CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

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Integrated Biological and Chemical Pest Management

The future of golf turf management will be shaped by what we seek answers for today. Turfgrass research is maturing where more basic science is being used to understand practical observations. More research projects that address plant genetics, physiology and soil microbiology will lay a solid foundation for future management programs.

Applied research programs that address environmental concerns—such as reduced reliance on potable water and reducing pesticide use as a means of pollution prevention—are vital in an increasingly regulatory environment. Clearly, we are entering an important transitional phase where more people will be asked to use non-potable water and will be required to reduce pesticide use to be more environmentally compatible.

Important research addressing these issues is underway, especially the integration of biological control programs with synthetic pesticides. Studies have shown that certain biological products are more effective when used in combination with pesticides. This will result in an overall reduction in pesticide use and an increased understanding of the mechanisms of biological control.

Your Daily Microbe?

Fungal diseases of turf are a major concern throughout northern climates and new diseases are wreaking havoc on southern turf. Diseases can work quickly to destroy high value areas and often preventative fungicide applications are required. Biological control of diseases has been plagued with poor performance (inconsistency) and an inability to suppress diseases during an intense epidemic.

A system was developed (BioJect® System, Turf Labs, Inc.) to deliver a biological control organism, TX-1, proven in the laboratory to control dollar spot, brown patch and pythium diseases of turf. However, complications with the delivery system and an inability to deliver economic results has hampered its success.

Researchers Bresnahan and Drohen at the University of Massachusetts conducted evaluations of the BioJect® System in 1998. One objective of the study was to evaluate the ability of the BioJect® to suppress dollar spot on fairway turf.

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This Times

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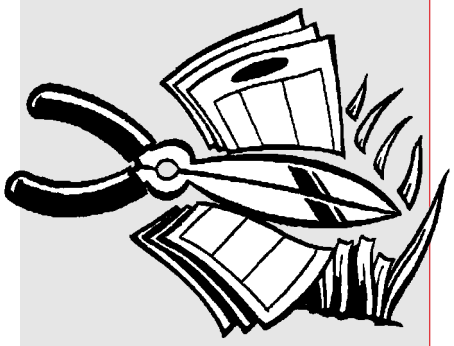
Clippings

For more than a decade NYSTA has provided over a half million dollars for turfgrass research. This research has helped to develop new technologies at Cornell such as emerging IPM and biological control products.

For 30 weeks, a succinct 2-page newsletter is emailed to NYSTA members with the latest weather records and forecast with exclusive access to a weather web site.



Turfgrass ShortCUTT

NYSTA Keeps You Informed

The 2003 season will be remembered for concerns over water use, devastating diseases and how to meet consumer demand for perfect turf with less pesticides. Each year meeting consumer expectations grows more challenging. The New York State Turfgrass Association is committed to assisting its members to meet that challenge through dedication to supporting research and education.

For more than a decade NYSTA has provided over a half million dollars for turfgrass research. This research has helped to develop new technologies at Cornell such as emerging IPM and biological control products. Cornell researchers have determined the movement of fertilizers and pesticides applied to turf, identifying key areas for managers.

Subsequently, the information is transferred in a meaningful way through the quarterly newsletter, *Cornell University Turfgrass Times (CUTT).* Yet it seems that information is needed in a more timely fashion now than ever before. Also, NYSTA members must be aware of research beyond New York's borders so that the best thinking can be brought to bear.

Several years ago the Cornell Turfgrass Team began the weekly electronic newsletter, *ShortCUTT* to meet the needs of an information hungry industry. Not only is the information the latest, but it is delivered in a timely fashion, right when you need it: during the growing the season!

For 30 weeks, a succinct 2-page newsletter is emailed to NYSTA members with the latest weather records and forecast with exclusive access to a weather web site. Also, regional observations from experts in the field and an update from Frank Rossi are included. Finally, there is a current topic that is discussed by the leading expert in the world. Much of the information is not available through any other source because of Cornell's unique access to university and industry experts.

As a NYSTA member the cost to you is simply supplying your email address. A major grant from NYSTA allows us to provide this service to you at no charge to members. So send your email address today to shortcutt@nysta.org and be ready when the 2003 season begins.

CORNELL Turfgrass ShortCUTT
Your Weekly Link to Turfgrass Information!

The latest research-based turfgrass information delivered to you every Monday during the growing season via email.

Be armed to succeed in 2003!

FREE to NYSTA members.

Supply email to shortcutt@nysta.org

Your Weekly Link to Turfgrass Information!

Defensive Disease Management

Pressure for "perfect" turf conditions remains high in spite of increased concern regarding the potential health risks of pesticides and pending restrictive legislation. A significant "middle ground" is available through the implementation of Integrated Pest Management (IPM) programs. A core aspect of IPM is the use of resistant species and varieties, yet significant site disruption seems to preclude widespread implementation.

A recent study conducted by researchers at Kansas State University investigated the relationship between bentgrass variety and fungicide use for disease control. Specifically, the project compared preventive and curative control programs on different bentgrass varieties. Four varieties were planted and managed as putting green turf and treated with a number of different fungicide combinations for the prevention and curative control of dollar spot and brown patch.

An important observation noted immediately was that none of the varieties provided adequate quality without a fungicide. However, L-93 was significantly more resistant than Penncross and Providence, which were more resistant than Crenshaw. The inherent resistance of L-93 allowed all fungicide programs to be reduced. Considering all varieties, a preventive strategy for dollar spot required more than twice (~30) as many applications as a curative program (~12 apps), however this was not evident for brown patch. Brown patch incidence was so severe a curative program could not help turf maintain acceptable quality.

The significant reduction in fungicide use in a curative strategy for dollar spot directly contradicts previous claims that a curative program will always use more fungicide. Clearly this is disease dependent and the importance of using resistant varieties is evident and likely worth the investment in time and resources in an era of concern with pesticide use.

From: Settle, D., J. Fry and N. Tisserat. 2001. Dollar spot and brown patch fungicide management strategies in four creeping bentgrass cultivars. Crop Science 41-1190-1197.

Compost Reduces Rust Disease

Landscape and sports turf professionals are regularly engaged in establishing new sites into turfgrass. Many sites are plagued with poor soil conditions due to the lack of adequate topsoil. Also, there are many long term concerns regarding the use of pesticides so that any effort at establishment that can aid turf health would be worth implementing.

Ohio State University researchers investigated the how the use of a biosolid (sewage sludge) compost material incorporated at establishment could influence turfgrass establishment. The compost treatment supplied about 2.5 lbs of N, 10 lbs of P and 3 lbs of K and plots were seeded with Kentucky bluegrass and perennial ryegrass alone or in a mixture.

The compost amended plots enhanced establishment at various periods throughout the study year. Differences for Kentucky bluegrass were not evident until week 5 while ryegrass plots treated with compost were twice as established as uncomposted plots in the 4th week. The differences persisted through most of the 52 weeks for the ryegrass plots, however, meaningful differences (>75% density ratings) ended after about 2 months.

Interestingly, the researchers observed significantly more rust (*Puccinia* sp.) in the perennial ryegrass that did not receive compost amendment. This effect persisted into the 2nd month of the experiment. The obvious explanation is that more nutrients were applied in the compost plots, yet a starter fertilizer and follow up treatment was made to plots not treated with compost. Furthermore, in the first two months of the experiment you would not expect a significant nutrient release from the compost, however leaf nutrient levels were not measured.

This study is the first of its kind to report how soil incorporation of a compost reduces the severity of a foliar pathogen. Of course when using compost it is vital for it to be tested properly for contaminants and consistency. Clearly there are many benefits to be enjoyed when a compost is used properly at establishment

From: Loschinkohl, C. and M.J. Boehm. 2001. Composted biosolids incorporation enhances establishment on disturbed urban soils and reduces leaf rust severity. HortScience 36:790-794.

Scanning the Journals

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Integrated Pest Management

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Daily applications of the organism were made following a 12-hour fermentation cycle. The organism was applied with a watering can between the hours of 9 pm and 12 am, to simulate nightly irrigation, not through the BioJect® System.

Dollar spot levels in the untreated plots were significantly greater than the action threshold that would require treatment (5 spots per 18 square foot plot). Dollar spot levels did not reach the action threshold in BioJect® treated plots and were similar to Daconil and Banner fungicide programs.

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Under more severe disease pressure, the BioJect® treatments provided 86% control but did not maintain acceptable quality turf, as dollar spot levels were well above threshold. Still, the BioJect® treated plots that only received Daconil or Banner when threshold levels were reached, reduced fungicide use approximately 70–80% as compared to fungicide treated plots without BioJect® treatment.

This preliminary study is the type of integrated research vital for reducing pesticide use during the transitional period until more effective biocontrol systems are developed. Yet, questions continue to plague the delivery system via irrigation lines.

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Clearly, the TX-1 organism developed by Dr. Joe Vargas at Michigan State University, when applied in the correct amount, is capable of reducing the need for fungicides. Further research will assist this technology by improving effectiveness. However, will superintendents be willing to reduce prophylactic sprays and set thresholds that allow for some infestation?

Grub Slow Down

Insect pests—as a result of their mobility and unpredictability—present a unique challenge for golf turf managers. Disease and weed pests often occur in specific areas as a result of environmental or traffic stress. However, distribution of insects in time and space challenge the most avid integrated pest management (IPM) practitioner.

Of all the pest issues influenced by the EPA's Food Quality Protection Act (FQPA), insecticide chemistry has been the most severely restricted. The focus on neurosystem-targeted chemistry, notably the organophosphate class of compounds, has eliminated the use of most rescue treatments (applications made once insect population is assessed). Consequently, the compounds left on the market offer mostly preventive control. This provides peace of mind but impedes potential reduction in overall pesticide use.

Entomopathogenic nematodes are an emerging biological organism for the control of soil inhabiting insects such as grubs. These wormlike organisms are able to infect the grubs and parasitize them, thereby causing their death. However, nematode performance, like most control systems that rely on a biological organism, is plagued by inconsistencies. Ques-

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Grub size strongly influences control programs.

tions have been raised and addressed regarding soil moisture, the amount of organisms to apply and specificity for different grub species. Many questions remain unanswered.

Recently, Professor Albrecht Koppenhofer of Rutgers University in New Jersey has led a team of scientists from Ohio, California and New Jersey in investigating a strategy that integrates nematode and insecticide use. Field and greenhouse studies demonstrated a synergistic interaction between nematodes and imidacloprid (Merit, Bayer Environmental Sciences).

The combination of the insecticide and the nematode improved grub control more than the simple addition of the control from each product used alone. Further some important mechanistic and logistical issues are being reconciled.

First, the nematode can be effectively tank-mixed with the insecticide without any loss in efficacy, an uncommon attribute among most biological control organisms. It appears that the efficacy of the combination allows each compound to be used at a reduced rate. Benefits include increased efficiency of the nematode, which can be costly to produce at high levels, and a 50% reduction in insecticide needed, which reduces overall pesticide usage.

From a scientific perspective, a key finding was the mechanism of the observed activity. It appears that the insecticide slows the grub's movement which facilitates the nematodes' ability to attach to and penetrate the grub. This finding alone could explain the reduced effectiveness of other nematode species that simply are not able to acquire their target. Incorporating this information into biological control studies could lead to important breakthroughs in soil insect management.

Judgement

A society can be measured by its investment in education and research. Junk science scandals and a need for short-term gratification has encumbered scientific advancements. Turfgrass research is but a small part of our national scientific community, yet it offers a highly integrated approach to understanding intensely human-managed landscapes.

A diversity of research that is a blend of basic and applied science is a requisite for meeting the needs of the turf industry. Results from this research should be readily implemented and focused on integrating technologies in an effort to improve our environmental compatability. After all, our compatability is how the majority of society will judge our efforts, not greens that roll eleven feet.

Frank S. Rossi, Ph.D.

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CUTT

Soil Insect Ecology and Turfgrass Entomology

Program Spotlight

A prime candidate is the annual bluegrass weevil (ABW). The ABW is a burgeoning pest problem in the Northeast and Mid-Atlantic, yet our current "best management practices" are too rudimentary to overcome its increasing pest status.

Two major challenges for the management of turfgrass insect pests are the inherent difficulty of studying subterranean insect behavior and the ever-changing face of the control environment. Pesticide restrictions and phaseouts, for instance, force us to reexamine pest biology in the search for new control opportunities, but efforts are stymied by our unfamiliarity with the soil habitat, and in particular how to access, interpret and manipulate interactions played out below ground.

The Soil Insect Ecology and Turfgrass Entomology lab is launching a new research agenda to begin to overcome some of these challenges and build on the expansive foundation constructed under the leadership of the late Dr. Mike Villani. We are structuring our approach around three points of entry.

Research Agenda

First, we will emphasize the key taxa as identified by stakeholder perception, injury levels, and the economic and environmental costs of current control strategies.

Second, we will address the most strategic research issues, considered as those that most transcend horticultural systems (lawns and golf courses, turfgrass and cranberries, temperate and tropical).

Third, we will focus on areas where our research group has a comparative advantage, such as advanced techniques for the evaluation of control products in the laboratory, radiographic techniques for the study of insect behavior below ground, and a strong collaboration with the chemical ecology lab for the study of insect pheromones. We believe we can have the most positive and rapid impact by addressing research issues at the intersection of these points of entry.

Research Initiatives

We are currently pursuing five initiatives. The first is a study of the specific biology and management of major turfgrass pests. Focused ecological studies are necessary if we are to keep up with the changing face of control opportunities and uncover new management opportunities. A prime candidate is the annual bluegrass weevil (ABW). The ABW is a burgeoning pest problem in the Northeast and Mid-Atlantic, yet our current "best management practices" are too rudimentary to overcome its increasing pest status. Gaps in our understanding of the pest's association with annual bluegrass limits advances in management. Our contribution will be to readdress pest biology, ecology and behavior to identify and exploit new windows for pest management. Rapid advances could be made in collaboration with the applied turfgrass entomology groups at UMass and Penn State, especially as we move from laboratory and greenhouse studies to field trials and ultimately the promotion and adoption of advanced management practices.

A second initiative addresses the orientation, detection and perception of subterranean insect pests to the soil habitat. How is pest be-

Annual bluegrass weevil infestation on a golf course fairway.

havior modified by the soil environment, such as the presence of pathogens, predators, pesticides, competitors, and host plants? Japanese beetle larvae can detect and avoid fungal entomopathogens, but we would like to understand how broad-based this perception is among other white grub species and soil insects in general. This research may open up new opportunities for baits and repellents as control tactics in specific turfgrass and horticultural systems.

A third initiative is on biological-based pest management. There is an increasing demand for more limited use of chemical pesticides in turfgrass systems. Under what circumstances can biological-based pest management be effective? Are these conditions widespread or reproducible? How can we overcome limits to the adoption of these technologies? We hope to more systematically investigate the additive and synergistic effects of combined tactics such as reduced rates of pesticides in tandem with biologicals. Limiting the economic and environmental costs of pesticides may require that we combine tactics into new management approaches, therefore we should evaluate insect susceptibility to control tactics while they are being challenged under different conditions.

A fourth initiative focuses on discovering and exploiting pheromones. In collaboration with the Chemical Ecology research team, we have a highly promising and productive opportunity to isolate and describe compounds from species of economic relevance, study the evolution and ecology of reproductive isolation mechanisms, and advance management applications such as monitoring schemes, mating disruption, and lure and infect systems.

A fifth initiative addresses the effect of control tactics on nontarget microarthropod communities. Although microarthropods are attributed a large role in certain soil processes, such as decomposition, our understanding of this major component of soil fauna is quite limited. In order to gauge the benevolence of pesticides used in lawn care, we are conducting field trials to test their effects on the abundance, diversity and function of nontarget arthropods, particularly those that are "out-of-sight, out-of-mind" without the aid of a microscope. Do these common lawn care products have an effect on nontarget fauna, such as mites and springtails, and is this relevant to soil processes, such as decomposition?

Our probability of success in launching these initiatives will depend on the outcome of exploratory research and funding proposals. The impact of our results, however, will be mediated by the depth of our dialogue with stakeholders and collaborators. We welcome your input.

Daniel C. Peck, Ph.D.

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1) key taxa as identified by stakeholder perception

2) the most strategic research issues, considered as those that most transcend horticultural systems

3) areas where our research group has a comparative advantage

Cornell Waste Management Institute

Compost Advanced Short Course

Three-Day Course Plus One-Day Optional Tour

One Time Offering • Limited Enrollment

October 26–29, 2003

Sunday October 26: Optional Tour

Monday-Wednesday October 27-29: Short Course

Holiday Inn Downtown, Ithaca NY

Topics:

Planning and Management

Feedstocks • Computing facility requirements • Odors and emissions • Filter strips • Pads and covers

Quality and Its Relationship to Compost Management

Biological indicators of compost quality • Disease suppressive quality • N, OM, weed seeds • Understanding the science of compost-plant interactions and micronutrients • Plant response

Testing/Labs/Consistency/Quality Control

Test methods • What to test for • Reading and understanding test results • How and why labs differ

Centralized Marketing and Facilities

Cooperative processing and marketing • Itinerant composters • Moving materials

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Panel and discussion

Marketing and Promotion

Potential use of labels and/or seal/certification programs • Panel: End-users—what do they need • What composters can do to meet consumer needs

Field Demos at Cornell University Composting Facility

What You'll Learn

Practical guidance using technical information to improve composting systems and compost marketing

Optional Tour

We will visit a variety of sites using different compost feedstocks, different composting methods and different end-product uses

Who Should Attend?

People with basic compost knowledge including:

- Private composters
- Consultants
- Certified crop advisors and nutrient management planners
- State and/or private soil and plant testing lab personnel
- Municipal composters
- Agricultural educators and advisors
- State environmental agency staff
- Agency staff: NRCS, Extension, Ag and Markets, DOT

Registration

Registration Fee: $275 before Sept. 15 ($325 after Sept. 15), includes materials, lunch, breaks, social hour
Optional Tour: $55 before Sept. 15 ($75 after Sept.15), includes lunch

Contact

For more information and to register:
Website: www.cfe.cornell.edu/wmi
Phone: (607) 255-1187
Email: cwmi@cornell.edu

Cancer Cause-and-Effect

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and the mothers of children late in the birth order are usually older. Being a later child does not cause the syndrome, it is only associated with it through the connection with older mothers.

Causality

Determination of a cause-and-effect relationship for a disease, or as it is frequently called in epidemiological circles, causality, is arrived at by the evaluation of the results from a large number of studies of the epidemiology as well as the basic biology of the disease. A set of standards for assessing causality were first formally set forth by a panel organized by the US Surgeon General during the 1960's. These standards established a set of experimental results which should be met to conclude that there is a cause-and-effect relationship between an event (exposure) and formation of a disease. Evaluation of how well these standards are met allow for determination of the strength of the evidence for exposure and disease associations. The standards are now known as the criteria for causality. Described below are the criteria for causality evidence for a cause-and-effect relationship between an exposure and a disease.

- Consistency of the association: The results of most studies agree using different methods and examining different groups of people.
- Strength of the association: The associated risk is strong enough to meaningfully affect the occurrence of the disease in real-life settings.
- Dose relationship for the association: There is a clear trend in the size of the risk of the disease that increases (or decreases) with the extent of exposure.
- Plausibility of the association: The biological effects of the exposure can be sensibly related to formation of the disease.
- Time of exposure for the association: The time between the exposure and occurrence of the disease agrees with the time required for development of the disease.

The following sections will discuss the key elements of these criteria. This discussion will use as an example the association between alcohol consumption and breast cancer risk. Alcohol consumption was chosen as an example because it is generally accepted to be associated (albeit moderately) with breast cancer risk.

Consistency of the Association

If there is a cause-and-effect relationship, it is expected that the results of most studies will be consistent. But a frustration frequently encountered by both scientists and nonscientists alike is the inconsistency of the results of studies examining the association of various exposures to the risk of various types of cancer. It is not unusual to find conflicting results. Some studies may report no association or a negative association between an environmental exposure and cancer risk while other studies may report a positive association with cancer risk. A number of factors produce these inconsistencies. The major contributing factors include the relatively low risk associated with many "environmental" exposures, the difficulty of accessing exposure due to the long period of time required for cancer development, and differences in experimental design (discussed below in more detail).

This lack of consistency provides a good example of the necessity for good scientific judgement in the evaluation of evidence. In many cases inconsistency arises from weakness in the study design. The best studies a) look at a large number of women who are representative of the larger population, b) accurately measure their exposure and when it may have occurred, c) account for the contribution of established risk factors to the breast cancer observed, and d) use a comparison (control) group of women who ideally differ only in the presence of the disease.

In addition, studies that collect information from healthy women and subsequently follow them over time for the occurrence of the disease are considered to have less chance for bias. In some cases, elimination of weaker studies that do not meet these good design characteristics, will resolve the inconsistency of association across studies. However, the size of the change in risk commonly seen with environmental exposures is also a contributor to this inconsistency. Thus, consistency would only be expected between studies examining a large number of women.

For example, there is consistency in the results of the many studies examining alcohol consumption and breast cancer risk. Out of 35

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Described below are the criteria for causality evidence for a cause-and-effect relationship between an exposure and a disease:

- *Consistency*
- *Strength*
- *Dose Relationship*
- *Plausibility*
- *Time of Exposure*

But a frustration frequently encountered by both scientists and nonscientists alike is the inconsistency of the results of studies examining the association of various exposures to the risk of various types of cancer. It is not unusual to find conflicting results.

Cancer Cause-and-Effect

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studies (of various designs and conducted in various countries), 26 found an increase in risk for women who drank the most. Nonetheless, 7 studies reported no effect of alcohol consumption on breast cancer risk and 2 studies reported a decrease in risk. This amount of inconsistency is not surprising considering the size of the risk associated with this exposure. There is about a 40% increase in the relative risk of breast cancer for women who have about 4 drinks daily. Nonetheless, the association of alcohol consumption with breast cancer risk is considered to be one of the most consistent of the dietary factors contributing to breast cancer risk.

Strength of the Association

The criteria for causality also predict that there will be a strong association between exposure and disease when there is a cause-and-effect relationship. The term "strong" must be seen as a relative one in this context and the values for "environmental" exposures are viewed accordingly.

Individual "environmental" exposures have not been associated with large increases in breast cancer risk. But it is important to realize that epidemiological studies use the term "environmental" exposures as a broad catch phrase to include exposures from air, water and food, as well as lifestyle, such as smoking and drinking. This is not to imply that these "environmental" exposures do not have a substantial contribution to the incidence of breast cancer.

The most accurate studies examining the contribution of environmental factors to breast cancer risk were conducted examining the differences in cancer diagnosis between identical and nonidentical twins. This recent large study of twins in Sweden, Denmark and Finland (547 pairs of identical twins and 1075 pairs of nonidentical twins) reported that about three quarters of all risk for breast cancer was due to environmental exposures. The low level of risk seen for individual environmental exposures is possibly due to differences in susceptibility between women and to the individual environmental exposures acting through interactions between themselves and with other factors rather than alone.

Typically, in evaluating the strength of "environmental" associations, changes in risk less than 20% are viewed as suspect. Statistical significance of the results is needed to assure that they are not due to chance alone. The risk of lung cancer for heavy smokers provides a good reference value. The relative risk of lung cancer for heavy smokers (40 cigarettes/day) is 1000% to 2000% higher than the risk for nonsmokers. "Environmental" exposures that are associated with an increase in breast cancer risk are much smaller. Using our alcohol consumption example, a study which pooled the data from six large, well-designed studies (including 322,647 women, 4335 with breast cancer) reported a 40% increase in breast cancer risk among women who had between 2 and 5 drinks a day. Alcohol consumption also provides a good example of the interactive nature of exposures. Several recent studies have reported significantly increased breast cancer risk among women who consume alcohol and also have a diet low in the B vitamin folic acid.

Dose Relationship for the Association

In most cases, the effect of a toxic agent increases with the dose or level of exposure; the causal criteria state that evidence for a dose relationship should exist. Most epidemiological studies divide the women studied into groups depending on their level of exposure. The level of risk is frequently calculated by comparing the risk of women with no or least exposure with those who had the highest exposure. However, examinations also evaluate trends of increased or decreased risk accompanying changes in exposure. The presence of such a trend or dose relationship provides good evidence for the validity of the finding.

There is a well-established dose relationship between alcohol consumption and breast cancer risk. Several studies have found that breast can-

Missing from most of this coverage was the placement of this article in the context of how epidemiological cause-and-effect relationships are established and the contribution of a single study to an understanding of this relationship.

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cer risk increases with the amount of alcohol a woman consumes each day. In the pooled data study described above, breast cancer risk increased 9% for each 10 grams of alcohol (about 1 drink) a woman consumed each day. Accordingly, women who consumed 4 drinks per day would be expected to have 40% higher breast cancer risk than women who did not drink.

Plausibility of the Association

This criterion states that if there is a cause-and-effect relationship between a toxic exposure and risk of disease there should be supporting evidence from studies of the effects of the toxic substance in cells, animals and humans. In other words, the effects should make biological sense.

For the association of alcohol consumption and breast cancer risk there is a large amount of supporting biological evidence that the association makes biological sense. Alcohol affects breast cancer risk factors (mammographic density and estrogen levels), mammary tumor formation in animals, dietary factors which are thought to be cancer preventive, and various changes at the cellular level. Each of these effects support the linkage to cancer formation.

Time of Exposure for the Association

This criterion is built around the idea that disease processes have a latency period, a period of time between beginning of the disease process by the toxic exposure and the appearance of the disease itself. An exposure which has a cause-and-effect relationship with a disease should occur at a time which agrees with the time period needed for formation of the disease. A latency period is especially important for breast cancer where the time period for disease formation is measured in decades. For example, a recent exposure is unlikely to be associated with the formation of cancer and would be viewed with skepticism.

The evidence for meeting this criterion for alcohol consumption and breast cancer risk is less strong than that for the other criteria. A number of studies have addressed this issue by examining if there are certain ages where alcohol consumption leads to the largest increases in breast cancer risk. Almost equal numbers of studies have found no period of highest risk as have found drinking at ages less than 25 or 30 to be linked to higher risk. Interpretation of this

evidence is complex since there are studies to suggest that alcohol may act at more than one stage of the cancer formation process. It could act at an early or an intermediate time point.

The criteria for causality define the experimental results needed to conclude that there is a cause-and-effect relationship, but knowledgeable judgment is also required for this evaluation. This is because the body of scientific evidence on almost any issue is usually incomplete as well as flawed.

Scientific studies do not proceed in a highly systematic manner with these standards being examined one by one. Rather, the forces that guide what studies are conducted are based on a number of factors including the availability of funding, the number of investigators with expertise to conduct the studies, the access to subjects for study, and the likelihood of a significant finding. These forces produce a body of evidence that may be very strong for some of the criteria and weak or nonexistent for others. Accordingly, evaluations must be made by examining the strength of the total body of evidence and the degree to which it meets the standards that would be result if a cause-and-effect relationship existed.

Conclusion

In conclusion, a determination of cause-and-effect relationships requires a substantial body of evidence as well as knowledgeable evaluation of this evidence. Individual studies comprise small pieces of the large body of evidence needed and the answers to these complex questions are arrived at only after a great deal of study and many trials and errors. It is our hope that this article will give you the tools to see the forest—evidence needed for cause-and-effect relationships—rather than the many trees—results of individual studies of risk associations—for the various risk associations that are reported in the popular press.

Barbour S. Warren, Ph.D. and
Carol M. Devine, Ph.D., RD
Cornell University

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CUTT

Exposure ➲ Cancer:

What Does it Take to Show Cause and Effect?

A Healthy Ecosystem

The finding of an association, however strong, does not necessarily mean that the exposure causes the disease.

Following the recent publication of findings from the Long Island Breast Cancer Study, a number of newspapers and magazines published articles and commentaries about the importance and impact of this study. (For more information, see the study's website: http://www.cancer.gov/cancerinfo/LIBCSP.)

Whether they approved or disapproved of the study, these articles generally overestimated the impact of a single study. Most of the articles about the study gave the impression that the results of a single study can determine if there is a cause-and-effect relationship between exposure to a specific chemical and changes in breast cancer risk. Some of these articles even went so far as to suggest that this single study provided conclusive evidence about the cause-and-effect relationship between all environmental contaminants and breast cancer.

Missing from most of this coverage was the placement of this article in the context of how epidemiological cause-and-effect relationships are established and the contribution of a single study to an understanding of this relationship. We hope to clarify these issues by describing the scientific evidence that is need before a cause-and-effect relationship can be established.

The Long Island Study

This recently reported part of the Long Island Breast Cancer Study was conducted to determine whether there was an association between women's blood levels of various organochlorine toxins and their risk of getting breast cancer. An association (which was not found) would have shown that there was a connection or linkage between the event (exposure) and the disease (breast cancer) and that this association would not be expected to have occurred by chance.

But the finding of an association, however strong, does not necessarily mean that the exposure causes the disease. An example of this involves the epidemiology of the birth of children with Down's syndrome. In this case, there is a strong association between the risk of a child having Down's syndrome and the child having a late birth order (being born late into the family and having a number of older siblings). Yet the cause of Down's syndrome is the addition of an extra copy of chromosome number 21. The association of Down's syndrome with birth order is observed because this extra chromosome occurs more frequently in older women,

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