Nematodes–

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The par 3, fourth hole at Waseca- Lakeside after tee to green reconstruction in 1995.

participated in the survey in 2005. The course has two greens that were diseased in 2002, healthy in 2003 and 2004, and diseased again in 2005. Green 8 was also a "problem green" again in 2006. In 2002, 2005 and 2006 several different mycologists examined diseased grass roots collected from those greens. All of them to date have failed to find and identify a pathogenic fungus. In 2002, Superintendent Rasmussen used a cup-cutter to collect three soil samples for nematode analysis from the course's two problem greens. He did that as almost a replay of what had happened at Keller seven years earlier when a pathogenic fungus did not seem to be the cause of that problem. And a very similar but not exact repeat of the Keller nematode story was also obtained as the result of his and our efforts. The results obtained then of at least 800 to more than 1,700 stunt nematodes, 11 to more than 3,100 spiral nematodes (Helicotylenchus spp. having a damage threshold of 600/100 cm-3 soil), and a few ring nematodes suggested as they had at Keller that 1) the greens of Lafayette Club were a very suitable habitat for plant nematodes and 2) that a reduction in the sizes of their populations might be the appropriate course of action to take to improve the growth of the turfgrasses there. But by 2005 it seemed as though fungi had to be considered again. The shift back in focus to fungi seemed necessary because the plant nematode populations by August, 2005, as determined from 10 Hoffer tube composite samples collected at specific locations (rather than randomly), had declined to the fairly unimpressive levels of 23-564 stunt, 0-732 spiral, and 0-47 ring nematodes/100cm-3. By October 24, 2005, the plant nematode population estimates for one location on each of the nine healthier greens were 270 stunt nematodes, 34 spiral, and 24 ring nematodes/100 cm-3. For Greens 7 and 8, which had been wholly or partially treated with a nematicide, stunt nematodes were still present although less abundant than they were in the other nine greens. The roots of the plants from the two problem greens were judged to still be inferior compared to the roots of the plants on all of the other greens. Poor root growth rather than chemical treatment seemed more likely to be responsible for the limited numbers (125 stunt, 63 spiral and 17 ring) of plant nematodes that were present in the two problem greens.

Do results like these leave us at a nematological dead-end? Superintendent Rasmussen and I obviously don't think so since the fall, 2006, samples for Lafayette Club's Nematode DataBase were collected in August and are safely refrigerated awaiting processing. We believe that a convenient one-time fall sampling cannot tell us what happens to nematode populations over the course of the winter and into the critical grass-growing recovery period of spring. And so the Nematode DataBase project intends to follow nematode populations with fall and spring samplings for two full cycles. And in some cases we will try to monitor nematode populations on a monthly basis through the duration of the "golfing season." Maybe the plant nematodes aren't shouting at us to the effect that they are directly or maybe even indirectly responsible for whatever ails Lafayette Club's Greens 7 and 8. But by looking at soil samples processed to extract soil-inhabiting nematodes, it has become laboriously clear that the root-zone samples from almost but not every established green contained abnormally large populations of "saprophytic" nematodes that feed on bacteria. Their population levels in the 2005 samples were only roughly estimated and treated as an unavoidable annoyance that made counting the plant parasites abnormally difficult. In Oscar Miles' August e-mail communication to Paul Diegnau about his TAP (Take-All-Patch) experiences he urged Paul to also consider the non-parasitic nematodes, the "saprophytes" if you will, as well as the parasitic stunt nematodes. Since Mr. Miles did not say why Paul should do that, let's take this opportunity to speculate. What is going on in the root-zone of turfgrasses that supports that prolific growth of all of those bacteria that presumably are necessary to support the large populations of the annoying "saprophytic" nematodes? Are those bacteria, which are not supposed to be the cause of root disease, doing something that directly or indirectly adversely affects the growth of the roots of turfgrasses? In August, 2006, I collected soil samples from three locations on Lafayette Club's Green 8 that I processed by a "sugar-flotation" method of soil extraction. I did so because I wanted to be sure that I wasn't missing some time by just using the Cornell Piepan procedure. No, that effort did not reveal the presence of a potent and previously undetected plant nematode. It did, however, open my eyes to the fact that there was a lot of apparently readily decomposable organic matter in the root-zone samples. I assume that samples from established greens on most other courses would contain equal amounts of such organic matter. I make that assumption because "Thatch Management" at Lafayette Club is a rigorous process similar to what other successful superintendents utilize. Will looking at soil samples and instigating procedures that might reduce the abundance of those bacteria help us answer the question about what they are doing? Maybe it will and maybe it won't. But right now

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it seems like abnormally large numbers of bacteria in the root-zone are somehow worthy of our attention and possibly concern.

Tylenchorhynchus spp., seem to be the dominant if not necessarily the most pathogenic plant nematodes that currently inhabit Upper Midwest golf greens. Stunt nematodes occupied that position back in 1969-70 when we first sampled golf greens. And they hold that position today since the 2005 "mini-survey" found that an average of 73.4% (50.2 to 98.4%) of all of the plant nematodes separated from those 353 soil samples were stunt nematodes. We believe that the greens at Forest Hills, Keller and Mankato were each sampled intensively enough to allow us to make a few more comments about the distribution of these and the few other turfgrass nematodes that we detected. Stunt nematodes made up about 95%, 64% and 81% of the total plant nematode populations at Forest Hills, Keller and Mankato, respectively. The stunt nematode was detected in 17 of the 18 samples from Forest Hills while other plant nematodes (lance, ring, or spiral) were detected in no more than five of those 18 samples. The stunt nematode was detected in all 36 samples from three of Keller's relatively young (16 years) greens. The ring nematode was in second place there, being detected in 33 of the 36 samples. The spiral nematode, which was abundant in some Lafayette Club greens, was detected in 11 of the 36 samples from the Keller greens. Root-knot nematodes, which were listed by Nelson in Turfgrass Trends, 1995 as being quite pathogenic (threshold for damage = 100/100 cm-3), were detected in eight of the 36 Keller samples. These were followed by the stubby-root, lance, Tylenchus spp., and lesion nematodes being detected in 6, 5, 3 and 2 of the 36 samples, respectively. The stunt nematode was detected in 19 of 19 samples from three of Mankato Golf Club's greens that exhibited TAP symptoms in 2005. Second in terms of frequency of occurrence was the spiral nematode that was detected in 18 of the 19 samples. Those plant nematodes were followed by the ring, root-knot, lance and Tylenchus spp. that were detected in 17, 7, 4 and 3 of the 19 samples, respectively.

Forest Hills Golf Course, with old – modified by top-dressing –push-up greens, seems to have "hot spot" or infection center populations of plant nematodes with only five of 18 sampled locations having "exciting" (for a nematologist, at least) stunt nematode populations of 445-1825/100 cm-3. The other 13 sampling sites were all found to contain plant nematode populations that we currently consider to be quite insignificant. Let's suppose that as the result of these studies that are currently underway or as the result of studies to be done sometime in the future that superintendents in Minnesota and Wisconsin eventually become convinced that they need to manage plant nematodes. From what we know now we believe that it will be difficult for the superintendent at Forest Hills to determine the plant nematode potential of her/his greens. The "hot spots" (infection centers) there seem to be so randomly distributed and relatively scarce. How would one go about finding them?

Although we know from Chapter III that Keller's greens had nematode "hot spots" when they were quite new, the plant nematode populations in those greens seem to have "settled-out." We might be tempted to go way out on a limb with just one year's data and suggest that

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in the future as few as one or two 5-core samples from one of the Keller greens would provide a nematode estimate that would be suitable for management purposes. But a very similar story was written with regard to the plant nematodes inhabiting two of Lafayette Club's old greens. Do nematode infection centers ("hot spots") come and go? Root-zone nematode populations at Keller in September, 2005, were fairly moderate (350/100 cm-3) and reasonably uniform (99-898/100 cm-3). Will the same kinds of nematode populations be present in the samples that Superintendent Diegnau collected in September, 2006? Or will the environment and/or the growth of the grasses in the absence of TAP during the past "doosey" of a summer have stimulated the "infamous Keller nematodes" to participate in a population explosion? Or maybe the disease-free and presumably better quality of those plants gave them an upper-hand that restrained nematode reproduction. Just how stable or unstable are these Northern plant nematode populations? I certainly am anxious to learn what the second set of entries into Keller's Nematode DataBase will tell.

Stunt nematodes seem to thrive (range = 425-3885, mean = 1075/100 cm-3) at all locations in each of the three greens that were intensively sampled at Mankato. Of the eight courses where fairly intensive sampling for nematodes was done in 2005, Mankato, at first appraisal, seems to be the one that either needs or is closest to being able to benefit from nematode management. Sampling Mankato's greens currently could be done in the same manner as it could be done at Keller. Superintendent Fred Taylor might even be tempted to go out on his beautiful course and sample with a cup-cutter. But, as we can learn from the contents of the next paragraph, he really should resist that temptation!

In 2005, almost all of the samples that were collected were divided into the root-zone (RZ) "soil horizon", the below root-zone to six inches (BRZ) "soil horizon", and for Forest Hills and Keller, the 6-12 inch deep "soil horizon". At Forest Hills and at Keller, 64.5 % and 69.6%, respectively, of all the plant nematodes that were separated from the soil cores came out of the RZ soil. Twenty-seven and 25%, respectively, of all the plant nematodes that were separated from the soil cores came out of the BRZ soil of the Forest Hills and Keller samples. And as should be expected because relatively few grass roots penetrate into the 6-12 inch "horizon," only 8.5 and 6.4%, respectively, of all of the plant nematodes that were separated from the soil cores from any given sampling location came out of the 6-12" deep "soil horizon" of the Forest Hills and Keller samples. At Mankato, 90.7% and 9.3% of all of the plant nematodes that were separated from the soil cores came out of the RZ and BRZ to 7" soil layers, respectively. The 6-12 inch deep horizon of Mankato's push-up greens was just too dense to permit deep sampling similar to what was done at Forest Hills and Keller.

Two other courses, in addition to St. Croix National, that did not have any pressing plant problems with their greens, were sampled because the superintendents wanted to learn more about the plant nematode status of those greens. Although some of the information about plant nematodes obtained by processing soil samples from greens on the five courses that has been presented so far can be used to support the view that there is quite a bit of similarity between greens, "there also is a lot of nematological diversity out there." Although the data obtained from the samples collected from both the Alexandria Golf Club and the Waseca Lakeside Club share many similarities, they are especially interesting because of their contributions to the diversity component of the Nematode DataBase studies. I am grateful that Superintendents O'Connor and Panuska have agreed to participate in the expanding study.

All of the root-zone (RZ) samples collected from the 20 greens at the Alexandria Golf Club contained less than the anticipated 100 cm-3 of soil. In theory that might mean that the plants at each of the sampling sites were harder for Superintendent O'Connor to manage during the summer of 2005 than would have been the case if they had more extensive root systems. Limited root growth can be due to many factors including the feeding activities of plant nematodes. The rather modest sizes of the RZ populations of plant nematodes at Alexandria may be in part due to the fact that only an average of 76 cm-3 of soil rather the requisite 100 cm-3 of soil was available for processing. In addition to sample sizes that ranged from 65 to 95 cm-3, the sizes of the populations of the "worry-some" saprophytic nematodes ranged from "few" to "excessively abundant." These and other intriguing variables will be kept in mind and definitely will require attention when subsequent sets of samples from Alexandria Golf Club are processed for nematodes.

Stunt nematodes, Tylenchorhynchus spp., were, as expected, the dominant kind of plant nematode in the soil samples collected at the Alexandria Golf Club making up an estimated 50.2% of the population. That relatively low percentage was a bit of a surprise since stunt nematodes made up 73.4% of all the plant nematodes that were detected with the greens sampling that was done in 2005. A lance nematode, a Hoplolaimus sp., that is thought to be more capable of causing plant disease than is the stunt nematode, made up 7.2% of the plant nematode population in the Alexandria Golf Club samples. For the five golf courses whose plant nematode populations have been described so far (St. Croix National, Lafayette Club, Forest Hills, Keller and Mankato), lance nematodes had made up less than 0.6% of all the plant nematodes that were detected. Spiral nematodes, Helicotylenchus spp., made up 28.6% of the total plant nematode population at Alexandria. Although plant nematodes do compete with one another for space and feeding sites, the stunt and lance nematodes occupy different ecological niches. The spiral nematode competes more directly with the stunt nematode than it does with the lance. And so it is interesting but unclear as to why the stunt nematode was a "loser" while lance and spiral nematode were "winners" at Alexandria. In addition to being unusually abundant, the lance nematode at Alexandria was only found in the BRZ (below root-zone) "horizon." If the sampling there had been limited to just the RZ, then we would have been inclined to describe the Alexandria Golf Club nematodes as being unlikely to have caused any measurable plant stress because its greens were inhabited by only some of the more weak pathogenic nematodes.

Although the plant nematode populations at Waseca Lakeside Club were more like Alexandria's than they were of any of the other courses, they also were different in several interesting ways. From the standpoint of similarities stunt nematodes made up only 55% of the total plant nematode population at Waseca. And spiral and lance nematodes made up 12.2 and 8.4 %, respectively, of that population. In terms of differences: at Waseca, 75.9% of the lance nematode population was estimated to inhabit the RZ horizon while

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Nematodes–

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only 24.1% inhabited the BRZ soil "horizon" that was home to all of its Alexandria kin. Root-knot nematodes, which previously had only surfaced in any numbers in Keller Green 18, made up 16.5% of the total nematode population at Waseca Lakeside. By participating in the " 2005 Survey", Superintendent Panuska, for however it may affect his management decisions in the future, now knows that about 24.9% of all the plant nematodes that are present in the soils of his greens are amongst the most pathogenic having damage thresholds of 100/100 cm-3 for root-knot and 150/100 cm-3 for lance.

.A major and continuing objective of our nematode survey of a limited number of Minnesota and Western Wisconsin's golf greens is to try to identify environmental factors and management practices that may restrict the multiplication and survival of plant nematodes. The 18 greens sampled at Madden's Resort taken as a group are, for currently unknown reasons, in 8th and last place in terms of being conducive to the multiplication and/or survival of plant nematodes. An average of only 175 plant nematodes of all types were separated from the soil samples collected from those greens. The average root-zone plant nematode populations/100 cm-3 of soil at the other seven courses were 1390 at Mankato, 1304 at Waseca Lakeside, 581 at Forest Hills, 475 at Keller, 328 at Alexandria, 262 at St. Croix National, and 258 at Lafayette Club. The stunt nematode was, as expected, in first place at Madden's being detected in 17 of the 19 samples and making up 73.7% of all the plant nematodes extracted from the samples from those greens. If there is a significant plant nematode there, it may be the lance. It was detected in 12 of the 19 Madden's Resort samples making up 15.8% of the total nematode population. It is physically and presumably biochemically a much more pathogenic nematode than most of the other nematodes that routinely inhabit golf greens in the Upper Midwest. Although plant nematodes could not be implicated as the cause of the plant problem that was evident on a portion of Green 8, Superintendent Hoffman did seem satisfied that his participation in the nematode survey was worthwhile since two potentially significant populations of stunt and lance nematodes were associated with greens that had a history of isolated dry spots where the turfgrasses were prone to wilt. And with that "testimonial" to the fact that maybe plant nematodes can be a previously unrecognized factor that may adversely affect the growth of turfgrasses here and now, we temporarily terminate the story of our multi-year nematode safari with the belief that the last words about relationships between plant and other nematodes in Upper Midwest golf greens remain to be written.

In this, the last paragraph of our efforts to try to describe our concepts and understanding of the ubiquitous organisms that are far different than "toads," we would like to leave you with the following 10 summary statements:

1. Plant nematodes are just one of the various and normal inhabitants of a golf green that are completing for a finite amount of carbon or energy. Their only source of that energy is living plant roots. They cannot obtain that energy from dead roots, thatch, fungi, bacteria or other soil-inhabiting animals.

2. Plant nematodes do have some capacity to damage plant roots mechanically. All plant nematodes possess a protrusible stylet or mouthspear with which they penetrate plant cell walls and membranes in order to feed. And some of the more pathogenic kinds of plant nematodes will physically enter into plant roots and with their between and through plant cell migrations cause damage/death to affected cells. Spores and other forms of inoculum of fungi and bacteria may be physically introduced into wounded tissues as the result of that process.

3. Plant nematodes, like the other kinds of plant pathogens (living causes of plant disease), are biochemically active. Their secretions introduced into plant cells through their stylets and their excretions introduced in plant tissues chemically alter the plant both where those chemicals are introduced and beyond. It is reasonable to expect that a chemically-altered plant may be predisposed to infection by other kinds of plant pathogens such as the fungus that causes Take-All-Patch. We consider the biochemical activity of plant nematodes to be the most important way in which they adversely affect plants.

4. Just about every soil sample collected from greens in Minnesota and western Wisconsin that we have examined has contained plant nematodes. The few greens that were free of detectable populations of such nematodes were almost invariably new greens. Such greens constructed from peat and/or sand may be expected to be free of detectable populations of plant nematodes for at least their first few years.

5. Our state-wide sampling of golf greens conducted in 1969-70 did not reveal any real pattern in terms of sizes of nematode populations that were detected. The following expression, "Expect plant nematodes where you find them," that developed during the course of that survey was applicable then as well as today. And to find them, one needs to go beyond just making assumptions. We need to do what has been advocated for recognition of the soybean cyst nematode problem wherever soybeans are grown: "Take the test, beat the pest!" In other words collect soil samples and let a laboratory process the soil and make the diagnosis.

6. Infection centers or hot spots where plant nematodes become very abundant do exist. They probably are temporary phenomena that develop in response to the occurrence of a presently unknown combination of favorable factors. It seems likely that they can be expected to disappear as the nematodes literally "eat themselves out of house and home" by destroying the living roots upon which they must feed. Although infection centers are presently considered to be of limited or, as developed for Keller Golf Course, of possibly misleading diagnostic value, they do indicate what can happen with these organisms in a green that experienced a broad spectrum of environmental and stress factors that prevailed in the weeks or possibly months preceding the development of such "hot spots."

7. Stunt nematodes, Tylenchorhynchus spp., are the most common parasitic nematode inhabitants of Minnesota's golf greens. Nematode analysis of multiple (at least six samples collected from each of nine greens in the autumn of 2005 revealed that three of those greens on one golf course (Mankato) were heavily and fairly uniformly infested with that nematode. Three other greens (Keller) were moderately and fairly uniformly infested with stunt nematodes. The other three greens (Forest Hills) fit the infection center distribution with only 5/12 sampling sites being infested with potentially significant populations. Efforts to develop-expand "nematode databases" for 3-4 greens on each of 11 courses by spring and fall sampling into 2008 will hopefully enable us to be able say more about the ecology of plant nematodes in Minnesota's and western Wisconsin's golf greens.

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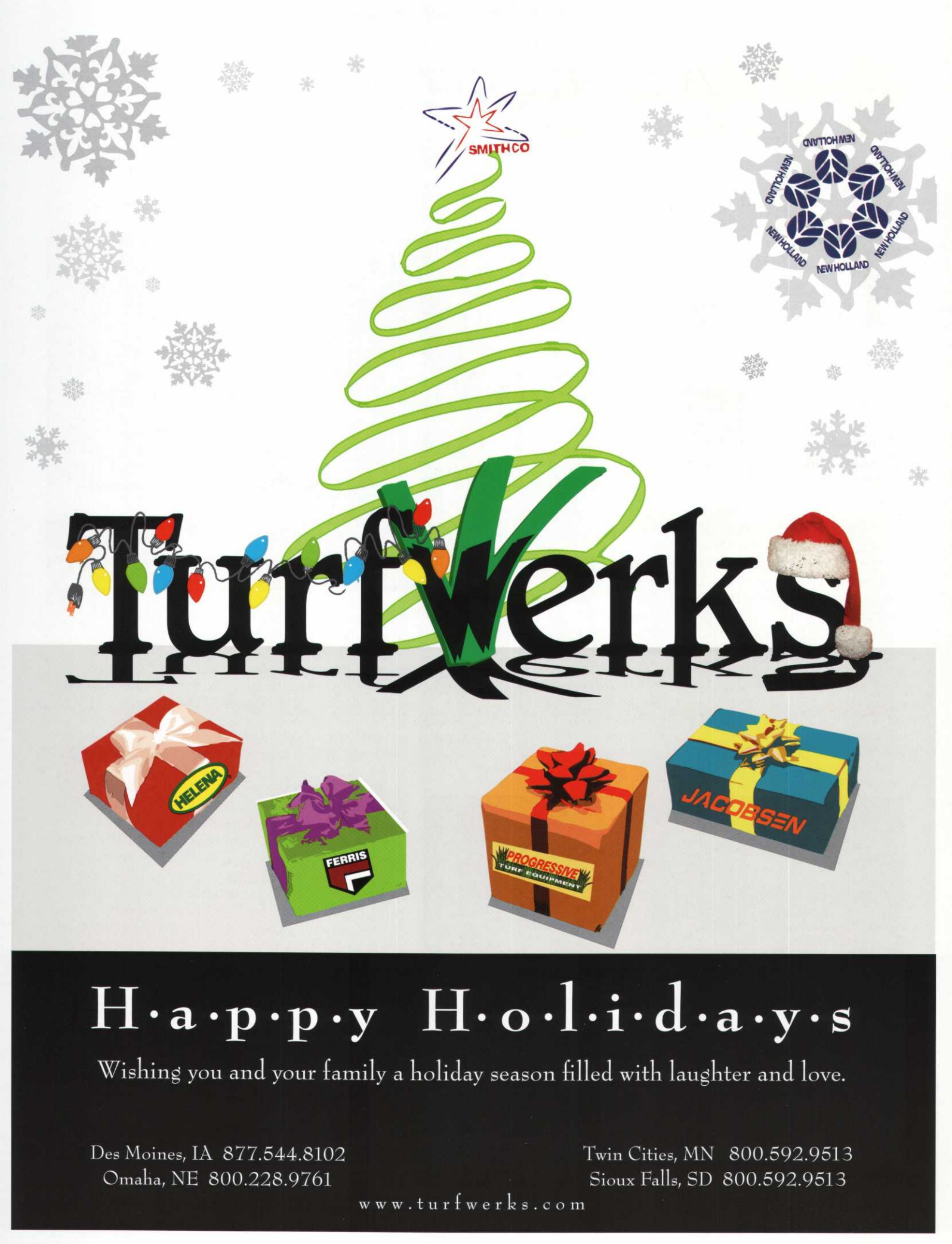

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An Adventure in Life

By RANDY WITT, CGCS
Senior Superintendent
Hong Kong Golf Club

This month I will attempt to answer some of the more common questions that I have received via e-mail and also from friends during a recent vacation to Wisconsin. The questions are both golf course related and in some cases about life in Hong Kong and China.

How long does it take to get to Hong Kong?

Some airlines have non-stop direct flights from Chicago to Hong Kong. These flights generally take about 14 hours of flight time. The route is north to the Arctic Circle, down over Siberia, Russia, and Red China into Hong Kong. Some airlines have a route that goes from Hong Kong into Tokyo; change of aircraft for a flight from Tokyo to either Detroit or the Twin Cities, and then to any regional airport. This second option will generally take about 20 to 22 hours depending on connection times and the particular airline. The one positive for the direct flight is not worrying about making connecting flights. One needs to allow a minimum of 1 hour for connecting flights as the arrival gate and the next departure may be quite a distance apart. During the flight, the view of the earth's surface over the Arctic Circle and Siberia is great. The time in the air has never presented a real problem for me, I actually enjoy the travel. The time actually seems to pass very quickly. One can really understand and realize how small the world has really become through air travel and the computer age.

What has been the biggest surprise in maintaining a golf course in Hong Kong?

The biggest surprise, which I was not prepared for at all, was the lack of knowledge and education about the game of golf and golf course maintenance. The common, blue collar Chinese individual has had very little or no exposure to the game of golf. Most of my staff members had never been on a golf course until working here. Part of our training program is educating the staff members about the game of golf and what the game is all about. This lack of knowledge has presented obstacles in normal, daily maintenance. Most of the Chinese population has never operated any type of power or motorized equipment. Most travel by bicycle, walks, or use the public transportation system. The employees first experience with a piece of motorized or power equipment is when they are trained on the equipment here. For the typical small, shy Chinese individual, a motorized fairway or rough mower can be quite scary and intimidating. Of my five Assistants, none has any sort of education relating to turf grass management. Some have very little practical experience in any type of golf course maintenance. The most important criteria in their hiring were that they had some type of college degree, and were able to speak English. Four of the five Assistants are currently enrolled in the Penn State online program. Four of the five would have a difficult time to be considered for Foremen's positions in the United States based on their level of experience and education. They attempt to make up for their shortcomings by being eager to learn,

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