# Soil Test Phosphorus Requirments for Sand Greens

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What does a putting green soil test phosphorus (STP) value of 25 ppm mean anyway? According to Wisconsin regulations it means P fertilizer can't be applied legally, but is 25 ppm STP enough to sustain healthy turfgrass?

Soil test calibration studies are necessary to provide context to soil test results. During a calibration study, various plant responses are assessed across a broad range of soil nutrient levels. Responses such as clipping yield, visual quality rating, deficiency symptoms, and stand density are commonly used to determine the soil test critical point; where plant demand for the nutrient is met by the soil supply. Turfgrass visual quality, clipping yield, and stand density are reduced when the soil test level is less than the critical point and application of fertilizer is recommended. Fertilization when the STP level exceeds the critical point is not recommended because additional nutrients are not likely to stimulate a turf response.

It's important to pay attention to the soil testing method used by your favorite lab. For golf course turf, especially putting greens and tees, the Mehlich-3 soil test has fallen into favor by many labs nationally because it is less sensitive to soil pH as other test methods. It is the method used at the UW-Soil and Plant Analysis Lab (UW-SPAL) for golf course soil analysis. Despite its widespread use, there was not Mehlich-3 soil test calibration data for creeping bentgrass putting greens or tees published in the scientific journals. In 2008, we began a study to determine the STP requirements of creeping bentgrass putting greens. Additionally we were interested to see if Primo MaxxTM (trinexapac-ethyl) had an effect on putting green P requirements.

**Basic Research Methodology**

To create a broad range in STP levels, a new putting green was constructed at the O.J. Noer Turfgrass Research Center with non-amended calcareous sand conforming to USGA particle size specifications. The green was seeded in June, 2008 with 'Penn A4' creeping bentgrass and established during that growing season. Various amounts of phosphorus fertilizer (monopotassium phosphate) were incorporated into the 32 research plots prior to seeding with a rototiller (Figure 1). Periodically that summer, six three-inch deep soil samples from each plot were pooled together and sent to UW-SPAL for Mehlich-3 ICP-OES phosphorus determination. Additional monopotassium phosphate was applied during 2008 broaden the range in STP values.

The actual data collection began in May 2009 and continued until October 2010. The green was fertilized twice a month with 0.2 lbs N/M, irrigated daily to 80% of ET, and mowed 6 days a week at 0.125 inches. Sixteen of the 32 plots were sprayed with Primo MaxxTM every 200-GDD (base 0°C) at the rate of 0.25 oz/M (11 oz/acre). Six soil samples to three inches, clipping yield, and visual quality ratings were taken during each month of the growing seasons. Turfgrass quality was rated on a one to nine scale where one represents dead, six minimally acceptable, and nine perfect putting green visual quality rating. After clippings were dried and weighed, they were sent to the UW-SPAL for mineral P determination. Regression was then used to create calibration curves for each month with or without TE.

**Turfgrass Mehlich-3 Soil P Requirements**

The fertilizer treatments succeeded in creating a broad range of STP levels and deficiency symptoms at the start of the study in May 2009. Soil test values ranged from 3 to 55 ppm phosphorus. This resulted in a broad range of turfgrass visual quality ratings. Plots that did not receive P fertilization during construction or establishment consistently had the lowest quality ratings (2 to 3). These plots were blue to purple in color, slowly growing, with thin/spindly leaves, and limited thatch or

| SOIL DEPTH | MEHLICH-3 SOIL TEST NUTRIENT LEVEL | |
|---|---|---|
| | PHOSPHORUS | POTASSIUM |
| Inches from surface | ------------------------ppm------------------------ | |
| 0 to 1 | 15.5 | 93.9 |
| 1 to 2 | 14.1 | 20.9 |
| 2 to 3 | 16.1 | 21.7 |
| 3 to 4 | 11.0 | 20.0 |
| 4 to 5 | 5.5 | 13.2 |

**Table 1. The distribution soil nutrients with soil profile depth. Plant roots redistribute nutrients towards the top of the soil profile. Consistency of soil sampling depth is very important because shallow cores will have higher soil nutrient values than deeper cores.**

mat accumulation. These symptoms were often mistaken for localized dry spot by people not familiar with the study. Turfgrass quality rapidly improved as STP level increased from 3 ppm, the P level of unfertilized sand, to the critical point which averaged 7 ppm. The exact critical point for each month varied from 6 to 11 ppm. Turfgrass visual quality did not change once Mehlich-3 STP values exceeded the critical STP point. There was not a clear trend relating critical point to season despite reports of reduced P uptake in spring and fall due to cold soil temperatures. Other factors, such as clipping yield, were used to calculate Mehlich-3 critical points but the critical point was not as obvious with those calibrations and turfgrass is fertilized to sustain visual quality not maximize clipping yield.

We hypothesized Primo would reduce the STP critical point because it would reduce leaf demand for P and reduce P loss during mowing. However, Primo MaxxTM did not change the STP critical point by a practically significant level. This is partially because the STP critical point is so incredibly low without Primo. Turfgrass visual quality was enhanced with 200-GDD Primo applications only once the STP level exceeded the critical point.

Mehlich-3 STP critical point for the green in this study was 7 ppm, the exact STP requirement for other creeping bentgrass putting greens is likely different. Factors such as soil mineralogy and pH, grass cultivar, environmental conditions (i.e. shade), and N fertilization rate can alter the STP critical point. For example, Dr. Kussow has demonstrated that plant demand for P increases as N rate increases growth rate (Kussow and Houlihan, 2006). Despite these factors, Mehlich-3 STP levels of 15 or greater likely satisfies most sand-based bentgrass putting greens of Wisconsin.

Another important factor affecting the critical point is depth of soil sampling. Plant roots re-distribute nutrients toward the top of the root zone. As a result, shallow sampling will lead to higher soil test values than deeper sampling. In June 2010 a cup cutter was used to pull a five inch deep plug for an area outside of the research plots. The plug was then sectioned into five one inch thick samples and sent to UW-SPAL for nutrient analysis. Nutrient levels declined further down the profile. A one inch deep soil core from this plug would have soil test phosphorous and potassium values of 16 and 94 ppm, respectively. A five each deep sample from the same plug would have P and K soil test values of 9 and 34 ppm, respectively. This result shows the importance of consistent sampling depth. These differences will likely become larger as the green continues to age. Soil sampling in this study was conducted at a depth of 3 inches.

**Figure 1. Various amounts of monopotassium phosphate fertilizer were incorporated into 32 plots during construction of the putting green with a rototiller. This method resulted in a broad range of Mehlich-3 soil test phosphorus levels and turfgrass deficiency symptoms.**

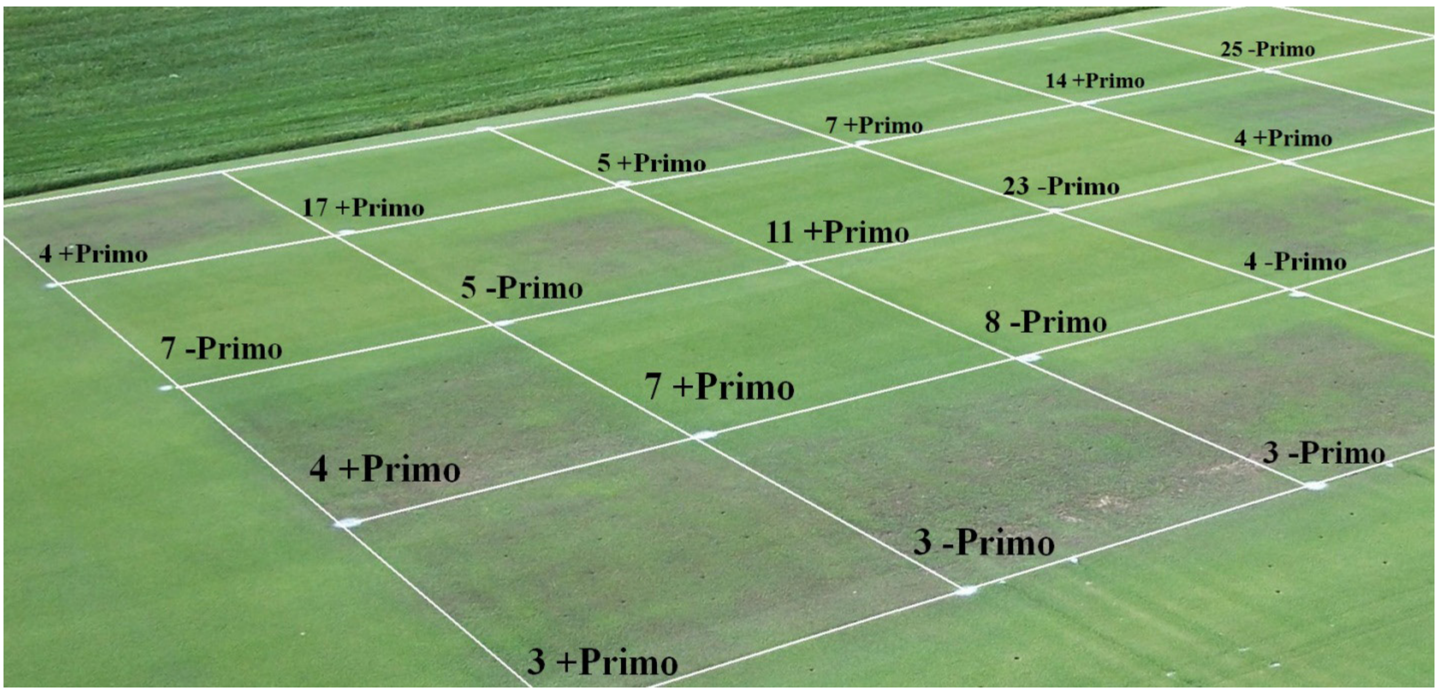


**Figure 2. A broad range of Mehlich-3 soil test phosphorus levels (STP) and turfgrass deficiency symptoms was created. The effect of Primo MaxxTM on STP critical point and STP decline was also assessed. Numbers represent Mehlich-3 STP values (ppm) for each plot with or without Primo MaxxTM. Soil test values below the critical point of 7 ppm displayed obvious P deficiency symptoms. After STP level exceeded the critical point of 7 deficiency symptoms disappeared and Primo MaxxTM increased turfgrass quality relative to the non-treated.**

**The Decline of Available Soil P**

Soil test phosphorus levels decline primarily for two reasons under a dense stand of turfgrass. Phosphorus removal during mowing is a process directly under the control of the turfgrass manager. Simply returning clippings can substantially reduce nutrient removal. This is usually impractical on golf putting greens where clippings can disrupt playability and aesthetics. Plant growth regulator applications, on the other hand, can suppression clipping yield and subsequent nutrient removal. Primo MaxxTM applications during this study reduced P removal by an estimated 32% or approximately 0.8 lbs. P/M during the 18 months of this study.

The other process of STP decline is soil P fixation. The rate of fixation depends on many factors including soil mineralogy and pH. The sand used to construct this putting green had and initial pH of 8.8. That pH value suggests the sand was buffered by calcium carbonate, typical of many sands of the upper Midwest, and some amount of exchangeable sodium. This is an ideal soil condition for rapid P fixation. During the 18 months of this study, the STP levels of all plots decline to the level of the unfertilized sand (3 ppm). Plots with a high initial STP values declined most rapidly. For example, one plot had an initial STP value of 55 ppm declined to 28 ppm after one month. At the end of the study the STP value of that plot was 11 ppm, a change of 44 ppm in 18 months.

*It could be easy to confuse P deficiency symptoms with localized dry spots. If Turfgrass isn't responding to irrigation, try adding a small amount of P fertilizer to the area*

Although Primo reduced P removal from mowing, STP levels declined at the same rate regardless of Primo treatment because rapid soil P fixation overshadowed P removal from mowing. The average pH value of this putting green declined from 8.8 at construction to 6.7 at the end of the study. Therefore, it is likely as the green continued to age and chemical properties change P fixation would slow and plant growth regulators may been more effective at sustaining STP level. This also has implications for soil testing frequency. Soil testing of new putting greens should be done annually for the first five years, at which point testing every two to three years is probably sufficient.

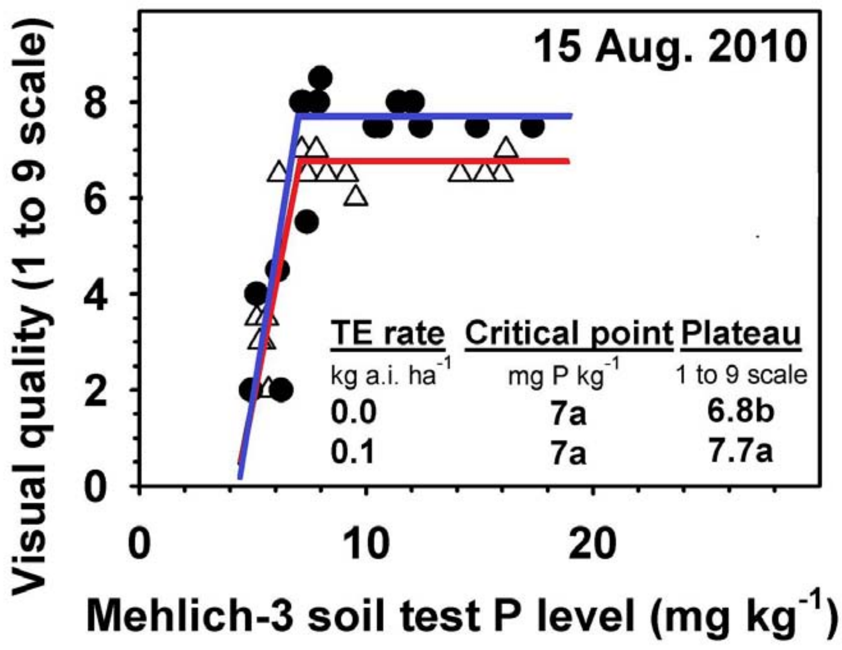


**Figure 3. Turfgrass visual quality rating clearly indicated the Mehlich-3 soil test phosphorus (STP) critical point for each month. This rating day is representative of the 12 rating days during the 2009 and 2010 growing season. Visual quality rapidly increased until the STP level exceeded the critical point. After STP level was greater than the critical point only Primo Maxx applied every 200-GDD further enhanced quality.**

**Treating Phosphorus Deficiencies**

It could be easy to confuse P deficiency symptoms with localized dry spots. If turfgrass isn't responding to irrigation, try adding a small amount of P fertilizer to the area. Even the slightest amount of P fertilizer application can quickly improve turfgrass quality. During establishment of this study, maintenance applications of liquid P fertilizer were applied to select plots to combat rapid P immobilization. A leaky spray nozzle dripped a very small quantity of P fertilizer onto plots that had not received P fertilization. Within a few days, a "river" of green turf could be seen cutting through the otherwise P deficient plot (Figure 4). The green "river" persisted for months even though the amount of P applied was miniscule.

Finally, at the end of the study all plots were treated a liquid application of monopotassium phosphate. After three weeks all plots that were P deficient for the past three years, and some thought dead, had completely recovered (Figure 5). The color, visual quality,

and growth rate was actually greater than the plots were never P deficient. This is a prime example of the 'Law of the Minimum.' Plant growth is always controlled by the most limiting nutrient. A vast majority of the time that is nitrogen. However, when P is deficient N is no longer the most limiting nutrient and accumulates in the soil. Plots that were not limited by P utilized all available nitrogen. Phosphorus was no longer the most limiting nutrient after P was applied. Then, the accumulated nitrogen underneath plots that were P deficient was available for use by the turf and caused the greater growth and darker color.

**Conclusions**

- The Mehlich-3 STP critical point for this putting green averaged 7 ppm, other factors such as N fertility, grass species, soil chemistry, and the growing environment will affect the critical point for other putting greens.
- Generally, Mehlich-3 soil test phosphorus (STP) requirement for sand-based creeping bentgrass putting greens is likely not greater than 15 ppm. Most testing labs put this number at 25-30 or even higher.
- Primo MaxxTM did not practically alter the STP critical point but did reduce P removal during mowing by 32%.
- Phosphorus was rapidly fixed by the soil of this young putting green and may justify more frequent soil sampling compared to older putting greens.
- Application of P fertilizer rapidly corrected P deficiency symptoms. Accumulation of N beneath P deficient turfgrass may cause P treated turf respond with greater color and growth rate.

**References**

**Kussow, W., and S. Houlihan**. 2006. The new soil test interpretations for Wisconsin golf turf. *The Grass Roots*. 35: 19-23, 25.



**Figure 4. A few drips of P fertilizer from a leaky spray nozzle caused the green streak cutting through this otherwise P deficient plot.**

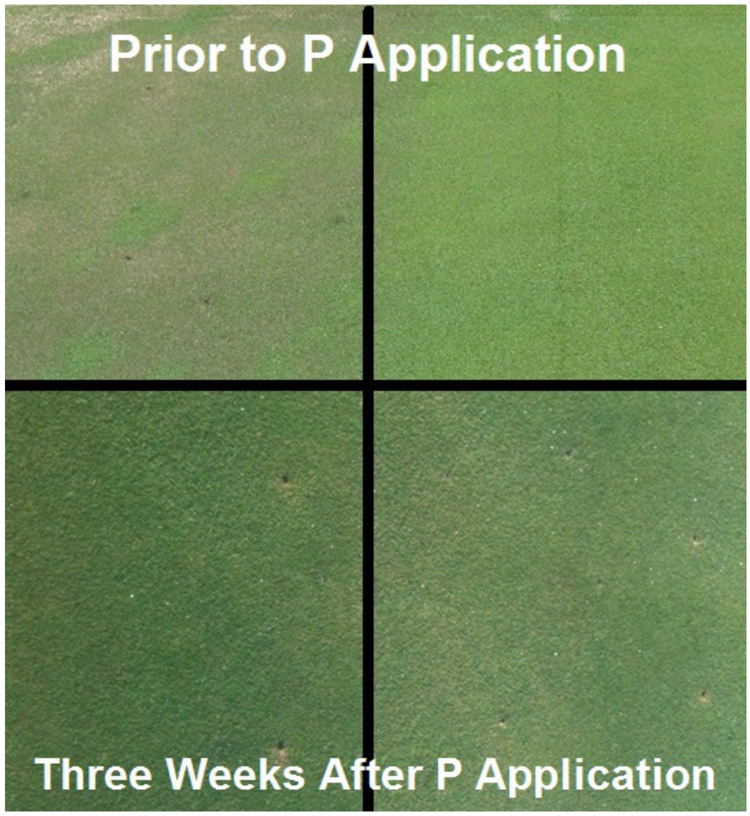


**Figure 5. A blanket phosphorus application was made to all plots after the experiment ended in October of 2010. Three weeks following application the plot on the left had completely recovered from the deficiency while the plot on the right was not affected. The plot on the lower left was more green than the plot on the lower right because nitrogen accumulated in the soil when the turfgrass in that plot was inhibited by the phosphorus deficiency.**