HOW MUCH ARSENIC FOR CONTROL?

Soil factors influencing arsenic soil tests and growth of selected turfgrasses. *R.N. Carrow. 1972. Michigan State University Doctor of Philosophy Thesis. pp. 1-223 (from the Department of Crop and Soil Sciences, Michigan State University, East Lansing, Mich. 48823).*

The objective of this investigation was to study the influence of the soil's physical and chemical conditions on the arsenic toxicity of turfgrasses. Extensive laboratory studies showed the Bray P_1 arsenic extraction procedure to be the most reliable indicator of available arsenic levels in the soil. A number of golf courses in Michigan were then sampled and determinations of the arsenic levels made to assess the most appropriate levels to utilize in subsequent greenhouse and growth chamber studies.

The experimental procedure used included incorporating the arsenic throughout the soil mix prior to seeding. The soil mix containing arsenic was then placed into a replicated series of pots followed by seeding to either annual bluegrass (*Poa annua*), Penncross creeping bentgrass or Merion Kentucky bluegrass.

The results showed that the arsenic had no effect on seed germination of annual bluegrass, Penncross creeping bentgrass and Merion Kentucky bluegrass when the arsenic was mixed with the soil and incubated prior to establishment. The incubation involved placing the soil-arsenic mix in a polyethylene bag for a period of seven weeks with weekly wetting and drying cycles. However, some decrease in seed germination of Penncross creeping bentgrass occurred at medium high rates when the arsenic-soil mix was seeded immediately rather than incubating the mix for a seven week period. The Bray P_1 arsenic extraction procedure revealed that the available arsenic levels were reduced during incubation.

Experiments concerning arsenic effects on shoot growth revealed that arsenic inhibited the growth of all grasses. The degree of reduction, from highest to lowest, ranked in this order: annual bluegrass, creeping bentgrass and Merion Kentucky bluegrass. Merion Kentucky bluegrass was consistently more tolerant of soil arsenic levels than was the Penncross.

Investigations of the phosphorous-arsenic interrelationships showed that high phosphorous levels tended to reduce the arsenic toxicity. However, the magnitude of influence was not great. Also, the arsenic toxicity to annual bluegrass was less effected by increasing phosphorous levels than for such species as Penncross creeping bentgrass and Merion Kentucky bluegrass.

Investigations of the soil reaction-arsenic toxicity interrelationships indicated a marked influence on turfgrass growth and arsenic toxicity achieved on annual bluegrass increased as the soil pH was decreased from 7.8 to 4.3. The amount of Bray P_1 extractable arsenic also increased as the soil pH was lowered. The greatest increase in arsenic toxicity occurred between the pH's of 6.0 and 4.5. The magnitude of the soil pH influence on arsenic toxicity was much greater than the phosphorous-arsenic interaction.

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Evaluation of arsenic toxicity over a range of soil textures revealed that arsenic activity decreased as the clay content increased. This response was also correlated with higher levels of extractable aluminum which may also have an effect. Finally, the extractable arsenic levels were generally highest in soils maintained at field capacity compared to the same soils maintained at levels of 70 to 85 per cent of capacity.

Comments: The first decision on golf courses where annual bluegrass is or has a potential for becoming a significant component of the golf course fairways is (a) whether cultural practices should be adjusted to maintain it or (b) to control it through adjustments in cultural practices and/or the use of chemical control procedures. The procedure to follow depends on the environmental and soil conditions in a given locality. There are a number of locations throughout North America where the best approach is to manipulate the annual bluegrass population in turfgrass communities strictly by cultural practices. There are other situations where chemical control procedures should be seriously considered. The above paper addresses itself to the latter situation and even more specifically to the considerations involved in the use of calcium arsenate (Ca_3 $As04)_2$).

A review of the history of calcium arsenate use reveals specific situations where excellent control of annual bluegrass has been achieved with no visual effects to the desirable species, particularly Kentucky bluegrasses. In contrast, there are also locations where serious problems have occurred in terms of phytotoxicity to the desirable species. The work reported in this paper assists in explaining some of the variability.

Calcium arsenate can be used very effectively in the control of annual bluegrass as indicated in the above paper. Annual bluegrass is much more sensitive to phytotoxic arsenic levels than are either the bentgrasses or Kentucky bluegrasses. The investigation also shows that arsenic has a

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minimal effect on the seed. Phytotoxicity develops after the seed has germinated and a sufficient quantity of roots is produced so that the arsenic is absorbed and translocated to the sites of phytotoxic action causing a relatively slow physiological death.

The basic problem with this herbicide and most others that are being considered for use in the control of annual bluegrass in fairways is avoiding phytotoxicity to the desirable species, such as Kentucky bluegrass and creeping bentgrass. The following considerations can be emphasized based on Carrow's word and supported by numerous field observations.

First, the Kentucky bluegrasses are much less sensitive to arsenic toxicity than the creeping bentgrasses. Field observations indicate that a majority of the successful fairway conversions from annual bluegrass to desirable species has involved Kentucky bluegrass. Unfortunately the margin of safety between the level of arsenic required for the control of annual bluegrass and the level of arsenic that results in phytotoxicity to creeping bentgrass is much less than for Kentucky bluegrass. As a result, greater difficulty may be faced in terms of potential arsenic phytotoxicity where the fairway conversion involves creeping bentgrass.

From the standpoint of soil chemistry, Carrow's work stresses that the soil reaction is far more important in influencing arsenic toxicity than the soil phosphorous level. Increased phosphorous levels, particularly in the higher range, will result in a higher level of arsenic required to achieve annual bluegrass control. However, the effect of soil pH, particularly as it is decreased from 6.5 to 4.5, greatly increases the arsenic availability and thus results in a substantially reduced rate of arsenic required to achieve annual bluegrass control. This explains why the rate of arsenic that has been used safely in the Midwest on less acidic soils is more toxic to the desirable species if it is used on the East Coast where the soils are more acidic in reaction.

From a soil physical standpoint, clay soils tend to reduce arsenic toxicity. Thus, higher levels of arsenic will be required to achieve control on soils having a high clay content. However, soils high in clay frequently have a soil drainage problem. The work of Carrow indicates that soils near field capacity will have an increased level of arsenic available for absorption by the plant. Here again this confirms field observations. Poorly drained depressional areas and wet soil conditions have resulted in serious arsenic toxicity to both the Kentucky bluegrass and creeping bentgrass species. It has been suggested, but not well documented, that surface water movement may carry arsenic particles into the lower areas resulting in increased arsenic levels in those sites and an inability to establish Kentucky bluegrass species. Carrow's work also suggests that the actual water level may affect the quantity of available arsenic.

It is obvious from this discussion that there are a number of soil

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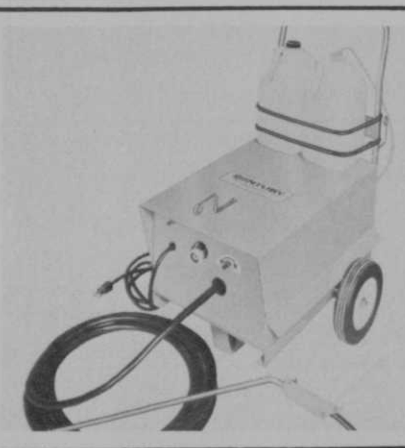
CORRECTION

On page 77 of the October/November, 1972, issue the wrong picture was inadvertently shown with the write up on Century Engineering Corp.'s new high-low pressure water (model HPW-3D). The correct picture is shown at right.



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chemical and physical properties that influence arsenic availability and control of annual bluegrass. As a result, no techniques have been developed whereby an accurate recommendation can be given about the quantity of arsenic required to obtain annual bluegrass control without detrimental effects to the desirable turfgrass species. The general procedure has been to slowly increase the soil arsenic level until annual bluegrass control is observed. When following this procedure, it should be remembered that the quantity of arsenic required to control annual bluegrass will be lower during the midsummer stress period than the spring or fall when growth conditions are more favorable. Thus, the turf should be allowed to pass through at least one summer stress period between each arsenic application in order to assess the amount of effective phytotoxicity present in the soil.

Because of the uncertainties associated with the use of arsenics for the control of annual bluegrass, there is one further consideration that should be stressed. This program should not be initiated until it has been tried on a small plot on one or more selected fairway locations that are representative of the conditions existing on the golf course. A 50 to 100 foot width across the fairway would serve this purpose nicely. The limited trial program should be initiated (a) to give the golf course superintendent the opportunity of learning how to properly use the material and (b) to obtain information concerning the quantity of arsenic that will be required to achieve effective control of annual bluegrass without injury to the desirable species. Conversely, the tests may indicate that the soil moisture and drainage conditions are such that arsenics cannot be utilized effectively without damage to the desirable turfgrass species. Thus, on-site experimentation concerning the use of this material should always be practiced before any decision is made to proceed with a long-term program on the golf course. □