Role of phosphorus in the suppression of Poa annua on bentgrass putting greens

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Summary and recommendations

The five-year-old A4 greens at Talega suggest that low soil phosphorus might play a role in limiting invasion by poa. This report summarizes the findings of a study conducted by George Kenny at Talega that reveals the approximate minimum level of phosphorus that is needed to maintain healthy bentgrass with the target of suppressing poa invasion. The target value is between 20 and 30 ppm based upon the observations below. However, it is possible that the addition of phosphorus to the surface of an established green will reverse the benefits of the low soil phosphorus that was observed during the first five years of bentgrass growth when the bentgrass was able mine phosphorus from deep soil profiles where poa roots can not reach. Once the original phosphorus was depleted and additional phosphorus is applied, the low phosphorus strategy may be broken. There currently is no practical method of placing phosphorus deep into the soil, below the poa roots where the bentgrass has access but the poa does not.

- In order to continue the poa control strategy of low phosphorus management, do not apply excessive phosphorus. The target is between 20 and 30 ppm Mehlich III P to maintain adequate bentgrass growth at the lowest phosphorus levels possible. For increased accuracy in phosphorus testing, use the Olsen test for phosphorus and target a minimum of 5 ppm in the soil for adequate growth of bentgrass. Olsen P values above 5 ppm may be needed if iron levels are increased or the turf begins to display the purple symptoms of phosphorus deficiency.

Background

Suppression of Poa annua (poa) invasion into bentgrass greens has always been a controversial topic. In the past when arsenic was used as a poa specific herbicide on bentgrass greens, low soil phosphorus levels were needed for full herbicidal activity of the arsenic. This led to the belief that poa was a phosphorus-loving weed that might be suppressed by low phosphorus soil conditions. However, once arsenic was no longer used, low phosphorus was no longer essential. Furthermore, experience in research trials where poa invades different varieties of bentgrass indicates that the highest quality bentgrass varieties are most capable of resisting poa invasion. The most robust and healthiest bentgrass provides the greatest defense against poa invasion. This result would suggest that low phosphorus levels might result in less aggressive bentgrass growth and more poa invasion. The opposite was observed at Talega Golf Club – low phosphorus containing greens had very little poa invasion with abundant poa population being present in the collars.

Materials and Methods

Soil phosphorus evalutions: Soil phosphorus levels were determined via Olsen, Bray II and Mehlich III extractions run by Brookside Laboratories (New Knoxville, OH). To compare the soil phosphorus levels between treated and non-treated areas, cup cutter samples were collected from treated and non-treated areas of the practice green (two treated and two non-treated samples), green 12 (one treated and one non-treated) and two samples from the poa infested collar and green 14 (one treated and one non-treated sample) and two samples from the poa infested collar. The top 3 inches of soil were removed from each cup cutter sample and the soils were analyzed. In addition to the soil samples from greens, two cup cutter samples were collected from the surrounds of green 12 and 14 were poa invasion was severe.

Diagnostic tests: The A4 greens at Telaga were planted in 2000. Poa invasion was extremely limited as of May, 2005. Bensulide pre-emergent herbicide was applied in March of most years to suppress poa invasion. No phosphorus was applied to greens between 2000 and April of 2005 with the goal of suppressing poa using low soil phosphorus as a strategy. The ryegrass overseeded bermudagrass collars were thoroughly invaded by poa (Photos 1 and 2).

The lack of poa invasion into greens is not the result of a lack of poa seeds. The collars at Talega are heavily infested with poa (Photo 2). The bermudagrass collars are overseeded every year with ryegrass and the lack of effective poa-selective herbicides results in heavy poa invasion. Poa-selective herbicides introduced in 2005 will help reduce poa invasion in collars in the future but these herbicides were only available for a few weeks at the time this report was written. In preparation for overseeding and to stimulate overseeded ryegrass growth and development, one pound of phosphate is applied every year as a 0-25-25 starter fertilizer. Phosphate is also applied to the collars and greens surrounds in a 29-6-3 sulfur coated urea product. The collars report about 40 ppm phosphorus – slightly lower than our general recommendation for sufficient phosphorus of 50 ppm.

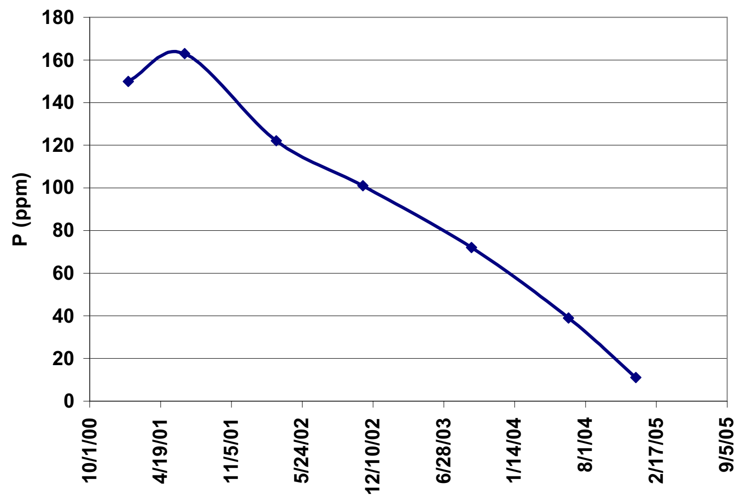
The greens at Talega exhibited classical symptoms of phosphorus deficiency when observed on May 3, 2005. This was the first year that dramatic phosphorus deficiency was observed even though soil tests revealed low phosphorus in 2004 – in the range of about 40 ppm. Severe deficiency symptoms did not show up until soil phosphorus levels dropped below 20 ppm. Although rapid blight was previously diagnosed from Talega, it was not observed in the symptomatic plants. The general and widespread distribution of the discolored plants also did not match the typical distribution of rapid blight. However, to be cautious, an application of Insignia (0.9 oz/1000 sq ft) was evaluated along with application of phosphorus as mono ammonium phosphate (MAP 11-48-0). The areas treated with Insignia alone remained discolored and did not recover. Only the areas treated with MAP began to recover dramatically. The strategy was to apply as little phosphorus as possible to maintain the low phosphorus poa-suppression strategy while providing sufficient phosphorus to maintain the bentgrass in a reasonably healthy condition.

To carry out the test, plywood boards 2'x3' were placed on the practice green, green 12 and green 14 prior to application of Insignia (0.9 oz/1000 sq ft) or application of 1/2 lb P2O5/1000 sq ft using monoammonium phosphate (11-48-0). The boards act as a non-treated check area for each treatment – Insignia alone or MAP alone. A second application of MAP was applied about 14 days after the first application (First application of MAP 4/12 and second on 4/26).

Results and Discussion

Figure 1 illustrates the trend in soil phosphorus levels based upon the historical soil testing that was available. Note the steady decrease in soil phosphorus that reflects the low phosphorus strategy used to suppress poa. Some turf stress was observed in 2004 when soil phosphorus levels dropped below 50 ppm. The stress was observed as a light purple color in cold weather on some greens and lower than expected response to nitrogen fertilization. More severe deficiency was not clearly identified until levels dropped below 20 ppm in 2005 and most of the greens revealed symptoms of phosphorus deficiency (Photos 3 and 4).

Figure 1. Trend in soil phosphorus levels at Talega Golf Club.



Photos 1 and 3 illustrates the appearance of the greens prior to treatment with either Insignia or MAP. Photo 5 illustrates the appearance of greens following MAP applications and the non-treated rectangle where no MAP was applied. The Insignia application had no effect on the performance of the turf – only the areas treated with MAP regained normal growth.

There was no significant difference in the phosphorus values in the MAP treated and non-treated samples when the Mehlich III extraction or Bray II extraction was used for analysis. However, use of the Olsen method of phosphorus analysis indicates that there is a significant difference between the treated and non-treated areas (Figure 3). The Olsen test is an old test that was developed for phosphorus analysis in high pH soils. The expected increase in soil phosphorus was about 5 ppm in the top 3 inches. The Olsen P test indicates that the average increase in soil P was about 2 ppm. This is a small but significant increase was enough to improve turf performance.

The correlation between the Olsen P and easily extractable Mehlich III phosphorus test is strong ($r^2 = 0.71$, $p<0.001$). Because the Olsen P test is more expensive than the Mehlich III test and most of the major laboratories use the Mehlich III extraction, a conversion has been used to provide an idea of what Mehlich III value would correlate to the minimum desired value on the olsen test of 4.5 ppm. The conversion equation is:

Easily extractable Mehlich III P = 19 + 4.5 x Olsen P

The minimum easily extractable Mehlich III P soil test for adequate growth of bentgrass at Talega is 21 ppm. This value is consistent with the observation that turf performance was reduced in 2004 when soil phosphorus levels dropped below 40 ppm with severe phosphorus deficiency at 11 ppm by the Mehlich III soil test. However, with the knowledge that the Olsen test is more representative of plant responses, it is recommended that soil P levels be evaluated using the Olsen test if the low P strategy is used in the future.

There were no significant differences in soil nitrate or ammonium nitrogen levels in treated and non-treated areas. There was, however a significant difference in the nitrate:ammonium ratio with a NO_3:NH_4 ratio of 1.2 in the non-treated plots and a NO_3:NH_4 ratio of 0.6 in the treated plots ($p<0.05$) reflecting the ammonium added by the MAP. The alleviation of typical phosphorus symptoms points toward an increase in plant phosphorus levels rather than a nitrogen response. Tissue chemical analysis were not conducted.

The unfortunate reality of applying phosphorus to the surface of the green is that the highest concentration of phosphorus will occur near the surface of the green and not deep in the soil profile. Once the sub-soil has been depleted of phosphorus as happened in 2005, it may not be possible to maintain a poa suppressive environment at the surface where poa invades. This factor may contribute to the invasion of bentgrass greens that is typically observed after 5 – 7 years.

Figure 2. Easily extractable phosphorus (Mehlich III) for the treated, non-treated and poa infested collars. Note that the treated areas do not report significantly more phosphorus compared to the non-treated areas. The poa infested collars report significantly more phosphorus compared to either the MAP treated or non-treated areas. Collar represents the average of the samples from the poa infested collars of green 12 and 14. The vertical bar represents the standard error of the mean. Non refers to the average of the non-treated samples and treated refers to the MAP treated soils.

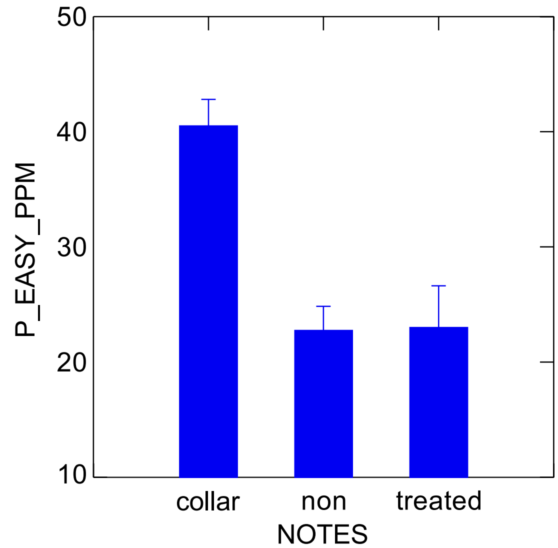
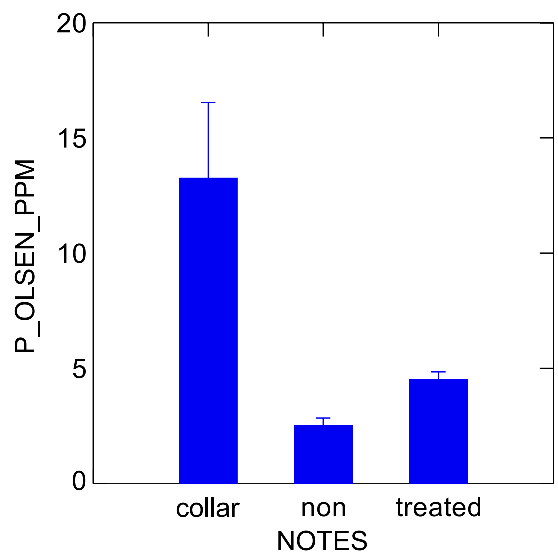


Figure 3. Olsen phosphorus for the treated, non-treated and poa infested collars. Olsen phosphorus test are frequently used for high pH soils. The Olsen P test correlates well with Mehlich III P but only the Olsen P test picked up the small but significant difference between the treated and non-treated areas when the Mehlich III test could not resolve the small difference.



Photos 1 (left) and 2 (right). Symptoms before treatment.
The entire green was discolored prior to application of MAP (photo 1 left). Notice the poa invasion in the collars (photo 2 right).

Photos 3 (left) and 4 (right). Practice green illustrating phosphorus deficiency.
The purple color of the practice green is characteristic of phosphorus deficiency. The close-up on the right illustrates the deposition of purple colored anthocyanins in the bottom of the leaves.

Photos 5. Comparison between treated and non-treated (rectangle) area.

Non-treated rectangular area where MAP was not applied. The surrounding area was treated two times using ½ lbs P_2O_5/1000 sq ft.

Statistical analyses

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The following results are for:
   NOTES$       = treated

                    P_EASY_PPM
  N of cases                 4
  Minimum             15.00000
  Maximum             29.00000
  Mean                23.00000
  Standard Dev         6.05530



The following results are for:
   NOTES$       = non

                    P_EASY_PPM
  N of cases                 4
  Minimum             19.00000
  Maximum             27.00000
  Mean                22.75000
  Standard Dev         3.50000



The following results are for:
   NOTES$       = collar

                    P_EASY_PPM
  N of cases                 4
  Minimum             35.00000
  Maximum             44.00000
  Mean                40.50000
  Standard Dev         3.87298

Durbin-Watson D Statistic        2.05313
First Order Autocorrelation     -0.08670
COL/
ROW NOTES$
  1  collar
  2  non
  3  treated
Using least squares means.
Post Hoc test of P_EASY_PPM
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Using model MSE of 21.306 with 9 df.

Matrix of pairwise mean differences:
                        1           2           3
             1        0.00000
             2      -17.75000     0.00000
             3      -17.50000     0.25000     0.00000


Fisher's Least-Significant-Difference Test.

Matrix of pairwise comparison probabilities:
                        1           2           3
             1        1.00000
             2        0.00041     1.00000
             3        0.00046     0.94062     1.00000
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The following results are for:
   NOTES$       = non
Data for the following results were selected according to:
      (AREAGTF$<> "c")

                        NO3NH4
  N of cases                 4
  Minimum              0.91304
  Maximum              1.41304
  Mean                 1.19896
  Standard Dev         0.24812



The following results are for:
   NOTES$       = treated
Data for the following results were selected according to:
      (AREAGTF$<> "c")

                        NO3NH4
  N of cases                 4
  Minimum              0.31818
  Maximum              1.12821
  Mean                 0.62826
  Standard Dev         0.38476
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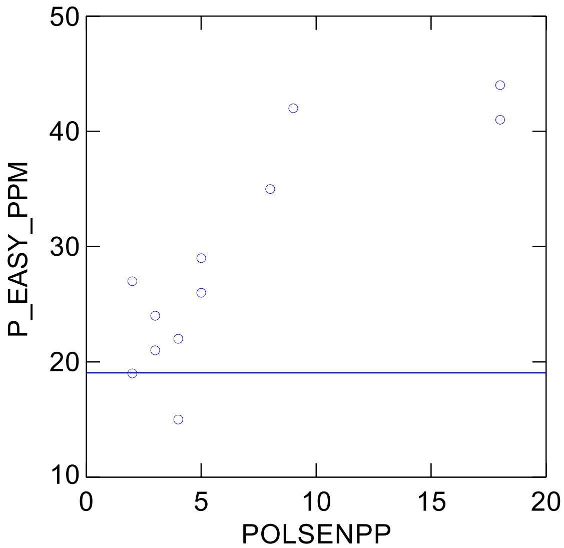

Mehlich III = 1.4 x Olsen P + 19.0

Dep Var: P_EASY_PPM   N: 12   Multiple R: 0.84708   Squared multiple R: 0.71754

Adjusted squared multiple R: 0.68929   Standard error of estimate: 5.36825

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	19.04658	2.47144	0.00000	.	7.70669	0.00002
POLSENPP	1.43754	0.28522	0.84708	1.00000	5.04015	0.00051

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	732.06934	1	732.06934	25.40314	0.00051
Residual	288.18066	10	28.81807		

Durbin-Watson D Statistic 1.59283
First Order Autocorrelation 0.15736

Data for the following results were selected according to:
(AREAGTF$<> "c")

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
NOTES$ (2 levels)
non, treated

Dep Var: P_OLSEN_PPM   N: 8   Multiple R: 0.89443   Squared multiple R: 0.80000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOTES$	8.00000	1	8.00000	24.00000	0.00271
Error	2.00000	6	0.33333		
