of rooting of creeping bentgrass 28 days after seeding.**

**FIGURE 7.**




**Soil test (Bray-1) P levels at different rootzone mix depths 30 days after incorporation of different concentrations of P to different depths.**

incorporated increased and the concentration of incorporated P decreased. While the clipping weight differences were not significant, this may not have been the case if the study had included more than two replicates of each treatment. The effect of concentrating fertilizer P near the soil surface rather than incorporating it to some depth merits further investigation.

Soil test P levels measured at different soil depths 30 days after initiation of the study provide strong evidence that fertilizer P was remarkably mobile in the rootzone mix (Fig. 7). Consider, for example, the case where mix containing 72 ppm soil test P was placed in the top inch of the column. With the addition of starter P as well, if no P migration had occurred, the final soil test P level should have been well above 72 ppm. The fact was that after 30 days, the soil test P level in the top inch of mix in this treatment was only 22 ppm. At a depth of 2 to 3 inches, the soil test P concentration had increased from 2 to 31 ppm. Thus, a substantial amount of P movement occurred in this short period of time. A small amount of P appeared to have migrated 10 inches or more.

The rate at which the fertilizer P migrated downward depended on the amount of P in the rootzone mix. This is understandable from the perspective that as soil test P levels increase, so do solution concentrations of the nutrient.

**SUMMARY**


The results of this study confirm that the optimum soil test levels of P for bentgrass establishment are approximately twice those for maintenance of the established turf. Therefore, fertilization to meet the P requirement for establishment automatically assures adequate P supply thereafter. An environmentally responsible management practice would be to allow soil P levels to decline to post-establishment optimum levels and then fertilize to maintain those levels.

For the 90:10 sand-Dakota reed sedge rootzone mix used in this study, the optimum soil test P for creeping bentgrass establishment was about 40 ppm Bray-1 P, or approximately 100 lb P/acre. Within three weeks after seeding the optimum soil test P was 16 ppm or about 50 lb P/acre. Both of these optimum P levels are considerably less than what is currently recommended by many soil testing laboratories.

Fertilizer P proved to be very mobile in the sand-reed sedge peat rootzone mix. For example, the soil test P in the top inch of the mix declined from more than 72 ppm to 22 ppm during 30 days in which water was such that very little drainage occurred from the miniature putting greens used. This suggests that there is no compelling reason to blend fertilizer P into the rootzone mix prior to green construction. Incorporation of 2.5 to 3.0 lb P2O5/M into the top inch or so of the green should ensure that in a short period of time there will be adequate P throughout the bentgrass rootzone.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