SOIL FACTORS AFFECTING ARSENIC TOXICITY ON *POA ANNUA*

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Poa annua (annual bluegrass) is one of the most serious weeds on golf courses today. It will persist and thrive under close cut, irrigation, high maintenance conditions and forms a very satisfactory turf. However, under stress conditions (cold, heat, drought) annual bluegrass is apt to be severely thinned.

Much research has been directed toward developing a selective postemergence herbicide for *Poa annua*. While some herbicides have shown promise none are as widely used as calcium arsenate. Even though arsenic has widespread use it has exhibited varying degrees of control . Certainly, its success has not been as great as most of the herbicides that superintendents normally use. For example, one expects and receives a very high degree of selective postemergence control of plantains and dandelions in a turf with 2,4-D. Many superintendents have probably wondered why arsenates are not more successful especially since they have been used for so long for *Poa annua*.

There are many reasons why *Poa annua* is so difficult to control under golf course conditions. One of the problems is that a superintendent generally does not wish to eradicate all of the *Poa annua* at one time. Instead, a gradual removal while overseeding with more desirable species is usually practiced. To accomplish this, the superintendent must obtain a delicate balance between enough arsenic for control and excessive amounts. Insufficient rates of arsenic results in little or no control while surplus arsenic may result in too rapid removal of *Poa annua* or even kill off preferred species.

Another problem is that you are attempting to selectively remove one grass species from another similar grass species. This requires a relatively narrow range for arsenic toxicity levels within the soil since the safety margin between kill of *Poa annua* and desired turfgrasses is often small. Such a narrow range is difficult to achieve due to the many soil factors influencing arsenic. Important soil factors are discussed below.

Phosphorus and arsenic are chemically similar and tend to react similarly in soils. An important difference is that arsenic is toxic to plants while phosphorus is not. These two elements will counteract each other unless a balance is achieved between them (2,3,a) (table 1). The appropriate balance will vary widely depending upon the unique soil conditions present. In greenhouse work we have found that on soils high in phosphorus, ratios of 0.5:1 to 2.0:1 of Bray P_1 extractable arsenic:phosphorus will result in gradual control of *Poa annua*. On soils where the phosphorus level is low, wider ratios are

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a) Carrow, R.N. and P.E. Rieke. Unpublished data.

b) Small, H.G. and C. B. McCants. Determination of Arsenic in Flue-Cured Tobacco and Soils. Soil Sci. Soc. Am. Proc. 25:346-348. 1961.

necessary. One important consideration when having a soil analyzed for the As:p ratio is that most phosphorus soil tests do not differentiate between arsenic and phosphorus. On soils high in phosphorus the influence of arsenic is less than on low phosphorus soils. Phosphorus does not influence the arsenic soil test due to selective distillation and collection of the arsenic in our procedure (b) (table 1).

Increasing phosphorus will reduce the effectiveness of arsenic (2,3,a) (table 1). Many golf courses have high phosphorus levels due to the frequent use of complete fertilizers (3,a) (table 2). This necessitates the use of higher arsenic levels to achieve control.

Soil reaction may affect the degree of arsenic toxicity (2) (table 3). Under acidic conditions iron and aluminum oxides are present. These may tie up the arsenate into relatively insoluble compounds and reduce its effectiveness (5). At a soil reaction of 7.0 or above various calcium arsenate compounds can form which range from intermediate solubilities to insoluble. Also the presence of free $CaCO_3$ or lime may cause the precipitation of arsenate into insoluble forms. Initial studies indicate that the influence of soil reaction on the form of arsenic in the soil may account for some of the variability in amount of arsenic required to reach comparable control on soils similar except for pH.

Available arsenic is the arsenic present in the soil which is available to the plant as measured by an appropriate extractant. This may range from a small percentage of the total arsenic in the soil to most of the total. In the greenhouse using Bray P_1 extractant on a soil low in phosphorus, 50-80 ppm arsenic gave sufficient control of *Poa annua* (a). The actual amount required on a site will depend on the soil and environmental conditions at the site.

Moisture level can influence arsenic toxicity. Waterlogged or anaerobic conditions in localized areas on fairways, for example, may cause arsenic to be in the more toxic arsenite form. The reduction of arsenate to arsenite is known to occur biologically (1). Moisture level in the soil may also have an indirect effect by influencing the physiological state of the turf and therefore its susceptibility to arsenic toxicity.

Soil texture influences arsenic toxicity. Finer textured soils (clays) tend to have more iron and aluminum oxides. Thus, heavier soils can tie up arsenic and reduce its toxicity (2,5). Sandy soils generally have more of their total arsenic in available form and as a result may require less arsenic to achieve adequate control.

Organic matter content in the soil may play a role in arsenic chemistry. This has not been closely investigated. Jacobs et al (5) state that organic matter contributes little to arsenic retention in soils but the data in this area is conflicting.

In addition to the above soil factors, other components which influence the degree of success of any arsenic program are:

1) Arsenic application rate - this depends upon the degree of control desired and the soil conditions present.

2) Time of application of arsenic - Early fall and spring applications are considered best.

3) percent of *Poa annua* present - If the percentage is low, complete removal at one time may be desired, but with high percentages gradual removal is preferred. It is possible that different strains of *Poa annua* respond to arsenic differently.

4) Maintenance practices - Under conditions which favor *Poa annua*, such as excessive irrigation, higher rates of arsenic may be required for any given degree of control. Also using additional phosphorus will require use of more arsenic. However, in compacted areas where *Poa annua* is also favored, it is possible that less arsenic may be required due to the reduced physiological health of the turf.

5) Environmental stresses - Any environmental stress which reduces the physiological health of *Poa annua* may result in an apparent increase in arsenic toxicity. This could cause more rapid control of *Poa annua* and leave bare areas. It could also decrease the tolerance of more desirable grasses to arsenic. Especially important are high temperature and excessive moisture.

For many years most of the soil factors discussed above have been known to influence arsenic toxicity. However, the relative importance of each factor is not well understood. Also the importance of interactions between factors has not been adequately investigated. Quantative data is needed in order to make specific recommendations as to the amount of arsenic needed to achieve a desired level of *Poa annua* control under the unique conditions of each site and soil. In the past the lack of such data has caused much guessing at the amount of arsenic required. This has resulted in a wide range of success even though similar programs may have been followed by different superintendents.

Several people are now active in investigating soil arsenic and the factors influencing it. Our work has been concentrated on the interactions between arsenic, phosphorus, soil reaction and soil texture. The hope is that such investigations will allow us to develop a scientifically sound arsenic soil test and recommendations for arsenic use.

Table 1. Influence of arsenic rate, phosphorus rate, and As:P ratio on <u>Poa annua</u> control and Bray P_1 extractable arsenic and phosphorus.

Lbs CaAs Applied per 1000 ft^2	Lbs P_2O_5 Applied per 1000 ft^2	ppm-As in Soil	ppm-P in Soil	As:P in Soil	Clipping Weight gms/pot
0	0	2.4	5.6	0.4:1	0.63
5	0	45.0	12.0	3.8:1	0.46
10	0	84.8	20.0	4.2:1	0.28
20	0	195.2	25.6	7.6:1	0.02
40	0	390.4	39.2	10.0:1	0.00
0	4.6	1.6	64.8	0.0:1	1.77
5	4.6	41.6	54.4	0.8:1	1.48
10	4.6	85.6	60.0	1.4:1	1.14
20	4.6	219.2	80.0	2.7:1	0.54
40	4.6	407.2	112.0	3.6:1	0.08

Table 2. Arsenic level and phosphorus level on golf courses in Michigan which have received arsenate. Bray P_1 extractant was used.

Greens:

Arsenic Soil Test Results	38 -112	73
Phosphorus Soil Test Results*	100 -212	145

Fairways:

Arsenic Soil Test Results	3.0- 64	26
Phosphorus Soil Test Results*	22 -204	93

*Values may reflect positive arsenic interference.

Table 3. Influence of soil pH on arsenic toxicity and arsenic soil test.

Applied per 1000 ft^2	Soil pH	ppm-As in Soil	Clipping Weight gms/pot
0	5.30	0.0	0.177
5	5.30	3.8	0.097
10	5.30	9.9	0.008
20	5.30	26.5	0.001
0	7.15	0.2	0.162
5	7.15	3.7	0.127
10	7.15	8.2	0.125
20	7.15	16.6	0.119

References

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