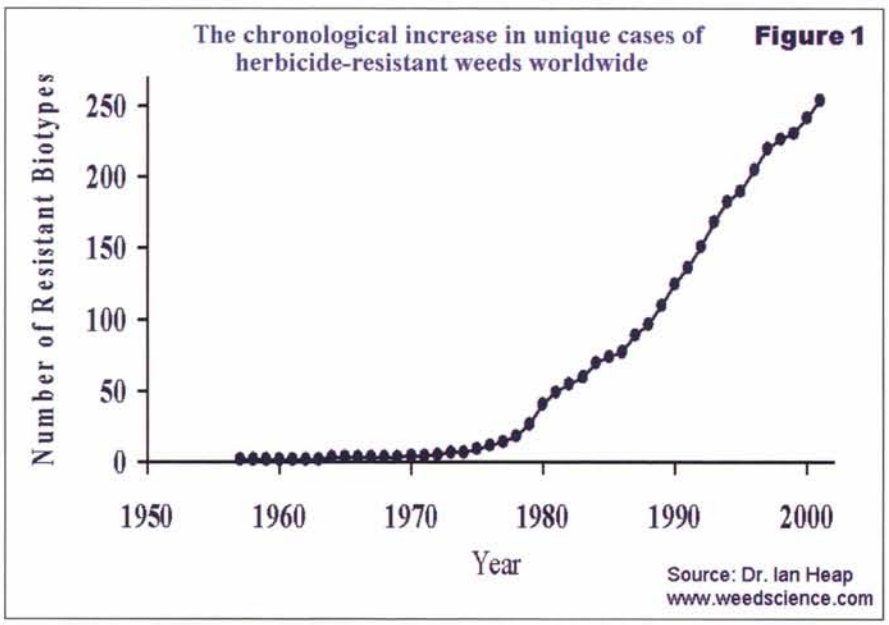
Lee Miller *Chicago District Golf Association*

Herbicide Resistance Issues –

Not a Common Weed to Hoe

Other than being a beautiful photo of New South Wales, this picture shows a population of glyphosate-resistant rigid ryegrass in a wheat field. The site had been exposed to 10 to 15 years of glyphosate use, with multiple applications each year.

As pesticide resistance goes, fungicide resistance has had the most impact and claimed the most notoriety thus far, mainly because we apply more and spend more on fungicides than insecticides and herbicides put together. With the advent of new and exciting technologies for selective Poa annua *and other weed control, the times may be a-changing. We should take heed of what we have learned about using chemicals to control other organisms, and pay attention to what has been taking place in the nation's farmland.*



Herbicide resistance is nothing new, but has not gained nearly the attention that fungicide and insecticide resistance have received. The first report of herbicide resistance occurred in 1968 with the discovery of common groundsel resistant to the triazine herbicides. To date, that number has increased exponentially (see Figure 1). Two main reasons for this increase are that more herbicides are being used now, and these herbicides are more selective in their mode of action on the target weed. This makes them much less toxic, but also makes it easier for a plant population to overcome their activity because a plant only needs a single gene mutation to confer resistance (more on that later).

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There are now 276 resistant biotypes of 166 different species (99 dicots and 67 monocots) of resistant weeds that have been identified. Turfgrass managers may not be familiar with herbicide resistance because most of these cases have occurred in agricultural crops. In Illinois, the documented herbicide-resistant weeds have all been agricultural (for example, lambsquarters, ragweed, pigweed and waterhemp), and have been mainly resistant to the herbicides in the triazine or ALS inhibitor families.

Well, what about herbicide resistance found in the turf realm, then? Here are some of the notable examples, most of which have occurred in the southeastern U.S. and have only been found very recently.

North Carolina, South Carolina, Georgia, Tennessee, Alabama, Mississippi, Florida: Goosegrass resistant to the dinitroanilines and dithiopyr (Treflan, Pendulum, Dimension).

New Jersey, Virginia: Smooth crabgrass resistant to fenoxaprop (Acclaim).

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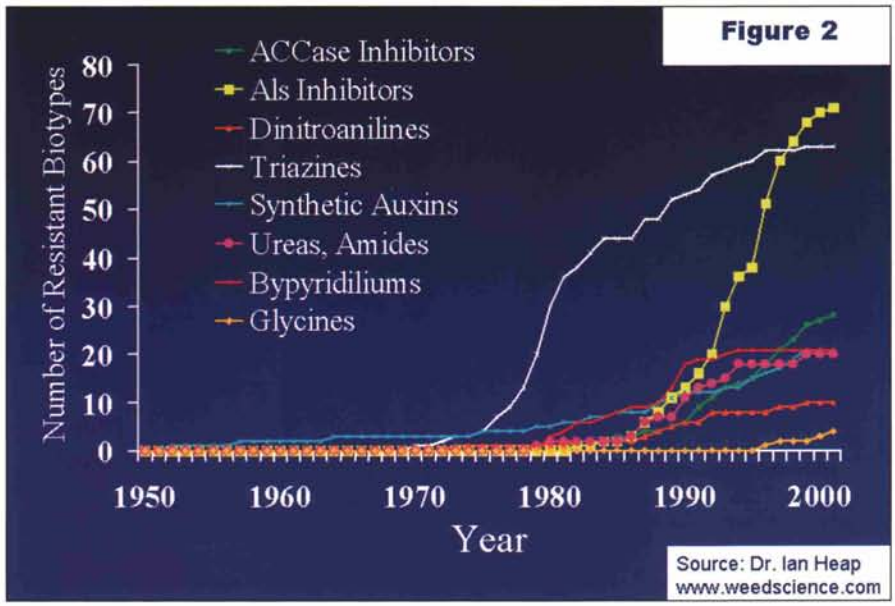

California: Smooth crabgrass resistant to quinclorac (Drive).

California, Texas, Arkansas: Perennial ryegrass resistant to fenoxaprop and selfometuron (Acclaim, Oust).

Oregon, North Carolina, Alabama, Mississippi, Virginia: *Poa annua* resistant to triazines, ethofumasate, pendimethalin and diuron (Atrazine, Prograss, Pendulum, Karmex).

Notice the geography of the last one? When you look at it from an ecological sense (and not from a pain in the you-know-what sense), *Poa* is quite incredible in the way it infests all different types of environments by using genetic variation. *Poa* makes huge amounts of seed that can potentially be different genotypes from the parent. These genotypes land where they may and will either die in an environment unsuited to them or establish themselves as a biotype and continue to their next generation. It has been estimated that *Poa* could have hundreds or even thousands of different biotypes, that each might have a different color, texture, growth habit or response to external stimuli like . . . chemicals. Two new chemicals, Velocity and Roundup via Roundup Ready (RR) bentgrasses, are on the horizon as ways to selectively control *Poa* out of bentgrass.

The chemistries of Velocity and Roundup are very different and lend themselves to different risks of resistance development. Velocity is in the class of ALS inhibitors, inhibiting a single enzyme so the target weed can't produce essential amino acids. This class of herbicides is known for its susceptibility to trigger resistance (see Figure 2), presumably because of this single site of action. On the other hand, Roundup, which also acts on a single enzyme in the shikimic acid pathway (although this is under debate), is in the glycine family and has only had four species that have developed resistance to it, after a long time of use. However, these biotypes, most notably of horseweed, have become economically important because they are surviving in fields planted with RR crops.

So what does all this mean for selective control of *Poa* out of bent with Velocity or with RR bentgrasses? "Maybe nothing," say experts Dr. Bruce Branham at the University of Illinois and Dr. Zac Reicher at Purdue University, "because we don't know if there is any natural resistance in *Poa* to these herbicides." After all, herbicide resistance is theorized to work in much the same way as fungicide resistance. The herbicide doesn't cause the weed to mutate, but selects for naturally occurring biotypes that have a higher tolerance to the application. If there isn't naturally occurring resistance out there in the population, then

there is nothing to select for. This may be why, in some instances, an applicator can use the same herbicide for 10 to 15 years with good results and have no indication of a problem. To answer this question, Dr. Reicher at Purdue, with his colleagues in New Jersey and Nebraska, is formulating plans on evaluating a range of susceptibilities of naturally occurring *Poa* to Roundup.

Hopefully nobody has been pulled into a full panic yet, because I must say that Dr. Branham, Dr. Reicher and myself are extremely excited about the prospect of having Velocity and RR bentgrass as tools to control *Poa*. As Dr. Reicher puts it, "Would you have said no to Heritage when it came out because resistance in some populations of grey leaf spot and anthracnose are popping up today?" I yell back, "H-E-double hockey sticks NO!" But we do need to think about using some of the same resistance-delaying techniques that we use for fungicides if and when we get these herbicides.

If using Velocity to eradicate *Poa*, you will need to commit to the action. "Don't spray it once and then leave it to recuperate; you will have started the selection process and wasted an application," says Dr. Branham. "Once you start the path, you must see it through until completion." (Sounds a bit like Yoda, doesn't he?) Dr. Branham also says that the path is probably about three applications to realize the full eradicative effect of the Velocity.

Most important, don't rely on just one of these herbicides for *Poa* or other weed control once initial eradication has been achieved. "Velocity, being in a different herbicide class, would be an excellent choice as a rotational partner with Roundup on RR bentgrass," Dr. Reicher suggests. Prograss or some preemergents could also be part of a plan to limit the number of applications for *Poa* control with either Velocity or Roundup. For broadleaf weed control in RR bentgrass, continued use of phenoxy and other types of herbicides is recommended so a chemical diversity is maintained and Roundup isn't overused.

Two new chemicals, Velocity and Roundup via Roundup Ready (RR) bentgrasses, are on the horizon as ways to selectively control* Poa annua *out of bentgrass . . . [However] we do need to think about using some of the same resistance-delaying techniques that we use for fungicides if and when we get these herbicides.

In conclusion, if you choose to use these new herbicides, use them with a level head. That way we can hopefully extend them to their full potential of having many summers without worrying about the *Poa*.

Much of the recent information about herbicide resistance contained in this article is from ***www.weedscience.org****, a fabulous Web site maintained by Dr. Ian Heap. If you would like more information about herbicide resistance cases, I highly recommend you pay it a visit.*

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Compost Tea: Is It The Brew For You?

A brewer used in the preparation of compost tea.

Have you ever thought about what you would do if the use of pesticides were banned? The future of certain pesticides and their availability for use is uncertain. Since the early 1990s, several pesticides have been banned and others have seen their use limited to a few applications per year. As a consequence, alternative methods for treating diseases have surfaced. Integrated pest management has been born, and new natural pesticides have been developed. New products with beneficial microorganisms and humic acids have been pushed on superintendents like the snake oils of old-time circus town. Can you hear the stout, plaid-clad ringleader, "Step right up here, ladies and gentlemen, what I have for you today will change your life forever. Why, imagine your greens storing carbohydrates like they never have. Superturf Tonic gives the plant the gamut of health benefits. Heat stress, drought stress, color, vigor, seedhead production suppression, my tonic will make the grass cut itself." How do some of these products work, you ask? The answer most often heard is: ". . . by increasing the amount of beneficial soil microbes."

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The Advent of Pesticide Alternatives

One of my first mentors in this business told me not to "over-think your job." We can argue that we should be open to new possibilities and examine new products with excitement and jubilation, which collectively, we do by all means. As the average golf course budget is $40,000 for fungicides every year, a lot of money is at stake. A conservative approach to the use of new products is common, and most superintendents are skeptical of products that claim exceptional results. We can be cautious to an extreme at times, failing to realize the true potential of a product. An understanding of a product's mode of action and the factors affecting its efficacy is necessary when evaluating new products. Who is to say that the use of a given product will not increase the turf quality of their fairways enough to give lasting disease suppression, or increased water-retention capabilities? We have numerous products at our disposal and a lack of any scientific testing on the effectiveness and interactions of these products.

With relatively little university examination, our golf courses have become our own testing ground. This is good and bad—good in that those new products are reaching our door faster than a Cushman driven by a 16-year-old, bad in that the success or demise of the products can literally be in the hands of a

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few cutting-edge superintendents who have the luxury of dollars and test plots in acres larger than some facilities' practice tees.

Certain products claim that they boost the beneficial organisms in the soil. Soil microbes range greatly in diversity and numbers, but they have yet to be classified as a whole. Do we really know which ones are beneficial? We have seen testing with some products that do achieve some beneficial results. Color, density and overall quality have improved with the application of certain biostimulants, but could this be due to a nitrogen carrier?

With pesticides being reduced, are we at risk of exposing ourselves to products that have not been effectively tested and evaluated? Is the risk of exposure to heavy metals any more dangerous than exposure to bacteria, or other microorganisms being touted as safe and beneficial? Pesticides that are labeled as such have passed the federal registration process. The label, with its consumer instructions, is the proof that all products can be used effectively and safely. Every pesticide must successfully complete as many as 120 government-mandated tests before the Environmental Protection Agency considers label approval and product registration. Many of these tests are specific for human health, safety and environmental quality. The entire development and testing process takes eight to ten years at a manufacturer's cost of $35 million to $50 million or more per product. Yet, on average, only one in 20,000 potential products ever makes it to the marketplace.

One of the newest approaches to treating golf course turf is the application of "compost tea" . . . This brew is compost that is purchased and put in a commercial brewer for 12-24 hours.

Compost Tea: One of the Newest Options

One of the newest approaches to treating golf course turf is the application of "compost tea." This technique has been around for some time; however, it is new to the turf industry. Use of compost tea involves the application to turf of a "brew." This brew is compost that is purchased and put in a commercial brewer for 12-24 hours. After the brewing process is complete, the tea is ready to be applied to turf through standard application equipment. This is the short version.

Ready for the long, long version? This process consists of the extraction of water through compost; then that extract is exposed to conditions that allow the bacterial and fungi populations to increase in number and activity. The exposure to carbohydrates, increased temperature and aerification of the tea is referred to as brewing. Once the tea has "brewed" for 20 hours, it is ready for application to the target plant through typical chemical-application techniques.

Compost tea can be further differentiated into manure tea, compost extract and compost leachate. Compost extract is produced by draining water through compost, and contains the right material for brewing an effective batch of tea. Manure tea can be high in salts, root-feeding nematodes and human pathogens, making it an ill-advised choice for brewing. Likewise, compost leachate is produced when water drains from oversaturated compost. This leachate contains very few organisms, and may include phytotoxic compounds.

So to recap, we take a bunch of leaves and spent clippings and run water over this mixture a few times and ta-da, extract, right? Not exactly; the extract has to come from quality compost. Since all of the soluble compounds that are in compost are going to be present in our extract, then our compost must contain only beneficial food sources. One aspect of quality composting involves the temperature reaching 135° Fahrenheit continuously for three entire days throughout the whole pile. This means the material must be turned. The material cannot go anaerobic for any length of time, or else the dreaded phytotoxic compounds may be present. If worm compost is used, the compost must be adequately processed by the worms. Time in the worm bin allows the destruction of all human and most plant pathogens.

What Influences the Quality of Compost Tea?

What does all this mean? It suggests that a huge number of factors are involved in providing the brewer with quality material. It is recommended to ask for data when buying compost. Relevant data that will indicate high-quality compost include the documentation of compost temperature duration and rotation, as well as oxygen concentration of the compost (or the reverse, carbon dioxide concentration) during the composting operation. Also affecting the extract are factors like the size of the screen that allows organisms to pass into the extract; it should be no smaller than 30 to 50 microns.

The brewer itself will also affect the quality of the tea. Some brewers are more efficient than others. Some brewers have more dead areas in the

pipes where conditions for bio-film development are present. The pumps on some brewers may be better at not killing organisms in the transfer of the tea. Bottom line, before you buy: research and ask questions, request data and talk to experienced brewers who have been successful.

Compost tea extract can also be plant-specific. Whoa—plant-specific? Yes, specific soils may require tea that includes more fungal biomass in the fungal-to-bacterial biomass ratio. So far, the researchers have found that teas applied to foliage should always be bacterial in nature. And the fungal-to-bacterial biomass balance is affected by . . . you guessed it, the composition of the compost. The ratios of manure, green material and woody material will determine the composition of the compost. Are we getting carried away yet? Maybe, but for a fundamentally sound reason. For instance, Growing Solutions, Inc. states that Norwegian or North Atlantic cold-water kelp is more beneficial than warm-water kelp. Cold-water kelp absorbs and retains more nutrients during growth, resulting in greater micronutrient benefits. Additives such as kelp can also play an important role in the success of an extract; you want to make sure it is a quality product.

A quality compost extract will contain an enormous diversity of bacteria, fungi, protozoa and nematodes. This diversity and the initial quantities reflect the quality of the compost and the extraction methods used. While bacteria and fungi will increase in numbers during a brewing cycle, protozoa and nematodes do not. Therefore, protozoa and nematode numbers come directly from the compost. Companies are still exploring the composition of different composts and resulting microbe counts.

Let the Brewing Begin

When your head stops spinning, and after scientific investigation and data examination you have made the decision to buy compost and a brewer, your package will arrive and the brewing begins! After your first batch of brewing, you will want to send the final tea into a lab for examination. Based on lab analysis, you can tweak your brewing process to maximize the quality of the tea. Most brewing takes from 12 hours to 24 hours; longer here is not better. Brew too long and the organisms will run out of food and may go to sleep or worse, die. The tea must be kept aerobic; an anaerobic tea or "dead-air" position in the brewer will result in the development of a bio-film. I don't care to get into the phenomena of the world of bio-fouling, but suffice to say, this is bad, very bad. Waters high in salts, heavy metals, nitrate, chlorine, sulfur, tannic acid, carbonates or contaminated with pathogens of any kind should not be used. Test your water and take corrective action accordingly. Temperature, humidity, evaporation and other abiotic conditions influence the growth rate of microorganisms, and yes, the quality of your tea. On a positive note, you may get foam. Foam is a good thing; it means there are free proteins, amino acids or carbohydrates present. Foam can be controlled using organic surfactants, such as yucca or vegetable oil (not olive or canola!). Be sure to

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NEVER USE COMMERCIAL DEFOAMERS. Every single one tested has killed the organisms in the tea.

Don't do this—be cautious with that. Do I sound negative? I hope not. I think the use of compost tea may be a positive approach to and important tool in golf course management. Many users of compost tea say their turf health has improved and the turf's use of nitrogen is more efficient; users also report a decrease in the amount of disease present. Research continues as this young process develops; look for compost tea to gain more favor as our understanding of the interactions and results improves. However, to become a successful standard approach, the use of compost tea will have to work for many individuals. In order for tea to work and provide results, its users will have to take care to understand the extraction and brewing process and factors affecting efficacy, and avoid making brewing and application mistakes that could be interpreted as product failure.

Joining the Tea Party

In San Francisco, California, Presidio Golf Club has not employed any pesticide treatments in one-and-a-half years. According to course superintendent Tom Brooks, they take a "minimalist approach, which is about managing all of the cultural elements on the golf course to produce the best possible turf." Brooks believes that this minimalist approach has been a success. By not using pesticides, the burden of maintenance has been shifted away from a chemical approach to one that favors ecological diversity. Also, while mechanical and cultural methods are labor-intensive, reliance on these still registers a financial savings over intensive pesticide applications. If the long-term environmental and human health factors were to be accounted for as well, the savings would be, according to Brooks, quite a bit higher.

The "big picture" for Brooks is that "golfers look for a golf course with good playing conditions. Those are the conditions that we (superintendents) have to meet or we're not in business." He stresses that his method is not extreme; it merely takes a more logical path towards maintenance in that all conditions and possible actions are factored into the decisions.

The use of compost tea was originally adopted by courses around the country in areas where cosmetic fungicide applications were banned. The resulting turf quality seen at those courses has lead to the birth of a generation of new brewers. In the Chicago area, Maple Meadows, The Arboretum and Palatine Hills are all using a brewer and applying compost tea to playing surfaces. The use of compost tea and its impact on turf quality are interesting and exciting. At this point, though, the complex world of brewing still has more questions than answers. Look for some of the answers to come out of Cornell University soon, where Dr. Frank Rossi is beginning his very own "tea party."