LARGE SCALE WEED CONTROL WITH ARSENIC ACID

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For some years the weed problem on our golf course had become more and more serious. It finally reached the stage where members were talking about establishing a weeding fund and employing an army of boys or unemployed men to hand-weed all the fairways. About that time we heard of the Green Section's experiments with arsenicals and we were so intensely interested in the possibilities which these chemicals offered that we asked the Green Section if we might be allowed to join in the practical tests which it was making in various parts of the United States. In April, 1936, the material and instructions for conducting the tests were received.

The test plots were laid out as directed on a representative area of fairway which contained a fair stand of Chewings fescue, Kentucky bluegrass, *Poa annua,* and a small amount of bent. There was a high percentage of weeds in the plots—mostly knotweed and dandelion, with a fair sprinkling of clover, plantain, and chickweed. The soil on our course is a very poor fine sand. The sodium arsenite was applied in solution on some plots and dry on others. The wet applications were made at the rate of 1 ounce to 1,000 square feet on some plots and 4 ounces on others. For the dry applications the chemical was mixed with sand and was spread at the rate of 4 ounces of sodium arsenite to 1,000 square feet on some plots and 12 ounces on other plots.

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Five applications were made at intervals of 2 to 4 weeks. Our conclusions were that the rates of application were too light for the type of soil we had but we could see considerable promise from the use of heavier applications. In order to test our theory, we laid out an area of some 30,000 square feet on one of our most heavily weed-infested fairways and treated it with a spray of 12 ounces of sodium arsenite to 1,000 square feet on September 3, 1936. There was much bent turf in this particular area which, although badly discolored by the treatment, was not killed. However, the one application of sodium arsenite at the 12-ounce rate resulted in practically 100 per cent kill of knotweed and about 50 per cent of dandelions and plantains. The area was seeded and fertilized and by the following spring was in splendid condition, with only a few scattered weeds visible.

Preliminary Treatments

Encouraged by this success, we decided in the spring of 1937 to treat large areas of fairways. We purchased a power sprayer having a tank of 240 gallons capacity and a 20-foot boom. The boom has 14 spray nozzles mounted 18 inches apart, center to center, and the orifices in the nozzles are 1/32-inch in diameter. The boom can be adjusted for height but we have found that best results are secured when the nozzles are 18 inches above the ground. The sprayer is lined with corrosion-resisting metal and is thoroughly washed out at the end of each day during which it is in use. We discovered that it was highly desirable to apply the solution as a fine mist. It was found that 150 pounds pressure in the sprayer gave the best results. Unfortunately, our sprayer has no motor on it and we therefore have been forced to use a tractor motor to operate the pump.

Spraying fairways on Toronto Golf Course. It was necessary to use an extra tractor to operate the pump, as there was no motor on the sprayer.

This necessitates the use of two tractors—one to pull the sprayer and one to operate the pump. This is an unsatisfactory arrangement, as it requires an extra man to operate the equipment. If we were doing it over again we would buy a sprayer with a built-in motor.

We were advised by the Green Section that arsenic acid was just as effective as sodium arsenite and might be purchased a little cheaper, so we endeavored to purchase a supply of it. To our surprise, we found that it was not available locally, but after shopping about we discovered that we could import arsenic pentoxide (As_2O_5) from Europe at a cost of 10 cents a pound, laid down in Toronto. This material, which comes as a white powder, is soluble in water and reacts with the water to form ortho-arsenic acid ($H_3AsO_4.\frac{1}{2}H_2O$). The arsenic

Sprayer showing 20-foot boom with 14 spray nozzles in action.

pentoxide is 84 per cent pure and therefore contains 54.77 per cent arsenic. Thirteen ounces of this material contains the equivalent in arsenic of 1 pound of the sodium arsenite we had been using. In order to figure our rates of application in terms of sodium arsenite, we made up a standard solution of 13 ounces of arsenic pentoxide in a pint of water and used this solution at the same rates as we would have used a solution of a pound of sodium arsenite to a pint of water. All rates given below are in sodium arsenite equivalents. Our standard solution was made up in batches of 30 gallons at a time by dissolving 195 pounds of arsenic pentoxide in 30 gallons of water and allowing it to stand for 24 hours. We used an oak barrel as a container and found that the solution ate right through it in one season. In loading the sprayer we used 17 pints of standard solution and added 230 gallons of water.

For our first test of large-scale operations, which commenced on May 11, 1937, we chose a fairway which contained about 80 per cent dandelions, plantain, and knotweed, and 20 per cent Kentucky bluegrass and *Poa annua*. Due to a mistake in our calculations in preparing the first batch of standard solution, we applied 12 ounces to 1,000 square feet, and needless to say the grasses were very badly discolored. However, we were agreeably surprised to find that practically no grass had been killed and in a few weeks' time it had completely regained its normal color. The Kentucky bluegrass actually seemed to have been stimulated by the treatment. Fully 75 per cent of the weeds were killed by the one application at this heavy rate and the fairway was left quite bare and muddy. No seeding was done but the area was well fertilized and kept thoroughly spiked and watered. By autumn of that year there was a good stand of Kentucky bluegrass and *Poa annua* and the weeds were few and far between.

That same spring we treated three other fairways but reduced our rate of application to 2 ounces to 1,000 square feet. Two of these fairways were treated once and the third fairway was treated twice with an interval of about 10 days between treatments. While the results on the fairways receiving only one treatment appeared to be good at the time, it was soon evident that practically all the weeds had recovered and there was no real benefit from the treatment. Good results were obtained, however, on the fairway which received two applications. With the lower rate of arsenic, there was no discoloration of the grasses.

As a result of our work up to that time, we felt confident that we were on the right track and that we could go ahead and attack our weed problem in a wholesale manner. We

decided to increase our rates of application in order to secure more effective control, and in the fall of 1937 we treated eight fairways. The first fall application was made at the rate of 4 ounces to 1,000 square feet, about September 20, and produced excellent results, with practically no discoloration of the turf. Knotweed was entirely killed by this application. The second fall application was made about October 14 at the rate of 6 ounces to 1,000 square feet and produced some discoloration of the grasses but not enough to be objectionable. The color was fully regained within 10 days. The weeds, however, including dandelions and plantains, turned completely black within three days after the second application. Chickweed and clover turned white and shriveled and the leaves of all weeds crackled when they were walked on. Within a week or 10 days we found the roots of most of the dandelions and plantains rotting and they eventually dried to a powder so that a pencil could be inserted into the hole where the dandelion tap root had been formerly. The clover, however, recovered to some extent but was somewhat thinner than previously. Some of the dandelions and plantains which were not entirely killed by these treatments were so weakened that they were killed by the frost during the winter.

Treating 12 Fairways

In the spring of 1938 we did a clean-up job on 12 fairways to kill the new seedlings before they gained a foothold. The first application was made about May 15, the second about June 1, and the third application was made on certain fairways on June 20. The rate of application in all these cases was 4 ounces to 1,000 square feet.

In the fall of 1938 we treated 14 fairways. The first application was made about September 14, the second about September 27, and certain localized areas received a third treatment on October 20. All applications were made at the rate of 6 ounces to 1,000 square feet.

Some idea of the area of turf we have treated may be gained from the following table.

AREAS OF FAIRWAYS ON TORONTO GOLF COURSE TREATED WITH ARSENICALS

Hole No.	Length (Yards)	% of Fairway Treated	Hole No.	Length (Yards)	% of Fairway Treated
1	366	25	10	353	100
2	393	100	11	390	100
3	488	100	12	368	100
4	189	None	13	524	100
5	465	None	14	156	None
6	394	90	15	407	100
7	180	100	16	500	90
8	420	100	17	222	75
9	456	100	18	342	None

It is impossible to estimate the percentage of weeds that were killed but undoubtedly the percentage was very high. One of the best evidences of this was in the reaction of the players. During 1937 they complained bitterly about the damage we were doing to the fairways but during the whole of 1938 we did not hear a single complaint. On the contrary, the members were commenting on the lack of weeds this year and could not understand what had happened to them. Visitors to our course also commented on our freedom from weeds and went home and advocated the same treatment at their own courses.

It should be emphasized that our soil is very sandy and the rates which we have used might need to be varied for a different type of soil. It should also be pointed out that fescue and bent are more susceptible to injury than are Kentucky bluegrass and *Poa annua*. One interesting thing we noticed was that the young *Poa annua* seedlings just appearing above the ground were not affected in the slightest degree by the treatments.

Cost of Treatments

For all the treatments made during the years 1937 and 1938 we have used 1,425 pounds of arsenic pentoxide at a total cost of $142.50. Using it at the 4-ounce rate (i.e., the equivalent of 4 ounces of sodium arsenite), the material cost per application is 2.03 cents for 1,000 square feet. At the 6-ounce rate, the cost is 3.05 cents.

Our total labor cost for these treatments for the years 1937 and 1938 was $196.15. Breaking this figure down and figuring the labor cost separately for each application, we find that it varies from a minimum of 3.49 cents to a maximum of 3.52 cents for 1,000 square feet. This is for three men running the equipment. If the sprayer had a motor mounted on it two men would be sufficient and the above figures could be reduced by one-third.

The total cost for labor and material at the 4-ounce rate has been about 5.53 cents for 1,000 square feet an application, or about $2.41 an acre. At the 6-ounce rate, the total cost for labor and material has been about 6.55 cents for 1,000 square feet an application, or about $2.85 an acre.

In our opinion, at least two applications are necessary at intervals of 10 days to two weeks. All the weeds cannot be eradicated in one season but over a period of several years effec-

tive control can be secured. Fall applications appear to be more effective than spring ones, particularly on the older established weeds. The spring application, however, is useful as a clean-up job to kill the small new weed seedlings before they become established.

Factors to be Considered

There should be plenty of moisture in the soil before the applications are made but better results are obtained if no rainfall follows the treatments for at least 48 hours. No mowing or watering should be done for at least 48 hours after treating. Applications made after 4 p. m. seem to be better than those made earlier in the day. We observed that severe burning occurred when treatments were made with the air temperature over 75 degrees.

Great care should be taken to keep the sprayer moving uniformly, and it is necessary to watch that its speed is not reduced on a hillside. To prevent severe burn due to the application of an excessive amount of the chemical, the nozzles should be shut off the minute the sprayer stops moving. No applications should be made on a windy day, as the spray will drift and cause streaking.

Physicians advise us that the men operating the equipment should wear gauze masks covering their mouths and noses and that they should wash their hands thoroughly after each application to avoid any possibility of arsenic poisoning.

Needless to say, we are very enthusiastic about large-scale weed control with arsenic acid and we intend to continue treatments spring and fall for another year or so, by which time we hope to have completely conquered our weed problem.