AN INDEPENDENT NEWSLETTER FOR TURF MANAGERS

Turf Grass TRENDS

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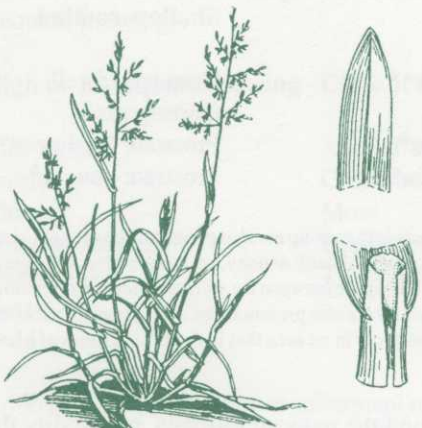
Using IPM to manage weeds in turfgrass

by Dr. Joseph C. Neal

Integrated Pest Management (IPM) can keep weed infestations below a predetermined treatment threshold by using all suitable techniques and methods appropriate for a site. That may be as simple as a change in cultural practices or site usage, or as complex as the use of best management practices for control of other pests such as diseases or insects. Using IPM to control weeds does not preclude the use of traditional chemical herbicides, rather chemicals can be one weapon in an arsenal that can be used at a given site to accomplish the task.



Annual bluegrass

The first task: identifying weeds

To develop an effective IPM weed control strategy, you must first identify the weed species present. This means the systematic scouting of the site to determine which species are present, an estimation of their populations, some measure of their condition, and a way to record their distribution. A good scout can also often estimate the so-called confounding factors, such as compact soils or turf thinned by insect or disease damage.

Identifying each dicot and monocot weed species can be a simple matter of visual identification for scouts with considerable experience, but it can be bewildering to someone who lacks first-hand knowledge. For beginning scouts or others whose chief duties do not necessitate exact weed identification, see table on page 3. It gives a selected list of weed identification references that can be helpful.

Identifying some weed species in the field can be a daunting task even with the help of guide books. Carefully take a sample and store it in a plastic bag with an identifying label. When taking a dicot weed sample, include any flower, as flowers are an easily identifiable part of dicot weeds. If the sample is a monocot weed, include any seed heads that are present. Many monocots can only be properly identified by their inflorescence.

Once you have identified a weed, mark its distribution on the site map with some estimate of the population density, such as light, moderate, or heavy. (See scouting story, map and key on pages 4 and 5.) If one person scouts, then a scale to represent population, i.e. 0-10% of the area infested equals light, 10-20% equals moderate and >20% equals heavy, may not be necessary. But, if scouting chores are shared, then a defined population scale and its uniform application are important for data consistency.

Next, document the growth stage of the weed. Phrases like "newly emerged", "immature", "mature" or "in decline" can be helpful in making control decisions. For ease of recording, both the population density and the growth stage, information could be coded as part of the identification key.

Finally, note any confounding factors, cultural practices or patterns that may contribute to the observed weed infestation or may help in the control decisions. Note such things as:

- thin turf areas caused by disease or insect damage

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- traffic patterns
- mechanical damage from equipment
- shade
- drainage
- poor or inconsistent irrigation practice
- past control history

Are your weeds trying to tell you something?

The answer is: "yes"! Your job in using IPM is to make sure that you know what they are telling you.

Weeds occur in turf for several reasons. A weed may be well adapted to persist in a closely mowed plant community such as annual bluegrass on golf courses. It may exploit a unique niche created by specific management practices, such as pearlwort on heavily watered golf greens. Weeds may also persist when turfgrasses have been weakened by environmental or management factor that produce conditions that favor weed growth over the more desirable turfgrasses. Many weed infestations can be minimized by altering the site or management practices to tip the competitive balance in favor of the turfgrass species.

Moneywort

How do you identify such situations?

One way is to take your clues from the diagnostic weed species that grow as indicators on many sites. The following two groups of diagnostic weed species are well adapted to either extremely dry conditions or to excessively wet site:

Drought Prone Sites	**Wet Sites**
Prostrate spurge	Moneywort
Black medic	Annual sedge
Yellow woodsorrel	Annual bluegrass
Goosegrass	Alligatorweed
Annual lespedeza	Pearlwort
Birdsfoot trefoil	Moss
Prostrate knotweed	Liverwort
Bracted plantain	Rushes

One or more of these weed species as the predominant weed species on a site indicates that the site suffers from moisture extremes contrary to optimum turfgrass growth. Their presence does not prove that extreme moisture exists, since they will also grow on sites with less moisture. But, the dominance of these species indicates that there may be too much moisture at the site.

Chicory

Compacted soil and shallow rooting that accompany this site problem have their own group of diagnostic weed species. They are:

Compacted soil	**Shallow rooting**
Annual bluegrass**	Corn speedwell
Annual sedge**	Goosegrass*
Annual lespedeza*	Prostrate knotweed*
Broadleaf plantain*	Prostrate spurge*

* Many of the weeds in this group are also present in the drought-prone group. Areas that have high soil bulk density, i.e. compaction, are drought prone because there is less space between the soil solids for water retention.

** These weed species are also present in the wet-prone site list as they are shallow rooted and grow in an area that is the first to drain of excess moisture.

Low soil pH and the reduced nitrogen availability that comes with it have a specific diagnostic species. Other sites with high nitrogen levels, from mineralizing organic matter or high supplemental fertilizer applications, have a different group of diagnostic weeds.

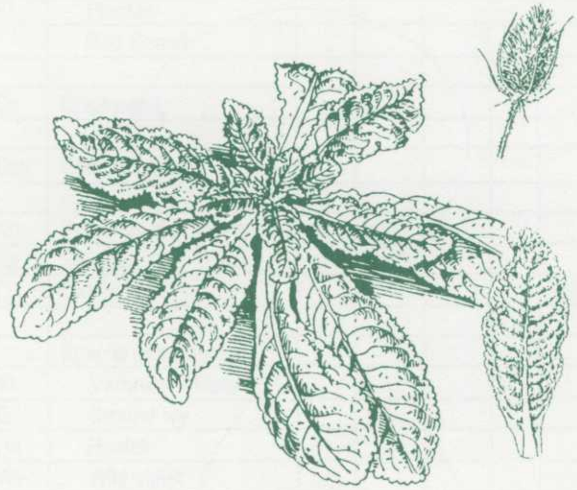
Low nitrogen levels	**High nitrogen levels**
Birdsfoot trefoil*	Annual bluegrass
Black medic*	Chickweed
Broomsedge	Moss**
Clovers	Ryegrass
Common speedwell	
Hawkweed	
Moss**	

* These species also appear on the drought-prone list. Low nitrogen sites often have very poor calcium and magnesium levels that cause

desirable granulated or flocculated soil structure to deteriorate into tightly bound plate-type, compacted soils.

** Some species of moss are better adapted to low nitrogen soils, while others are adapted to high nitrogen soils.

Mowing height and frequency can also influence weeds at a given site. Some of the more upright or rapidly growing



Teasel

weed species cannot tolerate low or frequent mowing because substantial portions of the plant are removed with each cutting. On the other hand, predominantly prostrate species do well at low heights and can tolerate close or frequent mowings.

High or infrequent mowing	Close or frequent mowing
Bull thistle	Annual bluegrass
Burdock	Chickweed
Chicory	Moss
Smooth bedstraw	Pearlwort
Sweet clover	Thymeleaf speedwell
Teasel	
Wild carrot	

Weeds adapted to high or infrequent mowings, common on roadsides or waste areas, can often be controlled by increasing the frequency of mowing or lowering the cutting height when mowing. Weeds adapted to close or frequent mowing will often lose their competitive advantage if the cutting height is raised or the frequency of cut is reduced.

As we have said, some of these diagnostic weed species can be found in several of the identified groups, i.e. annual bluegrass. Their presence alone does not indicate a complex interaction of various confounding factors, but the wise turfgrass manager would eliminate these conditions. The failure to deal with the underlying conditions that these groups "speak to" will frustrate even the most complex control strategies.

Turf health and density is the best IPM strategy

The best strategy for IPM weed control is to maximize conditions that will lead to turf health and density. Healthy, dense turfgrass has a competitive advantage over weed populations for these reasons:

- dense turfgrass can successfully compete for limited nutrients and water,

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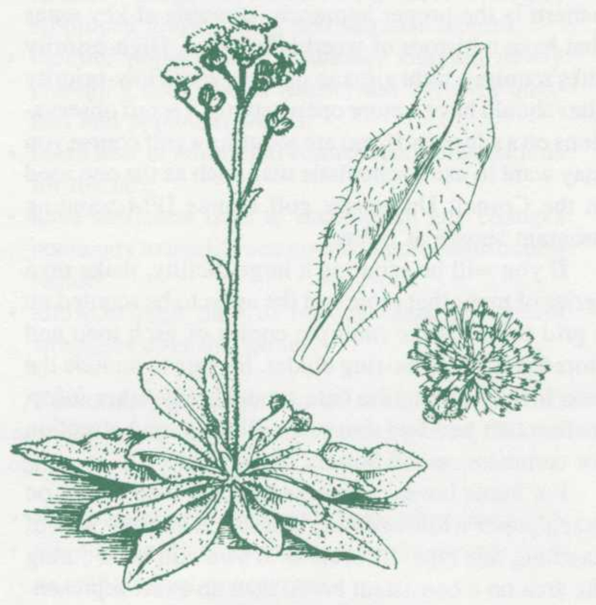


Hawkweed, paintbrush

Weed identification references

Title	Source
Common Weeds of the US.	US. Dept. of Agriculture
Guide to the Identification of Dicot Weeds*	O.M. Scott and Sons, Marysville, OH
Guide to the Identification of Monocot Weeds*	O.M. Scott and Sons, Marysville, OH
Identifying Seedling & Mature Weeds in the S.E.	Stucky, et. al.; N.C. State Ag. Res. Serv. AG-208
Weeds of the North Central States	University of IL, Ag. Exp. Sta. Bldg. 772
Weeds of Southern Turfgrasses	Murphy. et. al.: U. of GA, Coop. Ext. Serv.

* pocket sized

Scouting weeds takes methodical approach

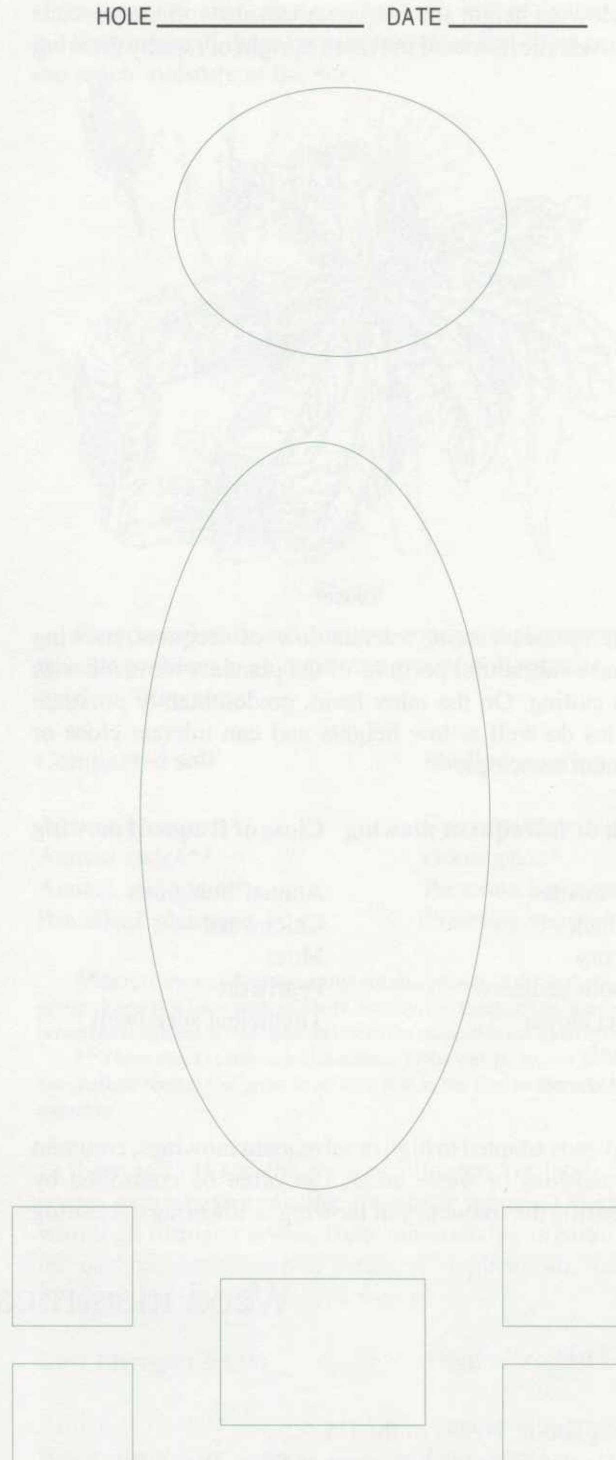
Scouting is relatively simple. The scout should divide the site into manageable units for recording the observed data. In the case of a home lawn, the manageable units could be the front, the back and the sides. In the case of a golf course the units could be the individual holes divided into tees, fairways, greens, and roughs. For larger areas such as large facilities, the units could be areas that either have a consistent environment, maintenance priority, use pattern, or some other logical ways of division.

Each unit should be have the same "treatment threshold". That way each unit will require the same level of input, thereby making treatment decisions less complicated.

Walking and riding in zig-zag patterns

Walking or riding over each unit in a zig-zag pattern is the proper appraoch, stopping at key areas that have a history of weed infestation. High-priority sites require a tight zig-zag pattern, while low-priority sites should have a more open pattern. Record observations on a site map. If you are scouting a golf course you may want to use a schematic map such as the one used in the Cornell University golf course IPM scouting program shown at right.

Schematic Golf Course Map



Map and Identification key courtesy of Cornell University

If you will be scouting a large facility, make up a series of maps that represent the areas to be scouted on a grid paper. Make multiple copies of each map and store them in a three-ring binder. Be sure to include the area identification, the date scouted, any other information that you feel that you will need, and a section for comments at the bottom of the page.

For home lawns, a representational map drawn on graph paper while scouting the site is an easy way of handling this type of location. If you will be scouting the area on a consistent basis, then an exact representational map of the area will be very helpful, particularly if you are scouting for multiple pests.

Make sure you have an identification key, such as the one on page 5, on each map sheet, or one key for all maps pasted on the inside of the binder or on the back of a clip board. The consistent use of the key and the recording of the identifying symbols on the maps are essential to the long-term success of IPM scouting. This consistent recording of scouting observations will allow the the collection of data to establish long term trends and patterns of infestation, gauge the success of the control strategies used, and provide the data for predictive pest management models.

Customize the identification keys to reflect your local and regional conditions and pest infestations. Group the weeds by type, dicot versus monocot, by season of their usual appearance, such as summer annuals versus cool-season weeds, and finally by difficulty of control, such as Veronica and Wild Violets versus dandelions and clover. As you become more familiar with the techniques of scouting you will find it easier to cluster easily-

# on map	WEED	% of area infested 1-10	11-20	21-50	>50	Pattern
BL	General Broadleaves					
D	Dandelion					
Cl	Clover					
Pl	Plantain					
	Red Sorrell					
Ck	Chickweed					
Csp	Corn Speedwell					
Kn	Prostrate Knotweed					
Sp	Spurge					
Ox	Oxalis					
	Special Broadleaves					
Vf	Veronica Filiformis					
Gi	Ground Ivy					
Ha	Healall					
Wv	Wild violet					
Yw	Yarrow					
Ws	Wild strawberry					
Mw	Mugwort					
AG	Summer Annual Grasses					
Cg	Crabgrass					
Ft	Foxtail					
By	Barnyard					
Wg	Panicums (witch)					
Gg	Goosegrass					
Ns	Nutsedge					
Ab	Annual bluegrass					
Bm	Black Medic					
Bt	Birdsfoot treefoil					
PG	Perennial grasses					
Tf	Tall fescue					
Nw	Nimbleweed					
Vg	Velvetgrass					
Og	Orchardgrass					
Qg	Quackgrass					
Rg	Ryegrass					
	OTHER					

Areas: T=Tee F=Fairway R=Rough G=Green
Patterns: S=Spotty P=Pattern TH=Throughout

controlled weeds as general broadleaf weeds, rather than individual species.

When should you scout?

Weed scouting is a continuous process. Each time you are on a site, look for new weed problems and make sure the information is entered on the map. The designated scout will know if the observed pest has already been identified or if the infestation is new and requires diagnosis.

The site should receive a formal comprehensive weed scouting once or twice a year. How often a site is formally scouted should be a function of the expectations and the use pattern of the site. If the site is a low maintenance, out-of-view site, then a once-a-year scouting is appropriate. If the site is a high-visibility location, such as the entrance to a corporate headquarters, a golf course, near the boss's window, then at least two scoutings each year are necessary.

The most important time to make a formal scouting in the northern tier of states is in late summer to early fall. During these times the scout can:

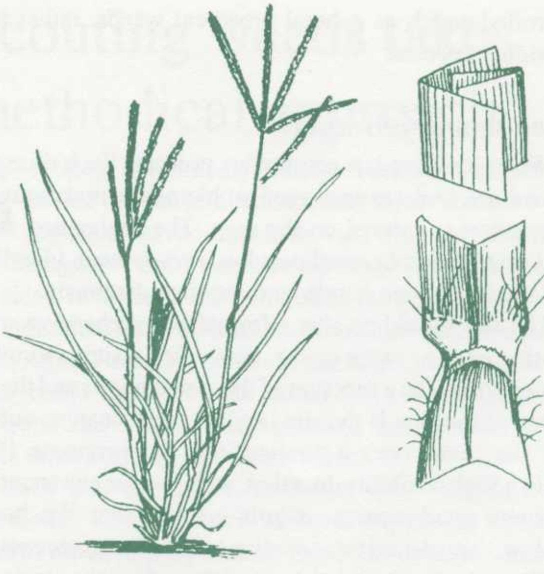
- formally gauge the success of control strategies employed in the spring and summer months,
- monitor populations of summer annuals, newly emerging cool season weeds, and left-over biennial and perennial weeds,
- make new or additional control recommendations for the fall,
- have sufficient time to accomplish any changes necessary to modify site conditions or contributing factors,
- allow enough time to reassess existing control strategies over the winter.

A secondary scouting can be made on high-visibility sites in the late spring or early summer period. This second scouting can:

- gauge the effectiveness of actions taken in the fall,
- identify newly emerging summer monocots such as crabgrass or goosegrass,
- make recommendations for the control of newly-emerged or immature weed populations while they are still vulnerable to control measures,
- make an assessment of the success of management strategies regarding turf health and density.

Scouting times for warm-season grasses

Scouting times for areas with warm-season grasses, areas growing in moderate climates, or sites under special local environmental conditions will need additional scoutings and soutings at different times. For these regions, your local cooperative extension agents can help you decide when to scout. Cooperative extension agents may also have information on local conditions, probable weed species, or unusual circumstances that can make your scouting efforts that much more efficient. ■



Goosegrass, silver crabgrass

Using IPM continued from page 3

- mature healthy turfgrass plants have an advantage over newly emerging or immature weed species,
- some weed species grow better in conditions that do not favor turfgrass species,
- higher leaf densities of healthy turf produce lower soil temperatures which discourage weed species that germinate at high soil temperatures.

When to use chemicals

It is true that dense and healthy turf is the best, first line of defense to weed infestations. Maximum beneficial cultural practices, fertilization practices, site varietal selections, site construction, and site utilization practices will produce a turf with little or no weed infestation problems.

Sometimes when funds for maximum beneficial practices are limited, it will be necessary to use chemical herbicides to achieve the desired results. Selecting the right herbicide and formulation from among the many that are available can be challenging. Listed below are guidelines in determining the choice of a herbicide:

- **Efficacy of control of the target weed species.** Will the herbicide work?
- **Longevity of residual control.** How long does the control last if the herbicide is a pre-emergent? Does it require multiple applications and will its use interfere with later plans to reseed?
- **Phytotoxicity.** Will it cause damage to the existing turfgrass species and if it does, can the turfgrass tolerate such damage?
- **Weed growth stage.** Will the herbicide work as a post-emergent if it is designed to be a pre-emergent? Should a post-emergent be used instead?
- **Weed control spectrum.** How many other weeds besides the target species will it control?

Legislative Watch

Herbicide, pesticide bills

The 1994 federal legislative calendar has several new bills and legislative reauthorizations pending that will may have effects on the turfgrass management industry. They are:

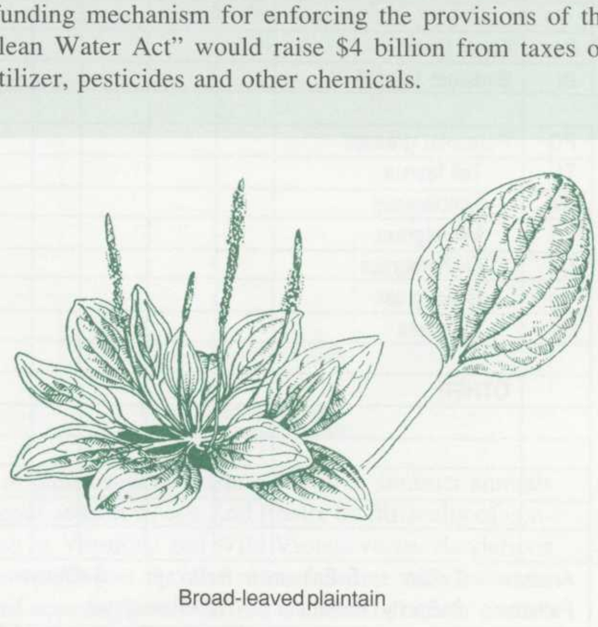
WPS: The Worker Protection Standards become effective in April. The WPS require new labeling of all affected pesticides as well as new training, protective clothing and the establishment of reentry periods for worker safety.

CERCLA: The Comprehensive Environmental Response, Compensation and Liability Act of 1980, the enabling legislation known as the Superfund Law is up for reauthorization in the fall. The reauthorization is expected to loosen the cleanup requirements so that sites can be cleaned up to a level that is appropriate for their probable uses, not the current standard that requires maximum cleanup of all sites regardless of their intended uses. To date the number of actual cleanups has been limited by massive legal wrangling over the high costs of reclaiming sites to the high standards of the existing legislation.

RCRA: The Resources Conservation and Recovery Act has several proposed regulatory changes pending that would reduce business regulatory requirements that would save almost a billion dollars a year.

HR 2543: Is new legislation that would extend certain provisions of the existing "Coastal Zone Management Act" to the whole country and would limit fertilizer applications to no higher than university recommendations.

HR 2199: The Polluter Pays Clean Water Act which is a funding mechanism for enforcing the provisions of the "Clean Water Act" would raise $4 billion from taxes on fertilizer, pesticides and other chemicals.



Broad-leaved plaintain

up in Congress in 1994

S 1114: Water Pollution Prevention and Control Act contains amendments regarding point and non-point source pollution control by mandating site management plans in many areas.

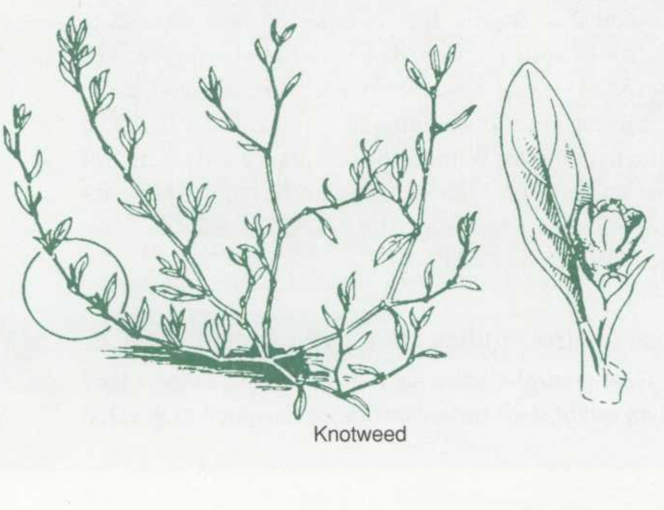
S 1547: Safe Water Drinking Act reauthorizing legislation that extends the provisions of that legislation to cover all surface and groundwater drinking water supplies.

HR 1360/ S 389: Would establish new containment standards on above ground storage tanks by establishing standards.

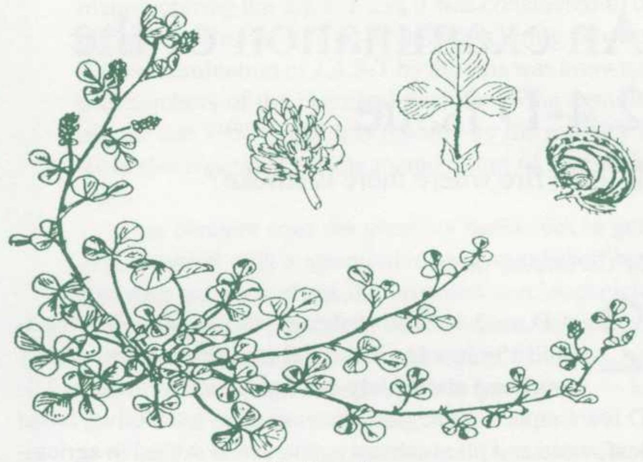
HR 1627/S 1478: Would replace the Delaney clause that prohibits any residues of pesticides that are potential carcinogens with a risk threshold of residues that may cause cancer in one in one million people exposed. Additional provisions would target agriculture to have 75% of all acreage under integrated pest management by the year 2000 and streamline the Environmental Protection Agency's (EPA) ability to remove suspect materials from the market place.

HR 967/S 985: The Minor Crop Pesticide Act would amend current standards of the legislation authorizing pesticide registrations, to allow or preserve pesticide registrations of minor-use pesticides whose registration is not being renewed for economic reasons.

HR 2910: The Risk Communication Act would require the EPA to conduct risk assessment studies on all matters regarding public health, safety and environment hazards and discuss information on the data, the methodology of the study, and use scientifically objective information when evaluating these risks.



Knotweed



Black medic

- **Application equipment requirements.** Do you have the proper equipment to make the application?
- **Environment at the time of applications.** Does the label preclude the herbicides use at your site because of minimum weather standards, location of bodies of water, site usage, or site topography?
- **Proximity of susceptible non-target species.** Are there landscape plants or trees that would be adversely affected by its use?
- **Environmental and mammalian toxicity.** Does the herbicide pose a safety problem to humans, animals or the environment?
- **Economics.** What will the use of the herbicide cost? What are the total labor, equipment and product costs?

Once you have made your preliminary selection, take two more steps. First, contact your local cooperative extension office, the state department of environmental control or the licensing agency to make sure that the herbicide is registered for use in your state. If it is a restricted-use pesticide, make sure that you know about the circumstances for the use of the product in your state. Second, contact the facility or site manager for approval of the herbicides. It may be required or you may just do it as a courtesy. You may be required to notify your client with the details of any restricted-use pesticide within 30 days before the use of it. If a nonrestricted-use pesticide has been applied, make sure that the application does not pose a hazard to people or pets. Post the area with signs or barricades, whether your state requires such action or not.

IPM is the future

The adoption of IPM weed control strategies will maximize the health and density of the turfgrass and minimize your weed pest infestations while dramatically reducing the potential for adverse effects to people, animals and the environment. ■

An examination of the 2,4-D issue

Is there fire where there is smoke?

by Christopher Sann

2,4-D, or 2,4-dichlorophenoxyacetic acid, first registered 45 years ago in the U.S., may be the most widely produced and widely-used pesticide in history. 2,4-D is a simple organic acid that is used as a selective, broad leaf, weed and plant control agent. 2,4-D is used in agriculture and forestry, for weed control on rights-of-way, on range lands, in parks, on golf courses, in water for aquatic weed control, and for commercial and residential turf management.

When 2,4-D is applied to plants it is absorbed through both the leaves and the roots. Once absorbed, it is sent throughout the plant by the vascular system, where it stimulates growth by simulating the action of naturally-occurring plant hormones. Older cells are rejuvenated and young cells are overstimulated causing abnormal growth and plant death. The internal plant functions that are affected by 2,4-D are cell production, enzymatic activity, and the carbon dioxide-oxygen respiration cycle. In addition it affects nucleic acid and protein synthesis, and the flow of water and nutrients through the vascular system. 2,4-D affects all plants to some extent, but it develops its selectivity because broad leaf plants have a larger surface areas than grasses and they absorb more of the material.

It was estimated that almost 70 million pounds of the active ingredient of 2,4-D was produced and used in as many as 1,500 different products and formulations in 1990. With this wide use has come a substantial amount of scientific testing. It was estimated that more than 40,000 scientific articles had been written about 2,4-D by 1978. Many more studies have been conducted in the 15 years since. None of these more than 40,000 studies have raised any significant concerns about the safety of 2,4-D.

A recent history of concerns about safety

Speculation about the safety of the phenoxy herbicide 2,4-D began in the late 1970's with the controversy surrounding the use of 10 million gallons of Agent Orange, a phenoxy-based herbicide mixture that contained 2,4-D. It was sprayed by the U.S. military to defoliate the jungles during the Vietnam war. In that uproar 2,4-D was not suspected as the controversial compound in the mixture but rather a dioxin-contaminated, ester formulated herbicide, 2,4,5-T or Silvex, was believed to have caused a variety of long term symptoms to American soldiers who had direct exposure to the material years before. The 2,4,5-T was itself not suspected of causing the observed problems so much as the dioxin. This dioxin contamination was a by-product of

Notes on 2,4-D studies

by Christopher Sann

As I researched the information for and wrote about the safety of 2,4-D in the preceding article, I became frustrated and bewildered. Frustrated enough that I felt the need to comment on my feelings.

Questionable techniques in control studies

I am frustrated about the use of such questionable survey techniques in the scientific community. Specifically, I don't understand why the researchers associated with the National Cancer Institute continued to release the questionable conclusions of their case control studies on the safety of 2,4-D over a period of five years, when the use of the study technique to establish a direct link between a cause — exposure to 2,4-D — and an effect — elevated levels of three cancers — was highly controversial.

The Institute continued to release its conclusions of successive studies even though the conclusions from its earlier studies had received a universally negative reaction to the design and the execution of those studies when they were examined by peer review panels.

New scientific theories generated by good science

The nature of the scientific process is rife with controversy, and has been for hundreds of years. Controversy may stimulate advances in scientific knowledge because of efforts by scientists to defend their theories in the face of established dogma. But, in order for new theories to displace existing theories, they must have been generated from good science. Good science is a process by which an established set of procedures and protocols are followed to test hypotheses. Without the acceptance and practice of good scientific procedures, all scientific inquiry becomes a complicated version of Abbott and Costello's classic piece "Who's on first?".

Case control studies are a part of good science

Case control studies are a part of good science: they are an established survey technique designed to develop an hypothesis concerning the possible cause of an occurrence. This is done by using an established format with well-designed procedures to try to establish a possible cause or hypothesis. Once the hypothesis has been developed, then a series of specific, controlled follow-up studies are performed to test the hypothesis. It is the results of these follow-up studies that must support the hypothesis in order for the hypothesis to become accepted as fact.

A well-designed case control study should meet certain criteria. First, it should have an appropriate control group to eliminate as many confounding factors as possible. Second, it should survey a large enough group of individuals so that the results can have statistical significance.

Because of the many unique aspects involved in designing case control studies, there are few if any off-the-shelf design directions to follow. It is left to the individual scientist to account for variables in his design. If the study is not well designed, or if it contains a significant number of sampling errors or confounding variables, then it is imperative that the examining scientist take these weaknesses into account and use caution when formulating his conclusions. If, as is the case with many human case-control studies, the scientist's concern for the specific health implications of the study override these cautions, then it is of utmost importance that the scientist make a major effort to see that his conclusions are rendered in the light of concerns for accuracy.

2,4-D case control studies were flawed

Unfortunately, it does not appear that these cautions or concerns for accuracy were the overriding considerations in the design, execution and conclusions of many of the case control studies on the safety of 2,4-D. All of this would not be of such concern if it weren't for the fact that the concerns for the safety of 2,4-D raised from these studies came at a time when questions about the use of pesticides in general and specifically by turfgrass managers were already at an all-time high. Whether they manage large facilities or home lawns, turfgrass managers are highly visible and are often the public's first and only direct contact with pesticide use or its users. The National Cancer Institute studies have made turfgrass managers' lives considerably more difficult and for no apparent reason.

There is an old saying in the data processing industry that seems appropriate in this context: garbage in, garbage out. ■

manufacturing the 2,4,5-T and it was considered to be difficult to eliminate from the manufacturing process. The contamination of 2,4,5-T by dioxins was known to the members of the chemical manufacturing community in late 1950's and was ignored by the military in their specifications for the manufacture of Agent Orange.

This concern over the phenoxy herbicides in general, coupled with a speculative study published by a Swedish scientist about the potential carcinogenicity of 2,4-D, 2,4,5-T, and their contaminants' connection to several unusual cancers — Hodgkin's disease, soft tissue sarcoma, and non-Hodgkin's lymphoma — led the EPA to issue the following statement in 1980.

"...EPA believes that available information on potential adverse health effects of 2,4-D does not warrant a regulatory action to remove its products from the market. The agency also does not see imminent hazard or unreasonable health effects when 2,4-D products are used according to label instructions and precautions."

This statement was issued despite the fact that the EPA had already suspended the registration and all uses of the suspect herbicide, Silvex.

Six years later, the National Cancer Institute published the results of a study of Kansas farmers. The study stated that a connection existed between the use of phenoxy herbicides for more than 21 days per year and a small increase in non-Hodgkins lymphoma. That study did not single out 2,4-D but covered herbicides in general. In response to some questions about this study, four independent reviews of the methodology employed and the conclusions reached in this Kansas study were initiated. All four of the reviews concluded that the study's conclusion of a cancer risk from exposure to 2,4-D was not supported by the data.

Undaunted, the Institute published a report in 1990 that said the same cancer link existed in a study of Nebraska farmers. A blue-ribbon panel conducted by the Harvard School of Public Health concluded that the link between the herbicide and the cancer that the new Nebraska farmer study had alluded to had not been established.

In 1991 the Institute published the results of yet another study that claimed to establish a link between the use of four applications of phenoxy herbicides per year on home lawns and the development of malignant lymphoma in dogs. Another review of this third Institute study concluded that because of poor design of the study, the conclusions about cancer in dogs was not shown.

Finally, the Institute published a fourth study concluding that there was a slight increase in the occurrence of cancer in Nebraska farmers. This conclusion was made despite the fact that there did not appear to be an increase in the occurrence of the cancer in the surveyed population with the passage of time nor was there a reduction in its occurrence when the farmer/applicator used protective clothing during the handling of the herbicide.

Studies show human exposure is low

The three possible human exposure routes to 2,4-D are the same as any pesticide:

- dermal: through the skin,
- ingestion: through the stomach and intestines,
- inhalation: through the lungs.

Because of the manner in which 2,4-D is applied, the predominant routes of exposure are through inhalation and dermal exposures. Ingestion of significant quantities of 2,4-D would be by a deliberate act or by accidental poisoning.

Human exposures are in five groups — farm workers, forestry workers, commercial applicators, homeowners, and bystanders. In the studies of farm workers, the potential for exposures averaged from 0 to 40 hours per year. Homeowner exposures depend on the frequency of use by the homeowner, but it can be assumed to range between 0 to 4 hours per year. Bystander exposures would be either accidental or by proximity to an area of application and would range from 0 to 2 hours per year. Forestry workers averaged 0 to 160 hours per year while commercial applicators have the highest potential exposures at 0 to 300 hours per year.

several cases they lacked clothing such as shirts and or had leaking equipment.

Actual measured exposures of various individuals in the groups varied from no detectable amount, less than 4 parts per billion, to about 1 part in ten million per 2.2 lbs. of body weight. Using information based on records of actual exposures, a hypothetical member of each group with an average body weight of 154 lbs. would have an average estimated daily exposure, see table below.

In general, human exposures and exposure quantities were determined by the type of application equipment used, the way it was used, the safety precautions taken in the application process, and the frequency of application. Applicators were at the greatest risk of exposure, homeowners had a very low potential for exposure and by-standers had the lowest potential of exposure.

98% of 2,4-D is absorbed through the skin

All available data indicate that 98% of 2,4-D absorption is through the skin, but tremendous differences of absorption rates, depending on the formulation and the area of the skin exposed, make it difficult to make a general statement about dermal absorption. But one might say that, if the exposure were by ingestion, as much as 25% would be absorbed within a half hour, and virtually all absorbed within 24 hours.

Once in the blood stream, 2,4-D spreads throughout the body but does not remain. About 90% of it is excreted in the urine within a week of exposure with the majority lost within the first two days. The remaining 10% of the 2,4-D is excreted through perspiration, most within two weeks.

The fact that almost all of the absorbed 2,4-D is excreted is important. It indicates that it does not lodge in tissues that have a potential for chemically-induced change and that any one exposure that occurs will be of a minimal duration, usually less than five days. 2,4-D is excreted chemically intact.

Because of its basic chemical composition, it does not

Average estimated daily exposure

Group	Average Exposure	Equivalent	Actual Product *
Homeowner	< 10 micrograms	< 1/48,000,000 of a lb.	0.0009 of a fl.drop
Bystanders	none	———	———
Farm workers	< 0.5 milligrams	< 1/480,000 of a lb.	0.009 of a fl.drop
Commercial applicators	< 0.5 milligrams	< 1/480,000 of a lb.	0.009 of a fl.drop.
Forestry worker	< 1.0 milligrams	< 1/240,000 of a lb.	0.09 of a fl.drop.

* based on a herbicide with a 25% 2,4-D component

Potential exposures are not always realized

Studies show that 90% of homeowners tested were found to have had no detectable residues and 100% of tested bystanders had no detectable residues from any application method other than by airplane. Studies estimating detectable farmer exposures are not available. Testing of forestry workers found that more than 70% of the over 500 aerial application crews tested had no detectable exposures, while the high exposure levels that were found among ground application crews were the results of failures of the workers to wear protective clothing other than gloves and boots. In pounds that have caused cellular breakdowns or tissue damage.

Scandinavian, U.S. studies complicate issues

However, the Hardell studies conducted in Scandinavia and NCI studies of human exposures in the Midwestern U.S. indicating that 2,4-D has a low potential to increase Non-Hodgkins lymphoma complicate the issues of whether 2, 4-D causes cancer.

Use of case control studies to determine direct relationships is controversial

There has been considerable scientific controversy about the methodology employed in the original two sets of human studies that indicated increased potential for cancers. The studies conducted in 1978 by Hardell and the National Cancer Institute in the 1980's were based on case-control studies.

Case control studies are general surveys of a specific population of individuals with the intent of determining the potential relationship between abnormal levels of an occurrence and the qualifications for that group. Prior to the Hardell study this study technique had not been used to determine if a particular substance had produced a particular outcome.

This methodology used to identify specific cause and effect relationships has led to acrimony in the scientific community. In the Institute study, survey participants were asked to remember specific information about phenoxy herbicide applications made as many as 30 years before the interviews, information such as days of use per year. Often the information was obtained from the next of kin who may or may not have had any direct information about specific compounds applied or the number of times applications were made.

Peer reviews of the survey methodology employed in the Institute's Kansas study has indicated that because of real-world farming considerations, the majority of the farmers in the survey did not meet the annual exposure data cited in the conclusions of the study, thereby limiting the number of qualified subjects. Also the number of reported cases of non-Hodgkin's lymphoma was so low that the data were not entirely statistically sound.

Case control studies often are not designed to eliminate confounding elements, such as exposures to other compounds or cigarette smoke. Even in studies designed to explore the various hypotheses developed by case control studies, it may be very difficult to control for these confounding variables. In a 1981 study designed to confirm the case control survey conclusions on phenoxy herbicides, over 1500 of the participants had been exposed to other pesticides, including individuals that had been exposed to up to three fungicides, nine insecticides, and 14 herbicides, some of which are known carcinogens.

Additionally, if these confounding factors could be controlled, this survey technique had no means of actually measuring direct exposures to the phenoxy herbicides. Using current exposure data from farm workers — 21 days or more of 2,4-D exposure — the standard identified in the Institute studies as the low parameter for exposure, would produce a hypothetical 120 microgram/ 1 kilogram of body weight as the annual exposure of survey participants. This rate of annual exposure would have made 2,4-D the most potent carcinogen known to man. Animal studies using dosage rates of at least 10 times that annual exposure rate and often thousands of times that rate would have expected to produce significant numbers of tumors. This has not been the results of such tests.

Subsequent case control studies are controversial

Since the original National Cancer Institute case control studies, there have been a number of additional so-called cohort studies aimed at confirming the results of the Institute conclusions. There have also been a number of additional case control studies to examine other potential exposures or risks with phenoxy herbicides. Cohort tests are used to try to reproduce the original results either through direct, tightly-controlled testing or, in the instance of human exposures through, examination of other populations of similar subjects.

In 20 recent cohort studies conducted since 1980, a few of the studies have indicated that some elevated results were found to have exceeded expected cancer occurrences, but the types of cancers reported and levels of the elevated responses did not fit any consistent pattern.

A significant number of additional case control studies have been conducted since the initial Swedish studies. Almost all of them suffer from the same problems as the National Cancer Institute studies, primarily a failure to establish consistent results and failure to establish exact exposures.

2,4-D does not appear to cause cancer

It may be said all the studies dealing with the safety of 2,4-D indicate that the conclusions of the Swedish and National Cancer Institute studies are not supported by the evidence. To be specific, 2,4-D is not:

- retained in the body but is rapidly excreted making exposures of short duration,
- metabolized into potent intermediate metabolites associated with other human carcinogens,
- chemically-connected to known human and animal carcinogens,

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News Briefs

New software

SimCity to SimFarm

The software producer Maxis has introduced a new companion title to its already successful SimCity and SimAnt software packages. Called SimFarm, the new software was devised with the help of farming experts to offer players the opportunity to succeed in their agribusiness careers or lose their farms to the auctioneer's gavel. The players choose the equipment, buildings, seed, fertilizer, pesticides and practices that they will need in their quest to battle the elements, in the forms of floods, droughts, and violent storms, to bring in a profitable crop and stave off possible bank foreclosures.

Ohio State University study

Shredded paper mulch better than wheat straw

A recent study from Ohio State University has shown that a new mulch has positive results when used in horticultural and agricultural situations. The new mulch produced higher yields, warmed the soil better, provided adequate weed suppression and was environmentally friendly when compared to the control material, wheat straw. The new, improved, low-cost mulch was made from shredded recycled paper.

Cornell University study compares clippings yields

Low maintenance turf growth rates compared

Cornell University compared the average clippings yield per cutting of eight mixtures of commercially-available seed blends and found that blends with high hard fescue content produced the least amount of clippings per cutting. The eight blends ranged from mixtures of ryegrass, bluegrass and fine fescues to all dwarf tall fescues, all bluegrasses, and all fine fescues. Each area was established under the same excellent seed bed conditions so difference in establishment characteristics were minimized. The table lists the seed blend and their average clippings yields.

Seed blends and average clippings yields

Blend	Species by %	Av. Clipping Yield	Clipping Yield
Loft's Ecosystems Ecology	80% hard,20%chewings fescue	2.0lbs*.	87lbs.**
Lesco Fine Fescue Links	30% hard,20% chewings, 40%creeping,10%sheeps	3.4	147
Scotts Perfect Choice Shade	30%bluegrass,30%hard,30%chewings	3.6	158
Agway Low Maintenance	15%ryegrass,15%bluegrass,50%hard, 20%chewings	5.0	219
Pennington Drought Tolerant Bluegrass	100%bluegrasses	6.1	268
Agriturf Far Rough	20%ryegrass,10%bluegrass,30%sheeps, 40%hard	6.4	281
Lesco Dwarf Tall Fescue	100% tall fescue	6.8	298
Agriturf Safelawn	50%ryegrass,25%chewings,25%hard	7.4	322

*(lbs./m.s.f.) **(lbs./A.)

TGT's view: *If reduced mowing is the primary objective, a low maintenance seed blend should not contain either ryegrass or tall fescue. If the area is subject to some traffic or wear then the inclusion of drought resistant bluegrasses will not dramatically increase clippings. If the area requires the lowest inputs possible, then the blend should be exclusively fine fescues with a heavy or complete emphasis on hard fescue varieties.* — CS.

University of Maryland study

Pre-emergent herbicides work the following summer

When pre-emergent herbicides were applied in November some showed excellent crabgrass prevention 10 months later. In an effort to widen the window of effective application times, testing at the University of Maryland found that when single applications of the pre-emergent herbicides, Pendimethalin, Prodiamine, and Dithiopyr were made late in the fall at sufficiently high rates, they provided smooth crabgrass control that ranged from 77% to 100% the following summer. The data in the table below shows a summary of the Maryland tests.

Pre-emergent herbicides effects on crabgrass

Herbicide	Form	Rate*	Rank	Average % Controlled
Pendimethalin	60.00DG	1.68	12	3.5
Pendimethalin	60.00DG	2.24	11	31.5
Pendimethalin	60.00DG	3.36	9	65.5
Prodiamine	65.00DG	0.43	6	82.0
Prodiamine	65.00DG	0.56	2	93.5
Prodiamine	65.00DG	0.73	4	89.5
Dithiopyr	1.00EC	0.43	8	67.0
Dithiopyr	1.00EC	0.56	5	88.5
Dithiopyr	1.00EC	0.84	1	97.0
Dithiopyr	.25G	0.28	7	69.0
Dithiopyr	.25G	0.43	3	91.5
Oxadiazon	2.00G	4.48	10	37.5
Untreated Check	13.00			0.0

* kilogram/hectare

***TGT's view:** The older established spring-applied herbicide, Oxadiazon, did not provide acceptable crabgrass control when applied in the late fall, and Pendimethalin only when applied at very high rates. The newer materials, Prodiamine and Dithiopyr, provided good to excellent control at all but the lowest rates. Dithiopyr in the .25% granular formulation showed excellent control at substantially lower rates than the 1EC formulation, indicating that this herbicide is particularly effective on a granular carrier and that the liquid application may require watering in to reach its full effectiveness. —CS*

California study

Oxadiazon enhances buffalo grass establishment

Buffalo grass is an increasingly important alternative species in drought prone areas. But it is slow to establish when plugged because of competition on from annual weeds. A California study of buffalo grass and pre-emergent herbicides showed Oxadiazon as the herbicide that provided the best annual weed suppression while allowing for the greatest lateral growth of the species. The table below lists some of the results of this study.

Pre-emergent herbicides and buffalo grass establishment

Herbicide	Rate	Rank	Buffalo grass cover	Weed Cover
control	—	—	16%*	44%**
Oxadiazon (50WP)	0.71*	1	89%	0%
DCPA (75WP)	3.60	2	58%	14%
Pendemethalin (60WDG)	1.10	3	44%	4%
Trifluralin (4E)	0.20	4	37%	22%
Benefin (60WDG)	0.71	5	36%	25%
Dithiopyr (1EC)	0.20	6	21%	16%
Bensulide (4EC)	3.60	7	15%	37%

* ounces per 1,000 square feet
** average % buffalo grass cover
*** - average % weed cover

***TGT's views:** The good-to-excellent weed prevention that DCPA, Pendemethalin, and Dithiopyr provided did not translate into good buffalo grass cover. Oxadiazon was the only material to gave both excellent weed prevention with low toxicity, the problem with all of the other herbicides checked. —CS*

Environmental leadership is an opportunity

by Dr. Eric B. Nelson

I have always been impressed with everything about turfgrass management—the complexity of the turfgrass ecosystem, the intensive management systems, the sophistication of the equipment used, the general education level of turfgrass managers, and their ability to grasp research results and complicated technical concepts. All in all, turfgrass managers and the turfgrass industry in general are a highly sophisticated and competent group of people.

From my perspective as a researcher, this means that I can present complicated concepts and expect they will be understood. It also means that, because of the sophistication of the industry, and the intensity with which turfgrass is managed, turfgrass managers have a considerable array of problems in need of answers. Some require more immediate solutions than others.

I compare the turfgrass industry with other agricultural enterprises. I have been involved in my career with floriculture, nursery growers, vegetable growers, and cotton and soybean growers. I have to say that, of all of these, turfgrass managers, more than any other group, recognize the complexities of their management systems and the important needs of the industry as a whole. Furthermore, they recognize the value of continued and sustained research efforts to the long-term viability of the industry. This is evident from the many turfgrass associations, lawn and landscape associations, and golf course superintendents associations.

Turfgrass industry must lead

From my academic point of view, and from my perspective as an outsider looking in, I see a number of important issues in which the turfgrass industry must either remain a strong leader or rise up and meet new challenges. Turfgrass managers must remain leaders in the environmental movement. Nearly every turfgrass manager that I speak with considers themselves an environmentalist; no, not the extremists that we typically hear about, but people genuinely concerned about the environment in which we live. The value of turfgrasses in conserving safe green spaces in an otherwise congested and polluted environment must be strongly promoted. Aesthetic values of turfgrasses aside, the beneficial properties of turfgrasses to the environment must not be allowed to be lost in the coming changes.

With its deep understanding of the complexities of nature, the turfgrass industry is uniquely positioned to take on the challenges of the growing pesticide issue. It can set an example for all horticultural and agricultural enterprises, by demanding and adopting new, more sophisticated non-chemical and biologically-based pest control methods.

As we've mentioned previously in *Turfgrass Trends*, it is important that turfgrass managers remain technologically and scientifically literate. Again, you must set the example for the green industry as a whole and demand and adopt the latest technologies and help support the technological developments important to the long-term viability of your industry. This will require a commitment on your part to help fund the studies that must done to provide solutions to our problems. It will also require that each manager become more politically active; you must make legislators aware of the needs and benefits of the industry. Turfgrass managers must come up with novel ways of making the public aware of the value of the industry. Most importantly, you must get involved with young people to instill in them an appreciation for turfgrass and the exciting careers in the turf management fields.

Young people: ignorant of the turfgrass industry

I frequently talk to students about turfgrass management and turfgrass science. I often find that many either know nothing about it, other than they have a front and back lawn filled with it and its a pain in the !@#%* to mow. More commonly they are amazed that anyone would even dream of working with turf. To these students turf management serves no useful societal purpose and it takes limited resources away from food crop production.

It is evident from my conversations with students that there are some bad misconceptions about turfgrass. We need to make lasting impressions on these young people that turfgrass is something to be valued.

Some academics are equally ignorant

I also frequently talk with scientists about turfgrass research. Surprisingly, many have the same opinion of the "commodity" as younger students do. I find that many of these so-called educated academicians are even more resistant to the idea that anything useful could ever come out of turfgrass research. Many of my colleagues and I, in turfgrass science, are constantly justifying our existence and I do my best to educate as many as possible on the importance of turfgrass to society and the utility of doing research on turfgrasses to not only address basic problems in biology but applied problems of society.

-continued on page 15

2,4-D *continued from page 11*

- capable of causing cancer in laboratory studies even at very high doses,
- consistently linked with cancer risk in case control studies.

Finally, measured actual human exposures indicate that, if 2,4-D were a carcinogen, it would be the most potent known. Furthermore, the studies that show an increased risk of non-Hodgkins lymphoma were not designed to eliminate viral and genetic confounding factors, factors suspected of contributing to lymphoma occurrences.

The EPA has the final word

In response to the National Cancer Institute studies, the Swedish studies and lingering suspicions regarding Agent Orange, the Environmental Protection Agency (EPA) announced in 1992 its intention to establish a panel to review all of the available scientific data on the safety of 2,4-D. That panel was convened in the fall of 1992. The outcome of that panel's work was the establishment of new labeling standards for the use of 2,4-D products that were introduced in the spring of 1993 for farm, nursery and forestry workers. The new standards go into effect in April of 1994 and will require that workers exposed to the phenoxy herbicides use good protection practices with appropriate protective devices and that reentry periods be established for sprayed areas.

What does this mean for turfgrass workers?

The current worker protection regulations explicitly exempt most turfgrass management uses of 2,4-D from complying with the new standards.

Given the history of the controversy over the safety of 2,4-D and the nature of the environmental politics that surround this issue, turfgrass managers should err on the side of caution and make an effort to comply with the new standards. The EPA is clearly hoping that turfgrass managers will continue with their excellent record of compliance and adopt the new worker protection standards, before the EPA removes the exemption. ■

Leadership *continued from page 14*

Need for a pro-active stance

In summary, I hope that turfgrass managers will take a pro-active stance on promoting the profession by continuing to practice state-of-the-art management strategies, always striving to learn more about the industry and the academic support that goes into the industry. I hope all of you will become even more scientifically and technologically literate so the turfgrass industry will set the example of how plant management can function in harmony with sound environmental stewardship. ■

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