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# 14 Information Transfer

**BECKY B. WESTERDAHL AND EDWARD P. CASWELL-CHEN**

*University of Califonia*
*Davis, California*

The number of research scientists developing new information is at a record high. An often-heard generalization is that "the majority of the research scientists that have *ever* lived are alive today" (Asimov, 1982). Science is experiencing an information explosion, and the quantity of new information offered is enormous. The ramifications of such information, and the demand and need for information also have increased. The information era is quickly becoming the era of electronic information. Still, the need for information quality must not be sacrificed to quantity.

Information transfer has changed dramatically during the past 20 yr. The quantity and availability of information is increasing, and the time lag between information gathering and dissemination is decreasing. The advent of networked computers and satellite relays has made information available on a worldwide basis. The availability of personal computers allows the storage, retrieval, and analysis of information on a scale unprecedented in the history of man.

The sources and means for generating and analyzing information now include such diversified techniques as aerial and satellite imaging (Denison et al., 1996; Skole & Tucker, 1993), global positioning systems (Herring, 1996), global information systems (Burrough, 1986), electron microscopy (Eisenback, 1985; Hall, 1995), confocal microscopy (Czymmek et al., 1994), scanned-probe microscopes (Wickramasinghe, 1989), automated remote data collection, computer databases (Eeckman & Durbin, 1995), DNA cloning, sequence analysis, genome projects (Caswell-Chen et al., 1993; Hodgkin et al., 1995), and bioinformatics (Marshall, 1996).

In the past, information transfer was relatively simple and accomplished via two primary means—verbal and written. The primary means for information transfer remain the same, but the technological means for effecting transfer are new.

The subject addressed herein is the development and transfer of information in nematology. An overview of information transfer at the basic and applied levels is provided. The objectives are to improve the reader's access to information on nematology, and to introduce new ideas.

The primary focus herein is on information related to nematode management. The types of information available for transfer and the techniques for infor-

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mation transfer are included. Also provided are caveats for successful transfer and use of information, and the needs of the audience or clientele to whom the information transfer is directed. Future directions are mentioned. Traditional methods, recently developed methods, and those on the cusp of widespread availability are given. Some of the types of information transfer considered herein apply to pertinent topics, such as the geographic distribution of nematode species, the host status of cultivars for specific nematodes, nematode-control strategies and tactics, crop rotations, DNA sequences, phylogenetic relationships among nematodes, and nematode biology.

No one best method for transferring information is given, because there are many types of information, many uses for the information, and many audiences for whom the information is intended. Therefore, the challenges of information transfer are endless and fluid. The capacity to effectively transfer information improves with experience and practice. With experience, one learns to better judge the level of presentation appropriate for different audiences and the most effective means of information presentation.

## NEMATODES AND NEMATODE MANAGEMENT

Nematology was accepted as a separate discipline in the early 1900s following the demonstration that nematodes were significant pathogens (Dowler & Van Gundy, 1984; Caswell & Apt, 1989). Entomopathogenic nematodes were embraced within nematology with the realization that some nematodes had potential as biological control agents for insects and other invertebrates of agricultural importance (Nickle & Welch, 1984).

Future management strategies for plant-parasitic nematodes in sustainable agriculture will require combinations of management tactics. Sustainable agriculture will require information on nematode ecology, especially fundamental knowledge of how different tactics influence nematode population dynamics and genetics. As the research community defines the important details of nematode population and community dynamics and the influence of genetic variability on nematode fitness, sustainable agricultural systems based on integrated nematode management strategies using cover crops, resistant cultivars, or biological control agents will be implemented. Because nematicides continue to become less available, individuals directly involved in nematode management have an increasing need for access to detailed information on available strategies and tactics. Thus, information transfer becomes more important.

From very applied beginnings, in which traditional management principles and classical taxonomy were the primary emphasis, the study of nematology has grown until today it is a diverse and complex science. Nematodes are utilized as model systems for many disciplines such as molecular and biochemical systematics, genetics, developmental biology, physiology, behavior, and ecology. Today, development of new management techniques for plant-parasitic nematodes depends heavily on discoveries in the many research specialties within nematology (Caswell-Chen et al., 1993).

## AUDIENCE AND CLIENTELE

When preparing to transfer information, one must consider the intended audience. This consideration will affect the content and depth of the information that is presented, as well as the most appropriate means for presentation. The major audiences for information on nematology include researchers, farmers or growers, pest control advisers, agriculturally related industries, government agencies, universities or colleges, the media, and the general public.

### The Teachable Moment

The optimal time to make a point to a student or client is at the time when the information is needed (Dunn, 1987). It is important that appropriate information be available when that moment arises. In nematology this has been traditionally accomplished via written materials, such as textbooks, journals, and extension publications, and in verbal forms such as formal classes, short courses, extension presentations to agricultural groups, and one-on-one consultations. With the development of the personal computer, the "teachable moment" may be expanded in ways that were not previously possible.

### Clientele—Farmers and Pest Control Advisors

Frequently, growers not farming nematode-infested land have little knowledge of nematodes. Such growers require introductory information, including pictures of nematode damage symptoms, guidelines on how to sample for nematodes and information on how to prevent nematode movement and introduction. Growers and corporations that farm large areas frequently hire pest control advisors (PCAs). Pest control advisors are professionals who earn their living advising growers on pest management strategies. Often, they are less knowledgeable about nematodes than about other pathogens and pests, although PCAs are sufficiently knowledgeable to suspect nematode infestations based on crop symptoms. Typically, they are required to obtain a prescribed number of hours of continuing education each year by attending courses, and so are frequently a focus of information transfer. Pest control advisors know how to take soil samples for analysis, can provide advice on nematode management, and know where to obtain further information on nematodes. Growers who have dealt with nematode problems for an extended period are often interested in more advanced topics, such as new chemical control techniques, crop rotation, and the availability of resistant cultivars.

Audiences at extension meetings typically include a mixture of growers and PCAs with varying levels of knowledge about nematodes. The challenge is to present sufficient introductory information as not to confuse the novice, and enough advanced information to keep the more informed interested. Growers and PCAs also are a primary audience for written guidelines and bulletins on pest management. One of the axioms of extension work remains the importance of one-on-one field consultation with growers or PCAs. Although such contact is expensive because of the time and travel involved, such interaction is invaluable for information transfer.

## Clientele—Industry

Food processors may take an active role in commodity production and employ field personnel to work with growers on crop production practices. Processors may be more involved in nematode management than one might anticipate. They establish planting and harvest dates for particular fields, and often dictate acceptable cultivars, pesticides, and lengths of rotations to nonhost crops.

Farm-equipment manufacturers need to know the factors affecting movement of various nematicides through soil in order to develop appropriate implements. Equipment should be constructed to minimize the spread of nematodes.

Pesticide manufacturers often employ fewer nematologists than professionals representing the other pest management disciplines. As a result, nematologists frequently must communicate with entomologists, plant pathologists, or weed scientists as related to the need for new nematicides and appropriate methods for evaluating potential products. Information on markets, pesticide-use data, and crop loss figures are of great interest to pesticide manufacturers. In some cases, markets have not been developed because of the lack of registered products, and because the only yield- and quality-loss data available for many crops are rough estimates.

Seed producers, plant producers, and breeders also have diverse educational backgrounds and may need encouragement to develop nematode-resistant or tolerant varieties. They must have information on the culture and maintenance of pure lines of various nematode species, and methods for screening large numbers of plants for host status to nematodes. Because of the divergence in definitions for resistance and tolerance, clarification on the way cultivars of various plants are labeled may be needed. For example, a nematode-resistant tomato (*Lycopersicon esculentum* Miller) is resistant to only some of the many root-knot nematode species, but the labels do not specify which species. Importantly, a resistant tomato limits reproduction of those species to which it is resistant, and so is valuable for use in crop rotation programs (Roberts & Thomason, 1989). In contrast, nematode resistant alfalfa (*Medicago sativa* L.) varieties may actually be tolerant, and are not damaged by the feeding of one or more nematode species even though they do allow significant nematode reproduction (Roberts et al., 1998, see Chapter 11).

## Clientele—Government

### Pesticide Registration

Nematologists may be asked by state or federal agencies to assist with the preparation of information needed to register, or otherwise evaluate, nematicides. The individuals within government agencies responsible for collecting such information may not be trained in nematology. The expertise of individuals in the agency should be determined, as it will affect the types of information provided. Often when a government agency needs information, it is an urgent need for all possible information on a topic. For example, the need for information to evaluate nematicides relative to environmental impact statements has become so great in recent years, that agencies have resorted to employing private consultants to prepare the reports. The contracts are typically given to companies or individuals with no nematology background, with the rationale that nematologists cannot prepare unbiased reports on nematicides. The contracted consultants then phone nematologists soliciting the needed information. The result is that in addition to providing the requested information, the nematologist also must try to provide a basic education in nematology over the telephone. This interface is part of the challenge of conveying information.

The registration of new nematicidal active ingredients is relatively rare, but when it occurs, someone from a government agency is likely to call university and/or USDA nematologists for information on the product. Questions asked typically concern the wording of various parts of the label with respect to application timing or methodology. Nematologists also are asked by growers or county agencies to assist with the preparation of applications for Section 18 Emergency Registrations and 24C or Special Local Need (SLN) Registrations (USEPA) (see your state department of agriculture for further information on these programs). Special registrations require, for example, information on the nature of the pest problem and historical information on nematode management. In some states, city and county agencies have the responsibility for enforcing pesticide regulations and, at times, need advice on various subjects involving nematodes and nematicides.

Often, governmental agencies are referred to as if they were a single, monolithic entity. A typical government agency employs hundreds or even thousands of individuals, often acting and thinking individually within a broad set of guidelines provided by the agency. This is worth considering, because in some instances one only needs to communicate with a single individual within an agency, and that individual will act on the information or will present it to others in the agency.

### Judicial Proceedings

Nematologists also may be called to testify at public hearings or judicial proceedings. Testimony can be presented verbally, in writing, or both. Hearing officers and justices are typically chosen to be unbiased arbitrators and have little knowledge of nematodes. If 35-mm slides are to be used as part of the testimony, copies should be made beforehand, because they should be submitted to become a part of the permanent record. Printed or hard copies of slides (e.g., color laser copies) or handouts may be a better choice than slides in such situations. Also, remember that the audience is the person or persons making the decision based on the testimony presented, rather than the other individuals testifying.

## Clientele—University Setting

### Education

Dickson and Meredith (1987) and Abrantes and Hague (1992) have surveyed and summarized the universities and colleges involved in teaching nematology. Some 22 universities in the USA and 16 in other countries offer at least one graduate-level nematology course. Only a limited number of institutions offer more than a single course devoted to nematodes or principles of nematology. Most courses in nematology are designed to supplement curricula in plant pathology, entomology, or closely allied disciplines. The majority of graduate courses in nematology are offered in alternate years and have average enrollments of 5 to 10 students. Some students entering nematology today do so because of an interest in pest management, but have primary training in plant pathology or entomology. Still others have their primary training in disciplines such as crop science, horticulture, biochemistry, physiology, microbiology, genetics, or molecular biology.

In addition to traditional university courses, several universities periodically offer nematology short-courses that last from a few days to a few weeks. The 10-d Nematode Identification Course for Professional Consultants offered annually at Clemson University in South Carolina is perhaps the oldest and best known. An International Nematology Course is offered at the University of California at Davis for 4 wk approximately every other summer, and a 5-d course in nematode taxonomy is offered in June each year by the University of California at Riverside.

Professors who teach nematologists recognize that their students will probably enter careers where they will be the only nematologist in a group of plant pathologists, entomologists, or related biologists. Approximately 50% of nematology graduates find careers with universities, 25% are hired by industry and the government, and less than 10% go into private business or administration.

Institutions that have a single faculty position devoted to nematology are the rule rather than the exception. This nematologist is typically housed in a department devoted to plant pathology or entomology, and frequently has teaching, research, and extension responsibilities. In many land-grant institutions, the nematologist also will be affiliated with the agricultural experiment station.

A range of course materials for teaching nematology are available. The need for self-study materials and for students to be able to interact with faculty in various specialties can be greatly facilitated through computers. A cooperatively published laboratory manual (Zuckerman et al., 1990) addresses a range of issues within nematology. In addition to formal course work, a great deal of training in nematology is gained through practical experience, with nematode identification serving as a particularly germane example. Although the basic principles can be learned in a course, the ability to routinely identify nematodes extracted from soil samples requires a year or more of practical experience gained in close collaboration with a trained nematologist.

Most of the early nematology teachers had their primary training in plant pathology or entomology and were raised in agricultural backgrounds. Many contemporary teachers still have their primary training in plant pathology or entomology, although fewer come from an agricultural background. Nematology is increasingly encompassing individuals with primary training in other disciplines.

Teaching nematology at the university or college level requires a balance between teaching historical developments in nematology (to minimize the tendency for students to "reinvent the wheel") and, more recently, developments and specialized concepts. To maintain strong programs within universities and colleges, nematologists need to describe nematology research and extension activities in terms consistent with the mission of the university.

## Cooperative Extension

Associated with U.S. land-grant universities is an organization known as Agricultural, or Cooperative Extension (CE) (Radewald, 1969). Programs and responsibilities of CE vary from state to state. Within some states, specialists in disciplines such as nematology, plant pathology, irrigation, or crops, are housed on university campuses and work in collaboration with researchers of the agricultural experiment station. The university may have offices in all of the counties in the state desiring to participate in the program. Funding for the county offices is provided cooperatively by the county, the university, and the federal government (via the USDA-ARS). Farm advisors or county agents serve as sources of information for farmers, PCAs, the general public, and 4-H youth programs. Specialists are the link between the county personnel and the university. They have primary responsibility for transmitting research information developed by the university to county agents, keeping university researchers apprised of problems that require further research, keeping advisors abreast of new developments in nematology, and assisting the advisors with the diagnosis of nematode problems. Specialists and advisors also conduct research in growers' fields. Advisors typically have expertise in the particular crop of interest, while the nematology specialist provides nematode expertise across a variety of crops. Cooperative extension administers the 4-H youth program to educate youth in agricultural principles and the Master Gardener program to educate a volunteer force of adults to assist home gardeners. Training in nematology is included where applicable in these programs. Moens and Maas (1992) discuss the similarities and differences in extension nematology in Europe and the USA.

## Clientele—The Media

When media representatives need information, they want answers quickly and may print what they are told (or their interpretation of it) the same day. Writers from the general press typically lack experience with nematodes, while farm press writers may be quite familiar with nematodes. When contacted by a writer, the challenge is to quickly focus thoughts about the topic, think carefully, and then answer. Asking the press representative some questions may buy time in which to formulate appropriate answers. When providing information, short, nonspeculative, objective answers are the best and the safest. Always request that a copy of the article be faxed or mailed to you so it can be reviewed for accuracy, but don't expect to get one.

The employing organization also may have a media office that will call looking for stories to put on the news wires. Their deadlines are usually not critical, and there may be an opportunity to edit the resulting article for accuracy. News releases have a way of reappearing periodically for several months as they are picked up by various trade publications. This is one means of conveying the importance of particular nematode problems across broad areas, for some period of time.

### Clientele—General Public

The home gardener frequently becomes aware of nematodes when they experience a crop failure due to root-knot nematodes in their own backyard. A recent publication by the Society of Nematologists Extension Committee (1988) lists publications written specifically for home gardeners. Some older publications that are still found in libraries may be outdated because they contain recommendations for nematicides that are no longer available for homeowner use. Current publications emphasize a diversity of management strategies relative to nematode biology, including fallow, crop rotation and the use of resistant cultivars (Flint, 1990).

The adverse publicity surrounding nematicides also can bring nematologists into contact with the general public. The challenges here are similar to those discussed in dealing with the media.

Because nematodes are small, and microscopes are rare in elementary and middle schools, nematodes are more difficult than many other organisms to incorporate into a science curriculum. Still, many nematologists participate in programs that bring scientists in contact with young students. Some visit classrooms to discuss nematodes and to demonstrate the disease problems they can cause. Others participate in outreach programs, and have students working in their laboratories during the summer. Some nematologists participate in programs that bring school teachers to campuses in the summer to develop new science curricula.

The use of computers in schools has increased tremendously in recent years. The use of computer networks, which we will discuss in later sections, can be used to provide students access to educational material on nematodes, including visual images and video clips of nematodes.

## EQUIPMENT AND TECHNIQUES FOR INFORMATION TRANSFER

Solutions to nematode problems are frequently of a regional nature. Therefore, the best source of information may reside with an extension nematologist at the nearest land-grant university (Table 14–1), USDA research station, or state department of agriculture. Within the USA, an expert can usually be located with a telephone call to the closest land-grant university. If the university does not have a department of nematology, resource personnel may be housed with departments of entomology or plant pathology.

### Publications

Many of the classic nematology textbooks are out of print, difficult to find, or are available only in libraries (Caveness, 1964; Chitwood & Chitwood, 1950;

Table 14–1. Extension nematologists employed at various land-grant universities.

| State | Nematologist | University |
|---|---|---|
| Alabama | W. S. Gazaway | Auburn Univ. |
| California | B. B. Westerdahl | UCD |
| California | J. O. Becker | UCR |
| California | M. V. McKenry | UCR |
| California | A. T. Ploeg | UCR |
| Florida | D. W. Dickson | Univ. of Florida |
| Florida | R. A. Dunn | Univ. of Florida |
| Florida | J. W. Noling | Univ. of Florida |
| Florida | G. C. Smart | Univ. of Florida |
| Georgia | R. F. Davis | Univ. of Georgia |
| Idaho | S. A. Hafez | Univ. of Idaho |
| Iowa | Greg L. Tylka | Iowa State Univ. |
| Louisiana | C. Overstreet | Louisiana State Univ. |
| Michigan | G. W. Bird | Michigan State Univ. |
| Mississippi | Joe A. Fox | Mississippi State Univ. |
| North Carolina | S. R. Koenning | North Carolina State Univ. |
| North Carolina | T. A. Melton | North Carolina State Univ. |
| Ohio | R. M. Riedel | Ohio State Univ. |
| Oregon | G. B. Newcomb | Oregon State Univ. |
| Pennsylvania | J. M. Halbrendt | Pennsylvania State Univ. |
| South Carolina | J. D. Mueller | Clemson Univ. |
| Virginia | C. S. Johnson | Virginia Polytechnic Inst. and State Univ. |
| Washington | G. S. Santo | Washington State Univ. |

Christie, 1959; Dropkin, 1980; Goodey, 1963; Jenkins & Taylor, 1968; Maggenti, 1981; Peachey & Chapman, 1966; Sasser & Jenkins, 1960; Southey, 1965, 1970, 1982; Tarjan, 1960, 1967; Taylor, 1967; Thorne, 1961; Wallace, 1963). Many of the more recent texts are edited efforts, composed of chapters written by acknowledged experts in the field with chapters organized by nematodes or by crops (Evans et al., 1993; Luc et al., 1990; Nickle, 1984, 1991). Some of the classic texts are periodically revised, for example, an updated edition of Mai et al. (1996) is now available.

A number of scientific journals are devoted to presenting research on nematodes, including: *Fundamental and Applied Nematology* (formerly *Revue de Nematologie*), *Indian Journal of Nematology*, *Japanese Journal of Nematology*, *Journal of Nematology* (published by the Society of Nematologists), *Nematologica*, *Nematologica Mediterranea*, *Nematropica* (published by the Organization of Tropical American Nematologists), *Pakistan Journal of Nematology*, and the *Russian Journal of Nematology*. Research articles on nematodes may be found in other journals, such as *Phytopathology*, *Plant Disease* (formerly *Plant Disease Reporter*), and the *Annals of Applied Biology*. The contents of each of these journals can be retrieved through *Current Contents*. *Current Contents* is available as a paper publication, on diskette, or CD-ROM (see http://www.isinet.com). *Nematological Abstracts* are published by the Centre for Agriculture and Biosciences (CAB) (http://www.cabi.org/) in the United Kingdom, and contain abstracts from the major nematology journals.

## Libraries, Museums, and Nematode Collections

Most major universities have libraries with collections of nematology books and journals. Most of the major educational centers for nematology (see Table 14–1) have libraries that contain many of the major nematology texts. Excellent documented collections of older reprints are available at the USDA in Beltsville, Maryland, and in the Department of Nematology at the University of California at Davis. The Society of Nematologists Archives are located on the campus of Iowa State University under the curatorship of G.L. Tylka.

Extensive collections of preserved nematodes exist in several locations. The Society of Nematologists Systematics Resources Committee published a list of voucher depositories in 1992 (Robbins et al., 1992). A major nematode repository for the USA is the USDA Nematode Collection in Beltsville, Maryland, established in June 1960 by A. Morgan Golden. The USDA collection includes over 33 700 permanent slides and vials of preserved mass collections, and approximately 19 000 species entries. The collection includes designated types for more than 1500 species. The USDA Gerald Thorne Collection includes 6600 slides, while the Steiner Mermithid Collection includes over 3400 slides with both collections including many original types. The curator of the USDA collection is Z. A. Handoo (e-mail address: NEMATAX@asrr.arsusda.gov).

The University of California Davis Nematode Collection, which was started in 1944 (UCDNC) (http://ucdnema.ucdavis.edu), has a large collection of plant-parasitic, free-living soil, freshwater, and marine nematodes. The UCDNC consists of a type specimen collection, a general slide collection, mass collections, and collections and voucher specimens. The type specimen collection includes nematodes from 16 orders and a total of approximately 640 species. Approximately 300 primary type specimens, and 10 000 secondary type specimens, are included in the collection. The general slide collection contains approximately 53 000 specimens, while the mass collections include almost 6000 samples from 96 localities. A special California Academy of Sciences Nematode Collection is included within the UCDNC. The current curator of the UCDNC is S. A. Nadler (e-mail address: sanadler@ucdavis.edu).

The University of California Riverside Nematode Collection (UCRNC) is among the world's largest museums of plant-parasitic and soil nematodes. The UCRNC includes approximately 15 000 vials of preserved mass collections, and 175 000 mounted specimens on 35 000 microscope slides. The curator is J. G. Baldwin (e-mail address: james.baldwin@ucr.edu).

## Scientific Meetings and Societies

Some of the largest annual gatherings of nematologists are found at the annual meetings of the Society of Nematologists (SON) in the USA, the Organization of Tropical American Nematologists (ONTA) held in the Western Hemisphere, and the biennial meeting of the European Society of Nematologists (ESN). Each of these organizations produces a newsletter that contains announcements and current information on the activities of the respective scientific societies. Nematology societies also sponsor periodic international nematology congresses.

Meetings of other scientific societies, such as the American Phytopathological Society (APS), the American Society of Parasitologists (ASP), Society for Invertebrate Pathology (SIP), the Entomological Society of America (ESA), and the Ecological Society of America (ECSA) are attended by nematologists. Research papers presented at these meetings may be given in separate sessions devoted to nematodes, or may be scattered throughout the program.

## Nematology Films and Video Tapes

High-quality films and videotapes of nematodes in action are available. A videocassette recording for teaching identification of the most common genera of plant-parasitic nematodes was prepared by J. D. Eisenback and E. C. McGawley in 1991, and is a valuable teaching tool for the identification of nematodes. Using time-lapse photography and video-enhanced contrast microscopy, U. Wyss has been involved in developing more than 13 excellent films of the feeding and development of *Heterodera schachtii* (sugarbeet-cyst nematode), *Trichodorus similis* (stubby-root nematode), *Tylenchorhynchus dubius* (stunt nematode), *Xiphinema index* (dagger nematode). These films have been produced and published in cooperation with the Institut für den Wissenschaftlichen Film, Göttingen, Germany, and are used worldwide in research and teaching. A trio of recent video tapes on the soybean cyst nematode are available: "Soybean Cyst Nematode Management" from the University of Kentucky; "How to Take a Good Nematode Sample" from the University of Missouri; and "Testing Soils for Soybean Cyst Nematode" from the University of Illinois.

## The Telephone

The telephone has gone from being a simple real-time, point-to-point communication device, to an important and essential tool for information transfer via messaging, conference communication, and data transmission. Portable, or cellular, phones have made travel with a telephone simple. Recently available features, such as call waiting, call forwarding, voice mail, and paging, have all enhanced the value of the telephone. Telephone lines now serve as transmission lines for data, allowing distance learning, video conferencing, and computer-to-computer communication.

Written documents can be transferred via phone lines using facsimile (FAX) machines or FAX boards in computers, or by electronic mail (e-mail, see below). FAX machines and e-mail are valuable for exchanging information because they transmit a hard copy of the actual document over long distances, and they do not require that the recipient be available to acknowledge receipt of the message. Many computers with FAX boards also have optical character recognition (OCR) software that is capable of turning FAX documents into ASCII text files that can be manipulated and processed by computer word processing and database applications.

Teleconferencing, a multiway telephone conversation between several people in different locations, can be a time and cost saving means to exchange information in a group setting. This may be necessary to achieve consensus when all the participants are in distant locations and can not possibly get together in one location for a meeting. Video conference via satellite or by the Internet (world-wide network of computers) is becoming commonplace, and in the future will probably replace the telephone conference call.

## Photography and Video

Photographs are used to document research and convey visual information, such as disease symptoms. Photographs are used as illustrations in books and journals, and color slides are used as illustrations in oral presentations. The standard photographic approach is being augmented by computer digitization and manipulation of images, and emulsion-based cameras are being replaced by digital cameras (Grotta & Grotta, 1996).

At the present time, a presentation illustrated with 35-mm slides is a popular method for information transfer at both professional and extension meetings, although projection of computer-based images is starting to replace photographic slides. The slide projector will probably remain the tool of choice for some time, as almost every room at formal scientific meetings is equipped with a slide projector. Documenting research as it progresses with a 35-mm camera and slide film increases the clarity of information presented, and simplifies the preparation of presentations.

Many factors should be considered when purchasing a camera. High-quality inexpensive cameras are readily available. If one will be involved in field work in a dusty environment with the possibility of inclement weather, one of the smaller, lighter, less expensive, auto-focus, auto-exposure cameras with a built-in zoom lens should be considered.

For permanent storage, slides and negatives can be transferred to a CD-ROM disk. This service is offered commercially, and approximately 80 slides or negatives can be placed on a disk, but this depends on the resolution and format of the saved images. To preserve several thousand slides, it becomes economical to consider the purchase of computer equipment to do this. With the pace at which computer technology is developing, their direct utilization at meetings may become standard within a few years.

Digital cameras have been improved substantially during the past 8 yr, and although the affordable models (less than $10 000) are not yet ready to replace emulsion-based cameras, the currently available cameras represent a range of options and quality (Grotta & Grotta, 1996; Hogan, 1996). The advantage of the digital cameras is that the images they save are ready for storage and manipulation on the computer, and hence can be transferred as standard digital information with no loss of quality. Digital images can be used in computer graphics, allowing presentations to be made using computer presentation software.

Video cameras represent another means for recording information. As noted previously, many different commercial nematology videos and films are available for research and teaching. Individual researchers can use video cameras to record field experiments or techniques in the laboratory. Video cameras can be connected to microscopes to record images of nematodes in action. Relatively inexpensive "frame grabbers" are now available that will digitally capture individual video frames. The captured frames can be treated as individual digital photographs and manipulated and stored using the computer.

## Remote Sensing

The benefits to be derived from airplane and satellite imaging have barely been sampled by nematologists. Some dramatic photographs of crops known to be infested with nematodes have been taken from airplanes (e.g., Radewald, 1978, p. 41), demonstrating that nematode damage to some crops can be discerned and delimited from several hundred feet above the ground. Such photographs are excellent teaching examples to demonstrate the uneven distribution of nematodes within a field and nematode dissemination, and from which to illustrate the merits of various sampling strategies. Aerial and satellite images can be used to monitor vegetation status, and have potential use in assessing geographic prevalence of nematode disease (e.g., Denison et al., 1996; Skole & Tucker, 1993).

The federal government has established a $10 billion fleet of satellites and ground control stations (Herring, 1996; Kinal, 1996). We benefit from these everyday with respect to communications and weather forecasting. Some of these satellites have been placed in geosynchronous orbits (consistently orbiting in the same location in relationship to the earth) and are used by the military for navigation. The government also allows civilians to utilize this Global Positioning System (GPS), although the positioning accuracy is degraded slightly for civilian uses (Herring, 1996). For example, small hand-held GPS receiver positioning devices are commercially available that receive signals from several satellites simultaneously, and report the user's location (latitude, longitude, and altitude) on a screen. Airplane pilots and boat operators utilize these devices for navigation. Such positioning devices also will assist the user to return to a previous location whose coordinates have been stored in the device, or, to move to a new location entered by the user. A limitation of the civilian access to the GPS is that the accuracy is generally limited to ±50 m, although the inaccuracy can be circumvented using "differential GPS" so that ±1 m accuracy is attainable (Herring, 1996).

Recently, GPS receivers on a PC (personal computer) card have become available. By plugging the card into a portable computer, field position can be defined and computations and mapping in the field can be pursued (Kinal, 1996). In the near future such GPS receivers will be placed in automobiles, and in conjunction with onboard computer maps, will provide drivers real-time navigational directions. It will be possible to navigate by keying in coordinates and letting the computer guide.

In the future, detailed information on the spatial distribution of nematodes in relation to various environmental parameters will be digitally collated using geographical information systems (GIS) (Burrough, 1986). Such compilations of information will eventually allow historical assessment of nematode disease prevalence, variability, and dissemination.

For example, highly accurate GPS information will allow researchers to return to exactly the same spot in a given field, enabling long-term monitoring of nematode densities in research plots. As fields are surveyed, growers will be able to create detailed maps of soil type, drainage, nutrient status (Denison et al., 1996), and nematode infestation levels. Farm equipment linked to the survey database and real-time GPS apparatus will allow precision placement of fertilizer and nematicides as the machinery traverses the field.

## Genome Analysis

The exciting analysis of nematode and plant genomes continues unabated, and the data generated are stored in a number of easily accessible computer databases. The *Caenorhabditis elegans* genome project is making great strides (Hodgkin et al., 1995). The data available on *C. elegans* are being managed through databases, such as "A *Caenorhabditis elegans* Database" (ACeDB) (Eeckman & Durbin, 1995). This database covers a wide range of information, and can be accessed via the World Wide Web (WWW) (http://probe.nalusda.gov:8000/acedocs), and the ACeDB source and binary code can be downloaded via anonymous ftp (file transfer protocol) at "cele.mrc-lmb.cam.ac.uk" from "pub/acedb." Computer-based transfer systems (WWW and ftp) are discussed later.

Nucleotide and protein sequences from plants, nematodes, and other organisms can be accessed through several databases, including the NIH database "GenBank." GenBank is the NIH database of all known nucleotide and protein sequences, and can be accessed via the WWW (http://www.ncbi.nlm.nih.gov/). The database entries include the name and taxonomy of the source organism, a concise description of the sequence, and a table of characteristics specifying coding regions and other sites of biological significance.

## Computers

The computer is the most important tool for information transfer to emerge in recent years. The following discussion is limited to the basic equipment and jargon needed to relate computers to information transfer in nematology.

The physical computer equipment is called hardware. The electronic instructions used by computers to accomplish various tasks are called programs, applications, or software. Currently available computer technology is revolutionizing information transfer. With this technology, persons needing information on nematodes can obtain information from formal classes, textbooks, slides, and videos via computers, and can ask questions and receive answers via electronic mail, Internet relay chat, or on-line video conference, at any time of the day or night.

### Sources of Information

Hundreds of books are available on learning to use a computer and on different applications. Many are devoted to specific programs and are frequently more helpful than the manuals actually provided with the software.

## Hardware

Computer technology is changing so fast that today's state-of-the-art computer will be antiquated in approximately 2 yr. Since the beginnings of the PC revolution in the late 1970s, the "best" type of personal computer to purchase has been controversial. Selection should be based on the tasks required, the software preferred, computers used by colleagues and support available. Over time, the differences among the various brands are decreasing, and users now consider economics and reliability as primary determinants in selection. The ability to share information among all computers has improved recently.

Portable computers have been getting progressively smaller and more powerful, and have longer battery life. Some people use only a portable computer, and don't have a desktop model. The main disadvantages at the time of this writing of a portable compared to a larger desktop model would be in price and smaller screen-size and quality.

It is standard today that computers have modems that allow communication with other computers via cables, infrared transmission, or over telephone lines, and the capacity to send and receive faxes. Several models allow one to make drawings on the screen that can be saved or printed, and some will even convert handwriting into printed text. One company manufactures a watch that will hold the address book and calendar from a desktop computer. Many of the hand-held computers utilize a thin card slightly thicker and bigger than a credit card, called a PCMCIA card, that is inserted into a slot in the computer. The PCMCIA cards that function as modems, network cards, or data storage devices are available. Hand-held computers can be connected to desktop computers for data exchange. Limitations of hand-held computers at the present time include the minimal size of the keyboard and screen, limited memory, and relatively slow speed. However, it is important to maintain some perspective, as almost every one of these hand-held devices exceeds the power of state-of-the-art computers of 40 yr ago—computers that would have occupied an entire room!

## Computer Printers

Printers used with computers are of three basic types known as dot matrix, ink jet, or laser printers. Ink jet and laser printers are available that produce high resolution black and white or color copy, and they can be used to prepare high-quality documents with print clarity equal to that of a book.

## Important Extras for Information Transfer

A number of additional devices are available, through a computer store, magazine, or catalog, that can be plugged into a computer to increase the effectiveness of information transfer. A few of the most common and most useful follow.

A modem allows a computer to connect to and utilize a telephone line for the transfer of information. The user can send information to, or retrieve information from, another computer located anywhere in the world. Computers of different types can exchange data in a format useable by both. The Internet is accessible and is described in more detail in a later section.

Video projection units allow computer output to be projected onto a screen for an audience. Several different types of projection units are available (Chinnock, 1996). A projection panel plugs into the monitor port of a computer, and is placed on the platform of an overhead projector to allow the projection of the image on the monitor for viewing. Video projectors that do not require overhead projectors also are available. Projection panels, or projectors, are useful for demonstrating computer software, such as databases or population dynamics models, and can be used in place of 35-mm slides. Computer graphical presentation programs are being used more frequently by speakers to present their information. Computers combined with the new projection technology allow the development of standard presentations, but also allow speakers to develop presentations involving still images, video, and sound.

Many new, excellent forms of projection are available. The cable connections can be somewhat confusing if not used often, so it is advisable to give the equipment a trial run prior to the actual presentation. Although this equipment can be invaluable for demonstrations to small groups, the resolution of many of the available systems is limited by the projector light intensity and may not be adequate for presentations to large groups.

The CD ROM stands for compact disc read only memory. These drives are in wide use. Approximately 35 million CD ROM drives will be sold in 1996 (Bell, 1996). The CDS are the same thin, circular pieces of plastic that have become popular in recent years for playing recorded music. The CD ROMs covering a wide range of subjects and applications are commercially produced, and soon CDS with information on nematodes will be available. Recordable CD drives now cost less than $1000. These are useful for archival purposes, and can be used for storage of images such as photomicrographs of nematodes. The CD ROM disks can hold approximately 600 MB (megabytes) of information, facilitating storage of large files.

The next generation of CD ROM, termed DVD-ROM (digital versatile disc), will appear in 1997 (Bell, 1996). The DVD ROM will hold approximately 14 times more data (approximately 4.7 gigabytes, GB) than current CDS, and anticipated innovations will allow development of 17-GB DVD ROMs (Bell, 1996). Recordable DVD drives will soon follow.

## Software

Software programs, or applications, refer to the instructions that a user loads onto the computer. Software is purchased, or is sometimes distributed for a minimal fee ("shareware"), and is available from a variety of sources on a variety of media. Programs also can be downloaded over a telephone line or network, or provided via CD ROM.

## Operating Systems

The most common operating systems for personal computers are Macintosh DOS (disk operating system), MS DOS, and Windows 95. A system called UNIX is common on mainframe computers, and a microcomputer version called Linux is available. Operating systems, as well as software, are periodically upgraded and improved.

## Applications for Information Transfer

For ease of explanation, the major uses of computers are divided here into several broad categories of tasks performed by the software. Some programs may address several tasks.

Word processing programs accomplish the equivalent of typing text with a typewriter with the added advantages of automated editing, spell checking, and grammar checking.

Spreadsheets provide a screen that resembles a sheet of paper composed of rows and columns and are used for entering and analyzing data. They provide a large number of automatic functions that act on the rows and columns to sort, summarize, and allow statistical analysis of data.

Statistics programs typically operate on data entered in a spreadsheet, with the treatments from an experiment listed in one column and individual variables that have been measured (such as nematode survival, yield, or gall rating) placed in succeeding columns. The amount of time saved by using a computer becomes immediately evident the first time one runs an analysis of variance program. Results that might take hours of hand calculation can literally be obtained in a matter of seconds.

Database programs are used to organize and manipulate large sets of data. Previous compilations of nematode parasites and their hosts have been available (Goodey et al., 1965), but they were only in book form. Database formats allow the user to enter, coordinate, sort, extract, easily rearrange, and print information. Data are separated into categories or "fields." For example, an address database would consist of separate fields for last name, first name, street, city, state, zip code, and telephone number. Each address in the database would be stored in a separate "record" similar to a card in a rolodex file. An example in nematology would be a database such as "NEMABASE," developed at the UCD (Caswell-Chen et al., 1995). NEMABASE contains summaries of nematode-host associations and related data such as soil type, study location, and reference.

Graphics or drawing programs provide a variety of tools and special effects for making publication quality illustrations, drawings, or 35-mm slides. Such programs often include a slide-show feature allowing entire presentations to be given directly from the computer.

## Developing Your Own Software

Although most users will find an application ready for whatever they need to do, a number of programming languages are available that more experienced operators can use to write their own programs. Learning the basics of one of these computer languages can take time, so before making a decision to learn a language, the objectives of the programming effort should be carefully defined.

"Macro" and script writing commands are available within many spreadsheet and database programs. These are easier to learn than formal languages and

Table 14–2. Selected World Wide Web (WWW) sites that have information on nematodes.

| Institution | WWW-URL |
|---|---|
| USDA | www.ars-grin.gov:80/ars/Beltsville/barc/psi/nem/home-pg.html |
| Univ. of Arizona | ag.arizona.edu/PLP/plphome.html |
| UCD | ucdnema.ucdavis.edu |
| UCR | nemweb.ucr.edu/nemhp.html |
| Univ. of Florida | www.ifas.ufl.edu/~ENTWEB/entomolo.htm |
| Univ. of Nebraska | ianrwww.unl.edu/ianr/plntpath/nematode/wormhome.htm |
| North Carolina State Univ. | www2.ncsu.edu/unity/lockers/project/plantpath/ |
| Texas A&M Univ. | cygnus.tamu.edu/PLPA/dept_toc.html |

will accomplish many of the tasks that previously could only be accomplished through formal program writing.

A number of population dynamics models have been developed for various nematodes. Descriptions of many of these are available in the literature.

## Integrated Pest Management/Nematology Programs

Computer resources in nematology are literally increasing as we write. NEMABASE is a database on the host status of plants to plant-parasitic nematodes and contains over 35 000 records (Caswell-Chen et al., 1995). NEMAPLEX is a phytonematology teaching aid for the PC (Ferris, 1996, personal communication). A database for teaching general nematology using the WWW has been developed, and can be accessed on the UCD Nematology WWW server. Nematology home pages on the WWW are available for many nematology institutions (Table 14–2), and will provide an up-to-date guide of what is available.

A number of pest management programs have sections devoted to plant-parasitic nematodes, for example, the UC IPM Calex Cotton Model (Goodell et al., 1990). The INTERACT computer system run by the UC Integrated Pest Management Project (UCIPM) is accessible over the Internet and the WWW (http://www.ipm.ucdavis.edu). It contains nematode pest management guidelines, programs to calculate degree days, a nematode-grape model, a nematode population-dynamics model, weather data from throughout California, and a database of pesticide use in California.

## Computer Networks

In 1966, the U.S. Department of Defense Advanced Research Projects Agency (ARPA) began using the phone system to link computers around the country, forming the ARPANet. Soon, nonmilitary computers were using the ARPANet approach and began to be Internet worked with the ARPANet, forming the Internet. The Internet now crosses international boundaries and, although the numbers change every day, there are approximately 3 million computers on the Internet connecting nearly 20 million users around the globe (Levine & Baroudi, 1994).

Access to the Internet provides the user with the following basic capacities: (i) sending and receiving e-mail, (ii) connecting to remote computers (Telnet),

(iii) transferring files from one computer to another (FTP), (iv) communicating with Internet users around the world in real time using Internet Relay Chat, (v) accessing news groups and bulletin boards via USENET, and (vi) searching the Internet for information on various subjects using WAIS, GOPHER, VERONICA, or ARCHIE (Levine & Baroudi, 1994). Each user on the Internet has an electronic address that allows him or her to be found on the Internet. This address is associated with a mailbox, which receives and holds e-mail. Many nematologists worldwide are active users of the Internet and communicate regularly via e-mail.

If Internet access is not provided, a number of private subscription services are available. The WWW allows Internet information to be viewed in a graphical format via a language (hyper text markup language, or HTML), that allows specification of links among documents on the Internet. Programs called "web browsers" (e.g., Mosaic, Netscape, Internet Explorer) allow users access to the WWW. Each site on the WWW has an address, or a "Uniform Resource Locator" (URL). Using a browser, you can go to specific sites by opening a location using the appropriate URL. Nematologists and other biologists are in the process of placing a variety of information on nematodes onto the WWW. An advantage of information presented on the WWW is that it can be continually upgraded with the most current data. This system allows users to easily monitor and obtain the most recent findings.

Easy graphical access to the Internet is a relatively recent development whose benefits are only just beginning to be realized. The explosion of interest in the WWW is nothing short of amazing. The worldwide availability of information that can be continually updated represents a knowledge transfer revolution. It is currently possible to track the stock market, go shopping, check satellite weather photographs, and consult physicians via the WWW. It is now commonplace that companies, magazines, and publishing houses have a presence on the WWW, and they include their WWW address in their advertising.

A number of institutions with nematology projects have information available on the WWW. The addresses of some nematology WWW sites are included in Table 14–2, and most of these servers have links to other sites.

## DIAGNOSTIC LABORATORIES AND CLINICS

### Importance to Information Transfer

Because of the microscopic nature of plant-parasitic nematodes, diagnostic laboratories are probably a more essential element in information transfer in nematology than in any other pest management discipline (Barker & Imbriani, 1984). Although symptoms observable in the field may indicate the presence of a nematode problem, the presence of plant-parasitic nematodes must be confirmed by microscopic examination. A possible exception would be if adult female cyst nematodes are visible on roots. Although the basics of nematode taxonomy and identification can be learned in regular courses or "short courses" offered by several universities, the ability to do this efficiently and accurately is a skill learned on the job while working for several years with a skilled nematologist. Consequently, some 150 people, or less, worldwide consider themselves skillful enough to diagnose nematode problems for others.

## Diagnostic Providers

Some states have diagnostic laboratories associated with the state department of agriculture or a land-grant university (Barker & Imbriani, 1984; Imbriani, 1985). The services provided in each state and the laboratory policies regarding who may submit samples, costs for processing samples, and the time required vary widely. Several states (e.g., California, Oregon, Washington) have one or more privately run diagnostic labs. Charges are typically higher than for the state run laboratories. A number of laboratories run other types of agricultural samples (e.g., salinity or soil fertility) that will accept nematode samples and subcontract them to a nematology laboratory for processing. The local university, state nematologist, farm advisor or county agricultural commissioner will likely know the closest laboratories, approximate charges, and reputation.

There is no single best method for processing nematode samples, and it is likely that no two nematology diagnostic laboratories use identical procedures. The procedures used within a single lab vary depending on the crop and nematodes involved, and facilities available. Differences in nematode size and motility are only two reasons for multiple extraction methods. Because of this, inquiry should be made regarding which methods were used if they are not listed on the laboratory report. Some laboratories provide recommendations based on the nematodes found, and others will not. If it is necessary to go to another nematologist to discuss the results, information regarding which laboratory actually ran the sample and the extraction methods utilized is important. Preferred methods for taking nematode samples vary by crop and location. It is best to consult with the laboratory to determine the preferred method for the locality. Some important concepts regarding sampling are: (i) nematodes are not usually evenly distributed in a field—a sample should be made up of a number of subsamples; (ii) most plant-parasitic nematodes will be found within the root zone of the current or previous crop; and (iii) samples should be kept cool (from room to refrigerator temperatures) from the time they are taken until they arrive at the laboratory (Barker, 1985; Goodell & Ferris, 1981).

## Diagnostic Services

Imbriani (1985) contains an excellent summary of the operation of a nematode diagnostic laboratory. Soil samples comprise the largest workload of such laboratories. If roots are included in the sample, a separate method will typically be utilized to recover endoparasitic species. In both of these types of samples, extracted nematodes are identified using dissecting or compound microscopes. Some laboratories also will conduct differential host-range tests as an aid in determining what root-knot nematode species are present, or to analyze for genetic diversity in a population, which might affect the use of resistant varieties. Isozyme electrophoresis is used by some laboratories to identify root-knot nematode species. Molecular techniques also are being developed for species identification of root-knot, cyst and lesion nematode. In some instances, molecular techniques are sensitive enough that they can be used to identify a single juvenile root-knot nematode to species (Powers & Harris, 1993).

## VERBAL PRESENTATIONS

### General Considerations

With the technology available today for remote or distance learning, it is interesting to consider the intangibles that still bring people together to listen to presentations by others. Why will we travel for a distance and pay to see a live theater performance when we could view the "same" performance on television or videotape in our own homes? It is interesting to contemplate some of the issues arising from distance learning; however, it is clear that personal appearances allow interaction between speaker and audience. The audience is provided an opportunity to ask questions in an interactive setting. This benefits the speaker and the audience, because the speaker is provided feedback on the efficacy of his or her presentation. In addition, growers and PCAs obtain credit for continuing education or for pesticide training. It is questionable whether impersonal video presentations can function in the same regard as live presentations. A few practical suggestions for successful presentations are worth consideration (Table 14–3).

### Specific Considerations for Nematology

Presenting information on nematodes to audiences is difficult because nematodes are microscopic. Providing the audience with a hands-on demonstration of nematodes requires much more effort than showing the same thing with

Table 14–3. The following suggestions deal with aspects of a presentation that can be addressed to help assure a successful presentation.

| Important points to consider | Specific suggestions |
|---|---|
| Visuals should not contain too much information | A maximum 10 lines of information per graphic—present the data on multiple visuals if necessary |
| Assess colors and fonts to assure visibility of graphics | Red-green color blindness is common, so avoid using these on same graphic |
| Avoid visuals that are too big for screen | Prepare visuals in horizontal or "landscape" format |
| Limit your presentation to the time allotted | Prepare the presentation to allow at least 5 minutes for questions |
| When speaking direct your attention to the audience | Avoid talking to the screen or blackboard |
| Speak clearly, at a moderate pace, and with sufficient volume | Repeat questions so all the audience can hear them and summarize key points |
| Check the room or venue prior to speaking | Determine if microphones, pointers, slide projector remote controls, lectern lighting, or other aids you may need are present |
| Preview your visuals in the venue | Make sure slides are properly oriented and that the carousel functions properly |

35-mm slides or a drawing on the blackboard. The increased impact, however, is worth the extra effort. Virtually any dissecting microscope with a magnification of 60 to 100 × and substage illumination can be used. For more detailed viewing, Swift (Swift Instrum. Int. S.A., Japan), for example, makes a small (approximately 10 × 15 × 6 cm), relatively inexpensive field microscope with a battery-operated light. It has excellent resolution at magnifications of 40, 100 and 400. Spare batteries and bulbs are recommended accessories as are paper towels, dissecting needles, a small bottle of water, small petri dishes, and an extension cord. Nematodes extracted from any soil sample can be stored in a vial and later poured into a petri dish for display under a dissecting microscope. A slide made with water and sealed with nail polish the day before works well for high magnification observation. A demonstration with one or two microscopes can be set up in the back of a meeting room in a few minutes. Larger displays utilizing a number of microscopes and plants with symptoms take considerably more effort to put together, but always receive high ratings from participants in meetings. Plants with root-knot galls or cyst nematodes are effective for demonstrations.

Entire meetings or portions of them can be devoted to hands-on demonstrations rather than a series of verbal presentations. Other possibilities include a display of sampling equipment and methodology, extraction techniques, nematicide application equipment, insect-parasitic nematodes, computer databases, video tapes or films, and nematode biological control agents. At larger meetings, demonstrations can be set up in several different rooms or different parts of the same room and the group divided into subgroups, which rotate on a time schedule through the various sections.

## Outdoor Presentations

Field days and agricultural tours require a considerable amount of coordination and preparation. However, taking the participants to the local experts and problems can be a more effective learning tool than bringing the experts and their 35-mm slides to the group. Standing in a field heavily damaged by nematodes while listening to a grower discuss the economic loss and the lack of adequate controls leaves a lasting impression. In addition to nematode-infested field sites, participants enjoy visits to local food processing industries. This is a situation where the local farm advisors can be an invaluable resource. If responsible for a field tour of several days' duration, planning 1 to 2 yr in advance is recommended.

An easel with a large tablet and colored markers are the usual substitute for a blackboard in the field. Basic information is frequently written on the tablet ahead of time and then added to during the presentation. Handouts also can be utilized to help present the information and taken home for later review. A shovel is useful for digging roots and looking for symptoms.

If the weather permits, setting up a microscope demonstration in the field is only slightly more difficult than in a meeting room. Usually enough natural light is available for a dissecting microscope, and higher power microscopes are available that utilize a battery-operated light. A table for the demonstration is useful, although the hood or trunk of a car or the tailgate of a truck can be used if needed. Handouts or pictures should be anchored in case of wind.

### Research Plots

Research plots can be excellent ways to transfer technology and information to growers. Some argue that a plot established for demonstration does not need replicated treatments. However, nothing is as reassuring or convincing as being able to look around a plot and see the same difference in various replicates. Consider giving each grower a plot map without the treatments labeled and asking them to rate the visual differences on a numerical scale for possible use in a future publication.

Still or video pictures taken during the course of a field experiment can be invaluable in explaining the significance of the results. Many growers will be more convinced by a photograph of the results than by seeing tables of data. Experienced farm advisors often sacrifice randomization by organizing treatments in a progression that will clearly demonstrate treatment affects to growers (e.g., low rate–high rate in a chemical efficacy trial or similar plant varieties in a cover crop trial). Field days should be coordinated with cooperating growers in advance to avoid any misunderstandings (e.g., irrigation or spray schedules that prevent entry).

## WRITTEN PRESENTATIONS

The Society of Nematologists Extension Committee has recently compiled a list of publications available in various states (1988).

For more than 50 yr, nematologists have prepared nematode-management recommendations for various crops and locations. In some states these are now available on computer, as well as in a written format. For example, the UC Pest Management Guidelines for different crops are available on the IMPACT computer system. These publications are typically oriented towards a particular crop rather than an individual nematode species. Such a publication may contain a listing of the nematodes likely to cause problems, symptoms and signs of nematode damage, directions on how to take soil and plant tissue samples, and general management recommendations. This electronic format has the advantage of being easily upgraded when new practices are developed or when chemical recommendations change, and the disadvantage of not being able to provide the depth of information frequently needed for nonchemical means of control. Growers are typically more aware of the presence of insects and some other plant pests than they are of nematodes. Guidelines for managing nematodes may be included with those for other pests on the same crop.

The Commonwealth Institute of Helminthology (CIH, St. Albans, Herts, United Kingdom) has published an excellent series, called Descriptions of Plant Parasitic Nematodes, that is available by mail order. These are black- and white-publications describing individual nematode species. Each description includes drawings and photographs of the nematodes, morphological measurements, type host and locality, systematic position, distribution and hosts, biology and life-history, host-parasite relationships, and control. Some contain photographs of symptoms as well.

The APS (Minneapolis, Minnesota) publishes an excellent series of compendia on plant pathogens on particular crops. They include color photographs of damage symptoms and literature citations, and each contains a chapter on nematodes.

The UC Integrated Pest Management Program publishes manuals on IPM for various commodities. Over the years the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, has published an excellent series of circulars on nematodes and nematode diseases.

### Grant Proposals

The opportunities for technology transfer that can take place through the grant process are easily overlooked. Some agencies providing research funding (e.g., commodity organizations) include reviewers who are not researchers. Most commodity groups have a grower committee that reviews proposals and provides advice on what should be funded. Presentations should be prepared with this in mind, as this situation could be a "teachable moment." Some organizations prepare and distribute research summaries to the media, various government, and nonprofit agencies and may use proposals in preparing them.

## OUTLOOK

The dramatic developments in information acquisition and dissemination are sure to change and improve nematology teaching, research, and extension. It is clear that several new technologies are becoming more widely used in nematology. Faster computers connected to the WWW will allow the rapid exchange of information. For research and extension, this will allow access to databases or electronic manuscripts that might otherwise be obscure. For teaching, this will allow the delivery of text, images and video to multiple, distant locations. This will enhance learning, and expand the audience of teachers and extension personnel. The new technology provides new tools to transfer information about nematode diseases and their management to our clientele. The linkage of large volumes of related data will be facilitated by the use of high-density digital storage. Integrated data sets on nematode taxonomy, host range, and genetics may aid the identification, diagnosis, and management of nematode diseases.

Molecular markers will assist the characterization and accurate identification of nematode isolates, allowing management to be matched to characteristics of the isolate. Such information will advance the development and application of unique nematode management tactics.

The GPS and GIS technology will foster development of more detailed information on the distribution and abundance of parasitic nematodes in the field. This information will be used in conjunction with new farm machinery that will allow precise application of fertilizers, nematicides, or even resistant cultivars within certain areas of a field where they are needed.

All of these new information technologies will advance the abilities of agricultural professionals to identify and monitor nematode problems in the field, research a wide range of possible solutions, and apply appropriate management tactics in a site-specific manner.

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