(SC), Aqueous Suspensions (AS), Emulsifiable Concentrates (EC), and Microencapsulated Concentrates (MC). The flowable, soluble concentrate, and aqueous suspension are all suspension formulations. They require proper agitation prior to putting them in the tank. This is probably not as crucial with the EC and MC formulations as these are in solution, but it is always a good idea to mix products thoroughly before putting them into the spray tank. In contrast to the granular formulations, the liquid formulations usually measure the amount of active ingredient in pounds per gallon. An example of this is Turfcide 400 4F, which has 4 pounds of active ingredient per gallon of product. On the label you will notice that the percent is also included. By knowing the amount of active ingredient in each product, you can determine cost per area applied, and use it for cost comparison-shopping.

Table 1. Formulation Types and AI Measurement Method

Formulation	Abbreviation	AI Measurement
Granular	G	% AI/lb
Dry Flowable	DF	% AI/lb
Dry Granular	DG	% AI/lb
Extruded Granular	EG	% AI/lb
Wettable Granular	WG	% AI/lb
Water Dispersible Granular	WDG	% AI/lb
Wettable Powder	WP	% AI/lb
Water Soluble Packet	WSP	% AI/lb
Emulsifiable Concentrate	EC	Lbs/Gal
Microencapsulated Concentrate	MC	Lbs/Gal
Aqueous Suspension	AS	Lbs/Gal
Soluble Concentrate	SC	Lbs/Gal
Flowable	F	Lbs/Gal

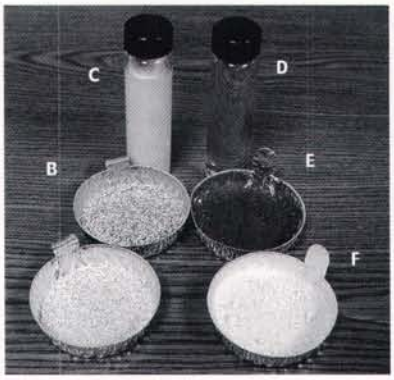

Figure 1. Formulations of fungicides; (A) extruded granular, (B) Water dispersible granular, (C) flowable, (D) microencapsulated concentrate, (E) dry flowable, and (F) wettable powder.

Tank Mixing

Even before the first chemical goes into the spray tank, be sure that you have read the entire label. Many tank mixtures have been evaluated in the past, and because of these evaluations labels usually have recommendations or restrictions when it comes to tank mixtures. Restrictions are imposed because some chemicals are not compatible together and can cause anything from mixtures that gel up to chemicals loosing their efficacy.

Before tank mixing you will want to perform a jar test. This simple test consists of putting all the components desired in the tank mix in a jar and evaluating the mixture. The jar test will only tell you if there are physical changes in the mixture, so you will have to rely on the label to provide any chemical reactions that might be detrimental to the mixture.

When tank mixing, it is good to use the following mixing order. When mixed in this order, there is less of a chance or incompatibilities and the mixture should be more uniform.

Mixing Order

1. Granulars (WDG, WG, EG, DG, DF)
2. Wettable powders (WP, WSP)
3. Flowables (SC, F, AS)
4. Solubles (MC, EC)

Topical Modes of Action

Topical mode of action is simply how the fungicide reacts with the plant to protect it from the fungus. Generally, topical modes of action are divided into five groups: contact, local penetrant, acropetal systemic, systemic, and the most recent addition, mesostemic. Most of these groups share similar modes of protection, but there are some differences among the groups.

Contacts

Contacts have the simplest mode of action. When applied to turf they provide a protective barrier on the outside of the plant. The re-wetting of the plant via rain or irrigation can redistribute the chemical on the outside surface of the plant (see Figure 2.). Since none of the chemical actually gets into the plant, the chemical is subjected to the elements, and therefore has a short life span. Most contacts have a life span of around 14 days, but based on the weather this could be much shorter.

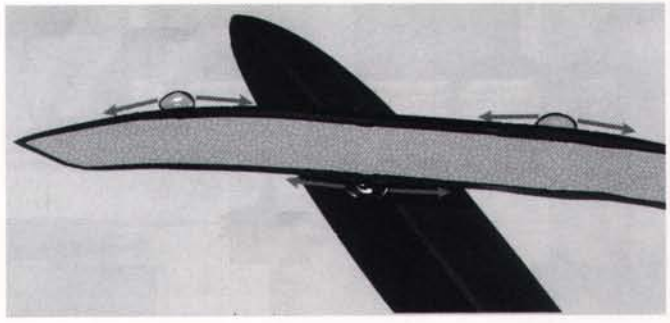

Figure 2. How a contact protects a turfgrass plant. (A) Movement of the contact fungicide is limited to the exterior surface of the leaf, but can be redistributed with irrigation or rain.

Contact fungicides usually have several biochemical modes of action (the biological pathway or process that the fungicide inhibits resulting in growth inhibition of the fungus). Because of this, resistance to the fungicide is unlikely, and these chemicals can play a vital role in preventing fungicide resistance.

Because contacts only provide protection on the outside of the plant, the fungicide will not affect existing infections inside the plant. Contact fungicides will, however, prevent the spread of disease to neighboring plants. It may be common to apply a contact fungicide, or any fungicide, and have lesion or mycelium develop the following day. This does not mean that the fungicide is not working, but the timing of the application was a little late. You can be assured that symptoms will subside in a day or two.

Fungicides that have a contact topical mode of action are chloroneb, chlorothalonil, ethazol, mancozeb, maneb, PCNB, and thiram.

*It should be noted that most other fungicides, when on the outside of the plant, will provide contact control of turfgrass pathogens. The other topical modes of actions also enter the plant and provide additional protection from within the plant.

Mesostemic

The mesostemic mode of action is a relatively new type of protection. Currently there is only one chemical that is in this category, trifloxystrobin. While having all the protection properties of a contact, this group adds some unique modes of action.

A mesostemic fungicide's most unique characteristic is its ability to redistribute by vapor movement. In simpler terms, the chemical goes into a vapor phase and will enter neighboring plants and other parts of the same plant where it will provide protection. Mesostemics can also penetrate the waxy cuticle of the leaf and provide a barrier against a fungus infection. The chemical can also enter the plant via translaminar flow. Translaminar flow is simply movement from one side of the leaf to the other by traveling through the intracellular space. So if the top of the leaf has chemical from an application, translaminar movement will also protect the underside of the leaf.

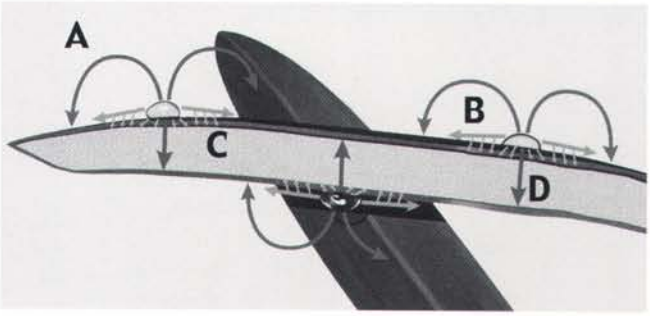

Figure 3. How a mesostemic protects a turfgrass plant. (A) The vapor phase movement, either to other parts of the plant or to neighboring plants. (B) The contact mode of action on the exterior of the leaf. (C) Some of the chemical is able to penetrate the cuticle wax layer and dissipate within it. (D) Limited translaminar flow to the side of the leaf that was not treated.

Mesostemics do have some limited movement into the plant and as a result have some protection from the elements. They have a life span of about 14-21 days. Mesostemics will also control infections already present in the plant; however, they will not prevent symptom expression of preexisting infections.

Trifloxystrobin, unlike the members of the contact classification, only has one biochemical mode of action. Resistance management strategies should be implemented with its use (resistance management strategies will be discussed later in the article).

Local Penetrants

This is the first group discussed that has significant movement into the plant. As stated earlier, this group will also provide protection on the outside of the plant similar to the contact topical mode of action. They also have some limited movement into the plant where it can provide protection. There is no major upward or downward movement in the plant so effective coverage of the plant is required to provide the optimal protection.

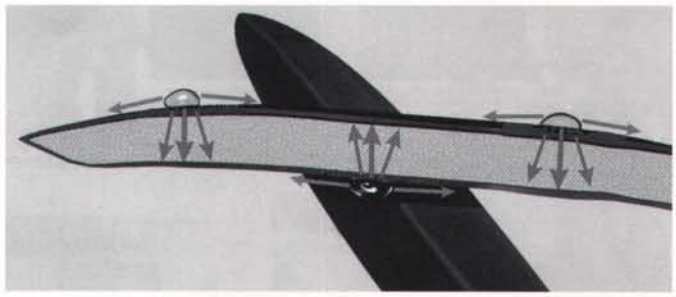

Figure 4. How a local penetrant protects a turfgrass plant. (A) The contact action of the chemical on the surface of the leave. (B) With this mode of action the chemical enters the plant and has limited movement within the plant from the point of entry.

The life span of members of this group ranges from 14-21 days, because of its absorption into the plant. It will also provide some curative properties against existing infections when it enters the plant. Once again, local penetrant chemicals have only one biochemical mode of action so resistance management must be practiced with their use. Documented cases of resistance have been reported on members of this chemical class. Members in this group include iprodione, propamocarb, and vinclozolin.

Acropetal Systemics

Acropetal systemics include the largest group of fungicides. Acropetal movement in a plant is upward

and outward movement, primarily through the xylem. When this type of fungicide is applied it will provide protection to any part of the plant above where it entered. It is usually best to make applications with higher volumes of water to ensure that the chemical enters the plant around the crown of the plant. Therefore, protection will include even newly emerging tissue. Absorption is also possible via the roots of the plant and translocated to the aerial parts of the plant. The root absorption makes these chemicals an ideal choice for root infecting pathogens.

Acropetal systemics, as a general rule, are highly resistant to the elements. In experiments conducted at the UW, some of these chemicals have provided upwards of 65 days of disease protection. But, life span can last anywhere from 14-60+ days depending on coverage and the rate of application.

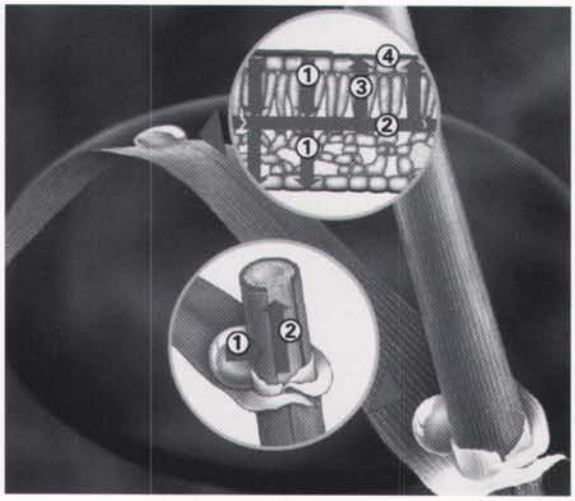

Figure 5. How an acropetal systemic protects a turfgrass plant. 1. Entering the leaf and translaminar movement. 2. Acropetal movement in the xylem of the plant. 3. Movement of the chemical to the surface of the leaf. 4. Contact activity on the surface of the leaf.

Protection against existing diseases is possible because these chemicals enter the plant. As with the other groups, protection of the leaf surface is provided similar to the contacts. Acropetal systemics also has translaminar movement, so that the opposite side of the leaf that receives the chemical application will also be protected.

Most of these chemicals only have one biochemical mode of action, so again resistance management must be practiced. This group is made up of chemicals from several families. These include azoxystrobin, fenarimol, flutolanil, mefenoxam, myclobutanil, propiconazole, thiophanate methyl, and triadimefon.

Systemic

Currently there is only one true systemic fungicide labeled on turf. In order to be classified as a systemic the chemical must be able to move upward and downward within the plant. The only chemical that has a systemic topical mode of action is fosetyl Al. Because of the main biochemical mode of action of this chemical, it will probably provide little protection on the surface of the plant, but it does induce defensive mechanisms within the entire plant.

Systemic chemicals will have some halting properties against existing infections, but may require some time to become effective. Since this group is absorbed into the plant, life span is usually around 14-21 days. Length of efficacy is reduced compared to other systemics because of the pathogens that fosetyl Al is affective against.

Figure 6. How a systemic protects a turfgrass plant. 1. Entering the leaf and translaminar movement. 2. Acropetal and basipetal movement in the xylem and phloem of the plant. 3. Movement of the chemical to the surface of the leaf. 4. Contact activity on the surface of the leaf.

Resistance may or may not be a problem with this group because the primary biochemical mode of action is a chemical induced plant response. But, as with most fungicides, resistance management should be practiced with any fungicide program.

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Heritage Fungicide. Zeneca. Pub# 10/99 20M ZPP-HER-051.

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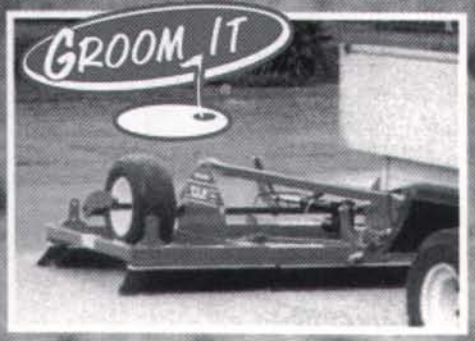

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Has Dollar Spot Control Been A Problem For You?

By Dr. Geunhwa Jung, *Department of Plant Pathology, University of Wisconsin-Madison*

Dollar spot caused by *Sclerotinia homoeocarpa* F.T. Bennett is one of the most important turfgrass diseases, capable of attacking both cool- and warm–season grasses. The causal fungus was identified and named by F.T. Bennett in 1937. The cool-season turfgrass species adapted to Wisconsin's climate are bentgrass (creeping and colonial), fescue (tall, red, sheep, and fine-leaf), and bluegrass (Kentucky and annual). We have all experienced difficulty controlling dollar spot during the last few years. The number of samples received at the Turfgrass Diagnosis Lab last year which tested positive for dollar spot is another clear indication of the recent unusual severity of this disease.

I will write about some factors that might cause an increase in the incidence and severity of dollar spot and a decrease in the efficacy of fungicides. Did you find that you needed to apply a higher rate of fungicides and more often to control dollar spot in the last few years? I went to the 2001 GCSAA conference in Dallas to attend a seminar entitled "Disease Identification and Control" given by Drs. Bruce Clarke and Bruce Martin. Dr. Bruce Clarke also emphasized the recent changes in dollar spot control. The optimum temperature for the dollar spot fungus is 70°-80° F, along with high relative humidity (>85% at night). These conditions likely prevailed for an extended period of time last year. The weather could be the major factor for the promotion of dollar spot, along with other factors such as low mowing heights, low nitrogen levels, improper applications of fungicides, and especially fungicide resistance development.

In addition, I would like to report on some important issues about dollar spot that others are talking about at the local and national meetings. First, the scientific name for the pathogen, *Sclerotinia homoeocarpa* has been debated, and will be given a new scientific name. The new name for this fungus will be *Rutstroemia floccosu*, the name being proposed by Drs. J. Powell and J. Vargas, 2001. Whatever the pathogen name is, the disease name, dollar spot, will be the same.

Second, I'd like to comment on the development of fungicide resistance in the pathogen. The definition of fungicide resistance is "The stable, inheritant adjustment by a fungus to a fungicide, resulting in a less than normal sensitivity to that fungicide" (Dekker, 1995). Basically, the fungus that was previously sensitive to fungicides has been put under the selection pressure of repeated applications of fungicides, and has genetically changed to obtain an ability or has been selected from the fungal population to be relatively resistant or tolerant to the fungicides. The development of fungicide resistance is dependent upon the fungicide's mode of action (for example, cell membrane toxicity, interference with DNA synthesis and lipid metabolism, and so on) and whether the fungicide is a specific (single) or multisite fungicide. Single or specific site fungicides inhibit only one function critical to the fungal cell, but mul-

tisite fungicides inhibit several functions of fungal cells. Most of the protectant and contact fungicides are multisite and, in most cases, their efficacy has remained stable over the years. In contrast, some systemic fungicides, e.g. DMIs, with specific site action are losing their effectiveness in a short period of time. The fungi that rapidly become resistant to particular fungicides often demonstrate cross resistance, meaning "resistance to more than one fungicide mediated by the same gene" (adapted from Disease Identification and Control by Golf Course Superintendents Association of America) to structurally related chemicals or to chemicals with similar modes of action.

We are all aware of previous instances of developing fungal resistance to heavy metal-based fungicides such as cadmium and mercury, benzimidazoles (Tersan 1991, Fungo 50, and Clearly's 3336), anilazine (Dyrene), dicarboximide fungicides (Chipco 26019), and demethylation inhibitors (DMIs: Rubigan, Banner, and Bayleton) in various regions of the United States. There are many ways of reducing the possibility of the development of fungicide resistance. Researchers may prefer one of following methods: a tank mix of reduced or recommended rate of fungicides, a rotation of chemicals with different modes of action, the timing of application, and proper management techniques. These methods usually should work well. The important thing to remember is to adapt at least one management strategy of reducing the development of fungicide resistant strain. When fungicide-resistant dollar spot fungi have not been observed, it indicates to me that alternate applications of systematic and contact fungicides registered for dollar spot control have been used in an integrated control program to prevent the build-up of fungicide-tolerant fungus strains. The systemic fungicide will continue to eliminate the majority of the dollar spot fungus population that is sensitive to systemics, while the contact fungicide will be used primarily to prevent the build-up of systemic fungicide-tolerant strains of *R. floccosum*.

The third and last topic is seasonal variation of dollar spot species, i.e. different fungal pathogens in early spring and fall. Do you remember a talk on dollar spot presented by Dr. John Powell (University of

Minnesota) at Wisconsin EXPO 2001? The seasonal variation among dollar spot isolates caught my attention. I asked him to send me his recent research paper on it, which is in press at the Journal of Plant Disease. In the northern U.S. two major seasonal epidemics (from May to late-July and mid-August to October) have been known to occur. Based on DNA sequence information, the authors concluded that the seasonal dollar spot epidemics observed in the northern U.S. are caused by a single species (*R. floccosum*) rather than several species of fungi. So, that result still did not explain why two separate outbreaks of dollar spot occurred in two seasons. Two hypothetical explanations for their results that come to mind are as follows: 1. The DNA technique they utilized could not detect the amount of variation among pathogen isolates for the two seasons. 2. For those particular years, the environmental conditions maybe were favorable for the dollar spot pathogen for extended period of time during the time of their experiment.

In conclusion, I am convinced that we should start collecting dollar spot isolates throughout Wisconsin this year, in order to detect any trace of fungicide resistance, and study the seasonal variation using different types of DNA techniques (random amplified polymorphic DNA, RAPD marker, The Grass Roots Volume XXIX (4): 37-41). If you have had difficulty controlling dollar spot, please let us know and we will collect dollar spot isolates from your golf course.

USGA

The Shape of Things to Come – 2001

By Bob Vavrek, *USGA Agronomist, North Central Region*

I was asked to look into my crystal ball and discuss potential problems that superintendents in the North Central Region might encounter during the upcoming season. At first, issues such as chlorothalonil use restrictions came to mind or the steady westward march of gypsy moths and Japanese beetles across Wisconsin into Minnesota. However, I decided to discuss a more general concern, one that most of us in the upper Midwest tend to take for granted – water.

The abundance of fresh water lakes/rivers, readily available groundwater, and over 30 inches of precipitation each year across Michigan, Wisconsin and Minnesota are the reasons why we rarely consider water to be an issue on the golf course as long as a relatively dependable irrigation system exists. Too little water or too much water (mostly too much), however, can have a considerable impact on the health of the turf and the quality of the playing surfaces.

Water impacts the golf course even before it is born. The presence of wetland habitat can limit the amount of land available for development at a particular site. Protecting wetlands and wetland mitigation can significantly increase the cost of building a course. Only time will tell what impact, if any, the new Bush administration will have on wetland development and other environmental issues.

Once construction begins, the washouts and erosion associated with heavy rainfall events can throw a monkey wrench into the timetable for opening a course. On the other hand, a lack of consistent rainfall during grow-in will hinder the germination and development of turf across slopes, mounds, in roughs and other areas that lack supplemental irrigation. Rough turf quality can be set back a year or more during a droughty grow-in.

Water continues to be an issue after turf establishment. An increasing number of courses are experiencing the problem of moss encroachment on greens. The ability of moss to compete in turf is enhanced by excessively close mowing heights, low fertility, and overwatered playing surfaces. Sometimes an extended period of wet weather causes a surge of moss growth, but

most often it was related to too much irrigation and/or poor surface/subsurface drainage through or across the green. I see a few more home remedies in my crystal ball, but don't expect any long-term success regarding moss control until the grass is a little higher and the greens are drier.

Heavy rainfall events during the 2000 season caused some of the most severe bunker washouts I have ever encountered. I see more superintendents experimenting with new erosion control materials, such as Bunker Woll, in severely sloped cavities. Experience will dictate how and where to employ these materials to minimize bunker erosion, but I doubt any material will be a panacea for erosion problems in all architectural styles of bunkers.

On a final note, I encourage everyone to have their irrigation water tested at least once this year. A number of reputable independent labs are available to determine pH, soluble salts, bicarbonates, and other characteristics of water that can, under some circumstances, have a significant effect on turf quality, especially during extended periods of drought.

Superintendents in the more arid regions of the country and those at courses where effluent water is used for irrigation will never take water quality for granted. The water is tested frequently and the steady buildup of salts near the surface of greens during dry weather is constantly monitored. Sand based greens are subjected to long irrigation cycles at appropriate intervals to flush the accumulation of salts from the upper soil profile – a stress that can cause injury to *Poa annua* playing surfaces.

Salt accumulation is not a common problem at courses in the upper Midwest because the frequent thundershowers that occur throughout the summer provide a natural flushing action through a green. On the other hand, the unusual weather patterns over the past several years have provided the type of conditions where damage to greens from excessive salts did occur at several courses. Damage that could have been prevented by simply testing the irrigation water and monitoring the soil profile with an inexpensive conductivity meter during periods of hot dry weather.

Feel free to call the North Central Regional office in Wisconsin (262-797-8743) anytime for information regarding water testing labs and conductivity meters along with any other water or non-water related turf concerns you may encounter during the season.

The Real Birthplaces of Golf

By Pat Norton, *Golf Course Superintendent, Nettle Creek Country Club*

There are seemingly a thousand different types of golf facilities out there. There are seemingly a thousand different types of golf facilities within any state...Wisconsin, Illinois, Pennsylvania, Arizona, or whereever. And with all due to respect to St. Andrews...the real birthplaces of golf are all located right here in our own back yards!!!

How many of us can trace our golf origins back to some small nine or eighteen hole layout...located in rural or small town America? I certainly can...you all certainly can...and I'll bet that the majority of Americans can trace their birthplace of golf back to some local layout that gave them the chance to learn this game in an unhurried, affordable, and yet very magical atmosphere.

Nobody ever forgets their own birthplace of golf. I will be forever grateful to guys like Jimmy Forbes, the golf pro at Monroe CC, who conducted endless Fri AM group lessons with wiffle balls scattered everywhere...or Jim Krieger, the owner of Windy Acres in rural Green County...where kids sort of graduated to...as they became old enough to be on their own for a day long feast of walking golf with their teen aged buddies!! Mr. Krieger, I remember, only had to scold us once about leaning on our putters and possibly leaving a blemish on one of his greens!!

Make no mistake about it, people...the golf course is a very magical place to most people, especially kids. In thinking back...I remember vividly how being able to walk out onto any golf course was a thrilling experience. It was like walking through a magical fairyland...green grass and trees everywhere, sun shining, wind blowing, lots of hills and hollows to explore...and a definite route to walk as we sort of wandered all over the property. And it was a different experience for each young golfer...the route that the white ball led us on depended totally on each kid's skill level...giving each of us that different 'golf experience.'

And the greens!!! How did they cut this stuff so short...and what is it really?? We had no idea...which only added to the mysticism of the place It was a great day as a young teen when I realized that I knew the golf course...and how to play the game...way better than my Dad...way better than my sisters...and most of the time...better than my older brother!!

The misconception is that northern areas of the US are home to most of these birthplaces of golf...which is only partially true. The fact of the matter is that there are still lots of these great facilities scattered around...and their location has more to do with urban vs. rural than it has to do with north vs. south or east vs. west.

These places all share the common thread of being the beginning point for hosts of young golfers each year and through their efforts...the sport grows, matures, and evolves...

In the 1990's though...we've seen the growth of golf via another route. Along with the strength of the US economy in general, we have seen explosive growth in golf through the development of thousands of new, 'upscale' public golf course facilities.

Many of these places are designed and priced such that walking golf and thereby junior golf, are subtly or actively discouraged!

My little corner of the golf world is a very good example. Nettle Creek CC...where I hang my hat...is very stretched out over 310 acres...and requires golf carts all weekend long. We do this for the revenue mainly...and have seen that today's golfers are pretty lazy and think that our course is unwalkable. Having hoofed it around this layout in four hours...permits me to tell you with authority that it is indeed a trek.

My son and his buddies tried for two years to participate in our junior golf program and then walk nine holes...which ultimately proved too difficult given the length, lack of shade at a new course, and the golf cart pressure from following groups. After awhile...they all gradually lost interest...and the ones who have continued have gravitated over to Morris CC.

Morris CC is a small, private 18 hole layout...is very walkable for golfers of all abilities...and allows junior golf memberships to be purchased independent of the fact that your parents are or are not members!! What a great encouragement for juniors!! That place definitely qualifies as a true birthplace of golf...in my opinion.

Our ownership group recently attended the 2001 National Golf Course Owners of America Annual Conference and Trade Show at DisneyWorld. Attending were owners of all sorts of golf establishments. Each facility is different from any other...yet all have very necessary similarities. The most obvious similarity is that almost everybody in attendance is aggressively trying everything possible to capture their share of their area's golf market.

It was a fantastic conference from a decidedly different viewpoint than the GCSAA or the PGA conferences. These course owners are definitely on the front lines in the battle to see