PROFILES

W. G. Duncan—Father of Crop Models

Dennis B. Egli*

Somewhere in Mississippi, a farmer in an air-conditioned office is watching a cotton (*Gossypium hirsutum* L.) crop develop on a computer screen. A crop simulation model in the computer is "growing" a crop from planting to maturity. When this crop is mature, s/he can grow another crop with different management strategies and decide which options provide the highest yield or largest profits. This rather remarkable event, even for our technological age, is the legacy of a remarkable individual, William G. Duncan, who decided more than 25 yr ago that it would be possible to construct computer models to simulate crop growth.

He visualized a model as "one way of putting what we know about the parts of a system back together to see how it functions as a whole" (Duncan, 1967). At that time, many crop scientists felt that crop growth was so complex and influenced by so many factors that it was impossible to construct a model that would realistically mimic the growth of the crop. Bill, however, realized that the complexity of the system made it an ideal candidate for a simulation model and that, if scientists could describe the system, the computer would handle the complexity. Today, this does not seem like such a rash proposition, but 25 yr ago it was an extraordinary idea and it took an extraordinary person to give birth to such an idea; W.G. Duncan was such an individual.

Duncan was born in Greenville, KY, in 1909. His initial education culminated with a B.S. degree in chemical engineering from Purdue University in 1930. Duncan went on to become a farmer and the operator of a successful fertilizer business in Hopkinsville, Christian County, KY. He became involved in many of the University of Kentucky extension programs and played a major role in the late 1940s in promoting the new forage grass, Ky.31 tall fescue (*Festuca arundinacea* Shreb).

In 1954, Duncan made a major career change when he sold his fertilizer business and went back to school to further his education in agronomy. He said he made this decision because he realized "how little I knew and by how little the people I was associated with knew about

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anything I really wanted to know" (W.G. Duncan, 1986, personal communication). The Dean of the College of Agriculture at Kentucky suggested that Duncan needed a Ph.D. degree and that it should come from another university if he wanted to join the faculty at Kentucky. Duncan enrolled at Purdue University and received his M.S. and his Ph.D. (1959) under the direction of A.J. Ohlrogge.

Duncan's research at Purdue was typical of his activities throughout his entire career. He did work on fertilizer uptake (Duncan, 1957; Duncan and Ohlrogge, 1958, 1959), and the effect of radioactive fallout on the use of isotopes in field research (Wilkinson et al., 1958), which no doubt reflected his advisor's interest in soil fertility; however, his Ph.D. thesis dealt with another topic entirely—the relationship between plant population and yield of corn (*Zea mays* L.) (Duncan, 1958). After a year's research experience at the University of California at Berkeley with Dr. Hans Jenny, Duncan returned east to a position in the Agronomy Department at the University of Kentucky. At this time he decided that he was more interested in plants than soils. He remained in this position for approximately 10 yr. Then he started to spend winters at the University of Florida, where his primary interests were first corn and then peanut (*Arachis hypogea* L.) (Duncan et al., 1978). Duncan gradually spent more of his time in Florida, returning to Kentucky for only a few weeks in the summer. Even though he was officially retired from the University of Kentucky in 1974, he continued his research until his death in 1986. His last paper was published in *Crop Science* in 1986 (Duncan, 1986).

During his scientific career, Duncan's interests were many and varied, but there was one single focus: crop yield—how is it produced and how can it be increased? The complexity of crop yield and the great tendency of scientists to break it down to its components and study only a single component without putting it back together was the driving force behind his successful efforts at building crop models. He once described the study of the pieces of the photosynthetic apparatus as being "something like being given the pieces of a good watch in a box and then being asked what time it is" (Duncan, 1967). Yield and crop models were the unifying theme of his career; however, he worked with several crops, perhaps as a result of circumstances, or more likely, the availability of cooperators. Duncan was probably best known as a corn man (Duncan, 1975), but he also worked with J.D. Hesketh and D.N. Baker on the early attempts to model cotton (Hesketh et al., 1971, 1972), with soybean [*Glycine max* (L.) Merr.] (Egli et al., 1978, 1987; Duncan, 1986), and peanut (Hang et al., 1984; Dreyer et al., 1981; Duncan et al., 1978). Duncan traveled extensively, visiting fellow scientists around the world to learn more about yield and factors that influence it. He always enjoyed interacting with graduate students and challenging them to look critically at the scientific basis of their research projects.

What made Duncan such an outstanding scientist? Following the accepted logic, he should never have succeeded. He started his career at an age when modern scientists are considered candidates for early retirement. He never received grant support for his research. Upon receiving his Ph.D. degree he immediately changed fields. Many would argue that this is not the route to a productive career, but Duncan was not only productive, he was a major force in the creation of an entirely new field: crop simulation modeling.

Duncan's successful career stands as a shining testimonial to the fact that good research does not always require large, well-equipped laboratories populated with technicians and postdocs. Duncan had none of this. His success was related to several factors. First, he was deeply interested in what he was doing. He wanted to thoroughly understand how crop communities produced yield. The fact that he received only token levels of pay throughout his career is a vivid testimony to his interest in his work. Second, he had the ability to get to the heart of the matter at hand. He didn't get sidetracked on unimportant details; he always asked the important questions. Duncan believed that the simplest explanation of a phenomena should be investigated first. Keeping things simple was probably a great help in focusing on the issue at hand. It is interesting to speculate on whether Duncan's ability to dissect a problem in crop productivity to its fundamental parts was a result of his model-building activities (building models requires a very analytical description of the processes involved) or vice versa.

Duncan considered himself a theoretician rather than an experimenter. Those who knew him were well-acquainted with his "thought" experiments in which he logically analyzed a particular question using available knowledge and concepts and arrived at an "answer." Although the answer was not necessarily a proven fact, it was a testable hypothesis and provided the basis for further experimentation. Duncan had little patience with experiments conducted with no clear hypothesis to be tested. His last two papers (Duncan, 1984, 1986) were very much in this mode, providing a theoretical basis for the relationship of corn and soybean yields to changes in plant density. He was critical of agronomists in general, because he felt they were often too quick to conduct another experiment and not willing to think through the problem and extrapolate from known information.

Duncan had a tremendous affect on agronomy and crop physiology. He made fundamental contributions to our understanding of how crop communities develop and produce grain yield, but his most important contribution was demonstrating that it was possible, with the help of the computer, to develop crop simulation models and thereby greatly enhance our ability to understand crop growth and its interaction with the environment. His first published model (Duncan et al., 1967) marked the beginning of a new era in crop physiology. We are only beginning to see the fruits of Duncan's ideas today as crop simulation models for a number of crops are being used in research and as management tools. His contributions are even more impressive when we remember that he began his scientific career at an age when many people are thinking of early retirement. The legacy of William G. Duncan, the father of plant models, will always be with us.

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ERRATA

James Michael Tiedje—The Man and His Vision

D. Jordan; J. Agron. Educ. 20:54-56 (1991).

The above article, which appeared in the Spring 1991 issue of JAE, contained a typo on page 55. In the paragraph beginning "Without question," the word *students* was printed instead of *studies* in the second-to-last line. The new paragraph is corrected below:

Without question, Tiedje is internationally known for his excellence and innovative approaches in research. He is a leader in microbial ecology and soil microbiology and biochemistry. His lab has produced some of the most promising methods for detoxifying halogenate chemicals such as PCBs and hexachlorobenzene (4,5,7). His denitrification studies (both field and laboratory) have contributed significantly to the understanding of this poorly understood portion of the N cycle (2). In addition, his lab has used N tracers (^{15}N and ^{13}N) to elucidate pathways and products in the N cycle (6). His current research focuses on molecular biology of denitrification (1), "molecular ecology" using molecular biology tools for studies of microbial communities in nature (3), and the anaerobic metabolism of pollutants (4).

SELECTIONS FROM THE MEDIA CENTER

VIDEO

Cotton Production—*Russel Laird, Production Coordinator; Brian Morris and Bill Maddox, Narration.* Creative Educational Video, Inc., P.O. Box 65265, Lubbock, TX 79429. 1989. 35 min. $49.95.

The video *Cotton Production* covers an overview of western Texas cotton production and traces the new product from the plant through the steps of processing into finished fiber and use of the delinted seed. Production technologies presented are not in-depth with respect to production technology and environmental sensitivity. The video covers multiple steps, processing, and quality control in processing of a blue jean cloth from the raw cotton. The terminology used is common jargon used in producing, harvesting, marketing, cleaning, and processing cotton.

This video would benefit senior-level high school agricultural students, cotton growers, and technical agribusiness people servicing cotton production. It would also be useful for beginning undergraduate crop science agribusiness students, especially those with nonfarm backgrounds or those lacking exposure to cotton. It is not highly technical and would not be appropriate for in-service training for production, processing, and marketing problems. It provided this viewer a true appreciation of special language developed by the cotton grower, marketer, and processor. It is a must for those who want to understand cotton as a natural fiber.—ROGER G. HANSON, *Soil Science Department, North Carolina State University, Raleigh, NC 27695.*

BOOK

World Agricultural Statistics—*Food and Agriculture Organization of the United Nations.* UNIPUB, 4611-F Assembly Drive, Lanham, MD 20706. 1988. 187 p. Paperback. $9.00.

This pocket-size book contains agricultural statistics for 162 countries from around the world. The purpose of the book is to provide in a concise and internationally comparable form the most important indicators relating to agriculture, fishery, forestry, and food for each country as well as for continents, economic classes, and religions of the world. Statistics are provided for items such as land use, population, labor force, production (including agriculture, fishery, and forestry products), external trade imports and exports, and several other categories. Information is shown for the years 1965, 1975, 1980, 1985, 1987, together with the exponential growth rates (1965–1986 for food supply; 1965-1987 for all other items).

This book contains a tremendous amount of information from around the world. I found myself leafing through it to compare one country with the next, with some surprising findings. This could serve as an excellent reference book for instructors who periodically discuss world agricultural production. Only basic data under broad headings is provided, for a cursory overview of a country's agricultural production, this booklet was very informative. Users requiring more detail information are directed to the *Food and Agriculture Organization of the United Nations Yearbook.*—MARVIN H. HALL, *Agronomy Department, The Pennsylvania State University, University Park, PA 16802.*

VIDEO

Acid Rain: A North American Challenge—National Film Board of Canada, 1251 Avenue of the Americas, 16th Floor, New York, NY 10020. 1989. 15 min. $200.00.

This video belongs in the circles of political lobbyists. It offers little more than a strong emotional appeal for help in cleaning up industrial pollution that in all likelihood is responsible for acid rain. Production of the video is of high quality.

No scientific arguments are presented that address the processes and interactions in natural ecosystems that might be affected when impacted by acid rain. The limited amount of data that is presented is lacking in objectivity.

This video has little value as an educational tool in the opinion of this reviewer.—P.M. WALTHALL, *Department of Agronomy, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.*

VIDEO

Herbicide Effect on Plants—Time Lapse Photography—*Edited by Craig Anderson and Jerry L. Hill.* Available from Dr. Larry C. Burrill, Department of Crop and Soil Science, Crop Science Building 107, Oregon State University, Corvallis, OR 97331-3002. 1988. 45 min. $50.00.

The video titled "Herbicide Effect on Plants" serves as an excellent resource for teaching how herbicides affect plant growth and development. I have used this video, in part, for some herbicide mode of action workshops.

The video contains 22 different segments each a little over 2 min in length. Each segment deals with an individual herbicide and at least one plant species (sometimes two: crop and weed). The time-lapse photography begins on the day of herbicide application and then follows how the plant(s) respond to the herbicide over several days up to 3 or 4 wk following application. For fast-acting herbicides like paraquat on corn, the sequence lasts 7 d. For slower-acting compounds such as diclofop-methyl on oat, it takes 28 d for the herbicide to completely kill the oat.

The video contains examples of herbicides from several different families. Herbicide families include the phenoxys (2,4-D), pyridines (clopyralid), bipyridyliums (paraquat), aryloxyphenoxypropionates (diclofop and fluazifop), amino acid derivatives (glyphosate), triazines (atrazine), ureas (chloroxuron), thiocarbamates (EPTC), dinitroanalines (trifluralin), acetanilides (metolachlor), and sulfonylureas (chlorsulfuron and chlorimuron). The video contains a number of different crops including corn, soybean, snapbean, oat, cotton, wheat, cowpea, barley, cucumber, sudangrass, sugarbeet, and tomato. Weedy species include Canada thistle, johnsongrass, cocklebur, jimsonweed, and pigweed.

In each segment, the narrator explains how the herbicide affects plant growth and development (e.g., mode of action), and describes the injury symptoms occurring on the treated plants. In many examples, a tolerant crop is included to help demonstrate the concept of herbicide selectivity. For example, diclofop-methyl, a herbicide labeled for wheat, is applied to a mixture of wheat and oat. The diclofop selectively kills the oat, but leaves the wheat unharmed.

The strength of this video lies in the distinctive symptomotology demonstrated in sensitive species following herbicide application. The video also does an excellent job in displaying the concept of herbicide selectivity. The photography is good in most segments and the accompanying narration is helpful in explaining the visualization.

Unfortunately, the color contrast in several segments is not detailed enough to see specific events or colors (e.g., slow chlorosis or yellowing to necrosis with atrazine). In addition, following the narration, each segment continues on for as much as a minute without any further explanation. This leaves a long period of silence. Finally, I think even the most astute audience (even weed scientists) would find it difficult to sit through 50 min of time-lapsed photography without becoming slightly weary. I suggest users select segments of interest (common herbicides in their area) or one herbicide from each herbicide family for their educational programs. In this way, an 18- to 20-min video could be shown.

In summary, this video has a place in high school crop production programs or university-level introductory weed science, herbicide physiology, herbicide mode of action, or other herbicide-related courses. It could be helpful for laying the foundation for further discussion on herbicide mode of action and how herbicides are used in pest management programs.—WILLIAM S. CURRAN, *Department of Agronomy, Pennsylvania State University, University Park, PA 16802.*

BOOK

Grazing Management: Science into Practice—*John Hodgson.* John Wiley & Sons, Inc., 1 Wiley Drive, Somerset, NJ 08875. 1990. 203 p. Paperback. $36.95.

"It has been conventional to describe grazing management as an art rather than a science. . . This has been due in no small measure to the difficulties of achieving an understanding of the interrelationships between plants and animals under grazing conditions, and the way in which these interrelationships might influence output from grazing systems. . . In this book I have tried to bring together the available information and relate it to the practical issues of planning and managing grazing systems." These short excerpts from the preface to *Grazing Management: Science into Practice* nicely explain the purpose and goals of this extremely informative book. The book is well written, contains very helpful figures and illustrations, and does a great job of incorporating science into the practice of grazing management.

Grazing Management contains 20 chapters that are loosely categorized into three sections. Section one, entitled "Principles," consists of 10 chapters that lay the foundation from which the remainder of the book draws information. Chapters addressing the underlying principles of grazing management practices are excellent. In addition, the author identifies subject areas that are not addressed in the book (because they are outside the scope of the book) and provides references that cover those subjects.

Section two is divided into four chapters that address the resource considerations in grazing management. The resources ("Plants," "Soil and Fertility," "Animals," and "Supplements") are presented in individual chapters and provide a compartmentalized look at the resource components of grazing management. Unfortunately, the "Plants" chapter discusses the predominant pasture species in New Zealand and Europe, ryegrass and white clover, but only briefly mentions other cool-season forages. This should not be viewed as an insurmountable obstacle to the use of this book because many of the principles are applicable to other species.

The final section, "Application," pulls all the information presented up to this point into five very nicely arranged chapters that help the reader to make the final transition from *Science into Practice.* The first three chapters in this section deal mainly with the "nuts and bolts" of applying the information previously presented. Chapter 19, however, entitled "Enterprise Planning and Feed Budgeting," addresses concerns and provides examples of planning and budgeting for several animal and grazing enterprises. The final chapter in the book, "Conclusions," provides a summary of the contents of this book. The book concludes with a suggested list of further readings and an index.

The book contains many excellent figures and illustrations that greatly aid in understanding the written material. In addition, several chapters contain a conclusion or summary. The addition of a glossary would benefit many readers who are not familiar with formal grazing terminology or New Zealand grazing terms. The book would make an excellent text for courses that deal with pastures and grazing; however, there is so much information in some sentences and paragraphs that it detracts from the flow. Upper-level undergraduate and graduate students who possess a basic understanding of plants, animals, and their interactions would benefit most from this book as a text. Its use for smaller class sizes, where in-depth discussion of the text is normally encouraged, would be ideal. Not only would this book be useful for resident education, but it may also be very helpful and informative to producers who utilize grazing as a management tool.—MARVIN H. HALL, *Department of Agronomy, Pennsylvania State University, University Park, PA 16802.*

BOOK

The Biology of *Frankia* and Actinorhizal Plants— *Edited by Christa R. Schwintzer and John D. Tjepkema.* Academic Press, Inc., 1250 Sixth Ave., San Diego, CA 92101. 1990. 408 p. Hardcover. $95.00.

This book is a comprehensive review of various aspects of the nitrogen-fixing symbiosis between actinomycetes in the genus *Frankia* and the plants that they nodulate. These actinorhizal plants are found in 25 genera and eight families and are generally woody shrubs or trees. Although the fact that nodules may occur on roots of certain nonleguminous plants such as alders (*Alnus* spp.) has been known for many years, successful culture of *Frankia* dates only from 1978. Since that time, much has been learned about the microsymbiont and host-microsymbiont associations, and the increased knowledge of the symbiosis has been paralleled by interest in use of actinorhizal plants in agroforestry, revegetation, and mixed-species plantings.

The book is organized into 18 chapters. After an introductory chapter and a chapter on historical perspectives (pre-1978), there are several chapters dealing with culture of *Frankia*, the nodulation process, host specificity of *Frankia* strains, and *Frankia* systematics. These are followed by chapters on the physiology of *Frankia* in culture and actinorhizal nodule physiology and hemoglobin and oxygen regulation. Where appropriate, the authors of many of these chapters make helpful comparisons with the rhizobia-legume symbiosis, which will generally be more familiar to many readers.

Subsequent chapters deal with nodule types (spore-positive or -negative), molecular genetics of the microsymbiont, genetics of host plants, and progress in micropropagation and genetic transformation of actinorhizal and related plants. Techniques for measuring nitrogenase activity and estimating nitrogen fixation are outlined, and the last five chapters deal primarily with uses of actinorhizal plants and interactions of these plants with other plants in the landscape.

Although the scope of the material presented is outstanding, organization of the chapter index into related sections with headings might make the material somewhat more accessible. Some of the chapters conclude with summaries or discussions of future directions for work, but other chapters do not include concluding sections. There are also some inconsistencies in writing styles and in the use of common vs. scientific plant names in the various chapters. These inconsistencies do not detract from the material in a major way, but they do make the presentation appear a bit uneven.

The editors indicate that the book is intended as a reference and "a handbook of methods for a wide audience," and it is likely that this book will be widely used by students and scientists in fundamental and applied areas.—SUSAN U. WALLACE, *Department of Agronomy and Soils, Clemson University, Clemson, SC 29634.*

BOOK

A New Approach to Energy Planning for Sustainable Rural Development—*S.K. Chopra*. Food and Agriculture Organization of the United Nations, Rome, Italy. Distributed by UNIPUB, 4611 F Assembly Dr., Lanham, MD 20706-4391. 1990. 43 p. Softcover. $9.00 plus shipping and handling.

This book contains five chapters, which describe the justification of developing a new type of energy planning in developing countries, methodology, implementation, and guidelines for establishing this new approach to energy planning. The presentation style of this book is rather unique in that each paragraph is numbered consecutively, as are references. References are located at the end of paragraphs. References from each chapter are combined and located at the end of the book.

This book should be more aptly called a reference paper, due to its size. It relates current energy planning problems in developing countries and assimilates world programs that have proven successful into this "new integrated approach." It also accurately describes the fact that agriculture lags behind the industrial sector in energy planning and development. This new approach does not describe what type of energy should be used in these countries, but rather how the planning should be done. In fact, this book is more an organizational blueprint for what goes into the planning process, such as selection of a pilot area, assessing energy consumption, resources and costs, and environmental impact—and who should do it. The author describes the problems associated with implementation of this new integrated approach, such as most energy programs in developing countries have a top-down and sectorial approach, lack of coordination, inadequate involvement of financial institutions, lack of trained manpower, and they don't normally take into account the needs of the rural poor. The author provides a flowchart and briefly discusses how these problems can be overcome. Guidelines for launching this integrated rural energy planning program are broken down into four phases, which include awareness building at policy-making levels and establishment of an energy task force to develop an "approach paper" as the first phase; the second phase includes the designing and preparation of pilot projects in "micro-regions"; the third phase is the actual implementation of the pilot projects, monitoring, and evaluation of the system; and the fourth phase is replication and expansion of the project to the national level.

I have two criticisms of the book. The first criticism would be the use of the term *sustainable development* in the title. It is mentioned briefly in the second and third paragraphs of the introduction and seldom thereafter. It is assumed the reader knows the term. The term is referenced but not well defined. The word *sustainable* has taken on new meaning for those of us in agriculture, and it would be ink well spent if *sustainable development* were better described, because it is a vital part of the big picture. The second criticism is this "new approach" has never really been tested, but is FAO's conceptual blueprint of how developing countries should initiate an energy plan. Although the author and FAO spent considerable time in developing this plan, it is probably too early to know if this plan has been implemented and of its success, but it would be nice.

Not everyone will be interested in this book, simply because it relates to energy planning and has an international and organizational slant. The information presented is rather arid and in 43 pages only two flowcharts are presented. But valid and interesting points are made, so that those interested in international development and extension may find this book to be a useful resource, because much of the information can be utilized in other disciplines. If I were a project leader on an AID-funded project I would have the technical assistants read this book as background information.—J.P. SHROYER, *Department of Agronomy, Kansas State University, Manhattan, KS 66506.*

BOOK

Soils of the British Isles—*B. W. Avery*. CAB International, Wallingford, Oxon, OX10 8DE U.K. 1990. 463 p. Hardcover. $118.

This is a book about soils and classification, and it is a pretty expensive one at that. However, it is a document that is very well done, and I think well worth having if one is into understanding concepts of soil by various societies in various regions. As Jeremy Rifken points out in his book *Time Wars*, with each new device created by humankind, our world and its events are reordered around that device—be it the clock, the computer, or a new classification system. A study of classification shows us how we have ordered and reordered our understanding of the phenomena about us. Hence, we benefit as we come to understand the language of a classification system different from our own, and learn to communicate using it.

Avery's book is organized as follows. The first chapter deals with the nature of soil and with the factors that affect soil variation. Within this chapter are also discussed soil classification in a generic sense (includes a section on attempts at numerical classification), and an introduction to soil surveys. A second chapter deals with soil surveys and soil classification in the British Isles, followed by a third chapter in which methods, "diagnostic" surface and subsurface horizons and "other differentiating criteria" are explained. The final five chapters present information about soils in the six Major Soil Groups as recognized in the British Isles. These are Lithomorphic soils, Brown soils, Podzols, Gley soils, Man-made soils, and Peat soils.

A comparison of the British classification category-by-category with the U.S. system and the FAO systems has been made by Avery in Chapter 2. The evolution of this system is also shown as one that came from the "Zonal—not Zonal" classification of the soils of Ireland, classification of soils of Scotland, and a 1980 scheme for the classification of soils in England and Wales. Categories presently recognized and described by Avery are:

1. Major Soil Groups: This is the highest level and appears to serve the same purpose as our soil orders with fewer genetic implications. For example, Lithomorphic soils are simply shallow. There is no implication as to how they formed beyond that. They may be Entisols, Inceptisols, or Mollisols as the U.S. system recognizes soils.

2. Soil Groups: These seem very much like the "great soil groups" within our "1938" system. Texture (Sandy Brown Soils—Psamments in the U.S. system), parent material (Alluvial Brown Soils), presence of carbonates, and the Podzolic process are examples of designators at the "soil group" level. This level seems to serve the purpose of our "great group" level more than a "suborder level," as we would understand it.

3. Subgroup: Subgroups seem to reach for and attain our subgroup concept, as well as part of the "family" concept as U.S. taxonomists are accustomed to viewing categories. For example, "Typic Luvic Brown soils" are recognized. That sounds a lot like a Typic Hapludalf to me. Also "Sandy Cultosols" and "Loamy and Clayey Cultosols" are recognized (Cultosols are man-made soils). Introduction of loamy and clayey designators sounds a lot like the family particle-size classes in the U.S. system.

4. Climatic Phases: There are six of these that are intended to incorporate the same concepts as the moisture and temperature regimes of the U.S. system. These are intended to encompass only those climates encountered in the British Isles. It appears that they are chosen not so much for their effect on soil genesis as for pragmatic considerations.

As Avery states, there is very little correlation of categories used to classify soils in the British Isles with either the U.S. soil taxonomy or the FAO system. Both the FAO system and the U.S. system attempt to provide a "slot" for soils in a global perspective. The system described by Avery is aimed at soil environments peculiar to the British Isles. Hence, it is reasonable that criteria would differ; hence, category correlation would be very low.

Parameters other than those used to form the upper levels of generalization in the system differ. For example, the boundary between sand and silt is 60 rather than 50 microns. Avery's silt then is our silt plus very fine sand. We put these together in our family particle-size classes, but not in our textural classes. Silty clay loam, and clay loam are from 18 to 35% in clay, and there exists a "sandy silt loam" with 20 to 50% sand and less than 18% clay. It appears that the boundaries of clay content (18 and 35%) used by the U.S. in family particle-size classes, are used as textural class boundaries in the British Isles.

Horizon designators differ somewhat from ours, and appear to be a combination of what was used prior to 1962 in the U.S. and what is now used here. For example, since organic soils take on a much greater importance in terms of extent in Britain than they do in the USA, their "Litter Layers and Organic horizons" include L, F, H, and O possibilities with five possible types of O horizons that are separated based on humification and/or cultivation. Most of the subscript designations (i.e., Bt) used have the same concepts as those used in the U.S. system.

It is common practice to compare systems used to classify soils in terms of what is the "best" system. There is no real reason to do this other than from the standpoint of interest. Classifications are developed to serve a purpose. If they serve that purpose, that is all that can be asked of them. The system described by Avery, and the groups of soils described according to criteria specified by the system, are those of the British Isles. The work outlined by "Soils of the British Isles" has by all evidence had the same thoroughness of development typified by the U.S. system. The system expresses the needs of that soil survey and the society that benefits from it. It is therefore a "good system" by my definition of the term.

This book, *Soils of the World* by P. Duchaufour, and *Soils of Canada* are the only three of their type that I have seen. All do an excellent job of portraying the great depth of study necessary to put together a classification of soils. All three also (along with the U.S. *Soil Taxonomy*) do a good job of transferring to the reader the philosophy that underlies the system. *Soils of Canada* shows the influence of the British (or maybe vice versa) thinking, but as one would suspect has much greater provision for prairie soils.

I used *Soils of the British Isles* this spring in my graduate-level course on soil genesis and classification as a reference in how classification of soils is approached in another society with perceived needs, capabilities, and environments that differ from ours. It is excellent for that purpose. The class would need to have a membership that is familiar with soil survey, and able to see the levels in communication that are sought at various levels in a classification. They need to be mature thinkers, in other words. I would not in good conscience require a student to purchase a book that costs $118, however.—DAVID T. LEWIS, *Department of Agronomy, University of Nebraska, Lincoln, NE 68583-0914.*

BOOK

Fundamentals of Soil Science, 8th Edition. *H.D. Foth.* John Wiley & Sons, 605 Third Avenue, New York, NY 10158. 1990. 360 p. Illus. Hardcover. $49.95.

Fundamentals of Soil Science, originally published in 1943 by C.E. Millar and L.M. Turk, is designed for use as a text in a college-level introductory soils course. This 8th edition represents a major revision of the 7th edition in several respects. New chapters include "Tillage and Traffic" and "Soil as a Natural Body." In addition, chapters previously entitled "Soil Genesis and The Soil Survey," "Soil Classification and Geography," "Soils and Mineral Nutrition of Plants," and "Fertilizers and Their Use" were each split into two chapters. These organizational revisions improved the overall outline and flow of the book and allowed a more thorough discussion of each topic. Another improvement evident in the 8th edition is the attention given to nonagronomic uses of soils including engineering, waste management, and environmental quality. Although these topics are not covered in great detail, their inclusion addresses the interests of the ever-increasing diversity of introductory soils students.

Chapters 1 and 2, "Soil as a Medium For Plant Growth" and "Soil as a Natural Body," provide a logical starting point and illustrate the edaphic and pedologic nature of soils. Good use is made of figures to provide "real world" examples and emphasize key concepts. Many of the concepts introduced in these chapters are expanded upon in the succeeding chapters. The next five chapters cover the physical aspects of soil and water. Chapter 3, "Soil Physical Properties," discusses soil texture, structure, consistence, density, porosity, color, and temperature. Example calculations are included to illustrate weight-volume relationships. The discussion of tillage and traffic (Chapter 4) has been significantly expanded. Chapters 5 and 6, "Soil Water" and "Soil Water Management," cover the basic and applied principles of water in the soil matrix. An excellent discussion of the soil water energy continuum precedes the topic of soil-plant water relations. The applied topics include water conservation, soil drainage and irrigation, and wastewater disposal. The nature and management of saline and sodic soils is also covered in Chapter 6. Wind and water erosion, and use of the universal soil loss equation is discussed in Chapter 7.

Chapters 8 and 9, "Soil Ecology" and "Soil Organic Matter," cover the biological aspects of soils. The central theme of Chapter 8 is the role of soil organisms in nutrient cycling. A good comparison is made of nutrient cycling in a forest vs. a crop ecosystem. The role of soil organisms in environmental quality is also discussed. Chapter 9 covers the degradation of organic matter and subsequent accumulation of humus. The equilibrium concept with regard to soil organic matter content is illustrated nicely using a case study. The unique properties of organic soils are also covered.

Chapters 10 and 11, "Soil Mineralogy" and "Soil Chemistry," complement each other quite well. A very clear and complete treatment of mineral weathering and silicate clay structure (Chapter 10) is used to introduce the concept of soil charge and ion exchange. The principles of ion exchange are discussed in greater detail in Chapter 11, as are the topics of soil pH and redox reactions. The basic chemical principles introduced in Chapters 10 and 11 provide a solid foundation for the subsequent chapters covering soil fertility. Chapters 12 and 13 discuss the macronutrients and micronutrients (plus toxic elements), respectively. Chapters 14 and 15 cover the production and nature of fertilizer materials, soil fertility evaluation, and fertilizer use. Included in these chapters is a very complete discussion of plant analysis and soil testing, fertilizer placement, land application of manure and sewage sludge, and the concept of sustainable agriculture.

Chapters 16 through 19 cover the general areas of soil genesis, soil taxonomy, soil survey, and land use. Chapter 16, "Soil Genesis," includes a good discussion of the factors of soil formation as they relate to soil profile properties. Chapter 17, "Soil Taxonomy," includes a straightforward discussion of diagnostic horizons and an up-to-date treatment of soil taxonomy, including Andisols. High-quality color photographs of representative profiles of eight soil orders are included in Chapter 17. The next two chapters, "Soil Geography and Land Use" and "Soil Survey and Land Use Interpretation," are a logical follow-up to the discussions of soil genesis and classification. The concept of soil taxonomy is illustrated quite well using examples of geographic land use patterns. The book concludes with Chapter 20, "Land and the World Food Supply," which examines world population and food supply trends and the politics of food distribution.

Fundamentals of Soil Science, 8th Edition is well-written and has very few weak points. However, there are a few constructive comments worth mentioning. First, covering saline and sodic soils in the chapter on soil water management, prior to the chapter on soil chemistry, seems out of place. The book's treatment of salt-affected soils might be improved by discussing this topic within the context of soil chemistry and after the concept of cation exchange has been fully developed. A good understanding of cation exchange is necessary to adequately describe the nature and management of saline and sodic soils and, particularly, the processes of flocculation and dispersion. Secondly, the discussion of phosphorus fixation could be improved by including a brief discussion of specific vs. nonspecific adsorption. Most introductory students understand anion exchange in acidic soils exhibiting positive charge (nonspecific adsorption). However, many students have difficulty distinguishing this electrostatic interaction from the specific adsorption of phosphate (i.e., via ligand exchange) even though the latter is extremely important in controlling phosphorus availability. Furthermore, an expanded discussion of the forms of phosphorus might improve the clarity of this section. Introducing terminology such as labile vs. soluble P (or quantity vs. intensity) would emphasize the concept of solid phase control of solution phosphorus concentration. Discussing the equilibrium concept in the context of available phosphorus would also supplement the discussion of soil buffering capacity, which is introduced in the previous chapter on soil chemistry. Thirdly, including a discussion of the role of chelates and expanding the discussion of organic complexes to include metal availability and modified transport would exhance an otherwise excellent discussion of micronutrients and toxic elements.

Although the text is directed toward the beginning soils student, completion of an introductory chemistry course would improve the student's comprehension of the material presented. The book offers very clear explanations of the key concepts and contains very few errors. Good use is made of summary statements to review and emphasize critical concepts. A short, but adequate list of references concludes each chapter. The glossary, adapted from a 1987 Soil Science Society of America publication, is complete and up-to-date. Also, an index and several useful appendices are included. Both English and metric units are used in the book and a table of conversion factors between SI and non-SI units is found inside the front cover.

In summary, *Fundamentals of Soil Science, 8th Edition* is a well-rounded, complete text providing clear and concise explanations of the principles of soil science at a level quite suitable for an introductory soils course.—STEVEN L. McGEEHAN, *Division of Soil Science, University of Idaho, Moscow, ID 83843.*

BOOK

Agricultural Biotechnology: Introduction to Field Testing—*Edited by H. Graham Purchase and David R. MacKenzie.* Department of Information Services, Division of Agriculture, Forestry, and Veterinary Medicine, Mississippi State University and Office of Agricultural Biotechnology, U.S. Department of Agriculture, Washington, DC. 1990. 58 p.

A recent manual provides a starting point for beginning the complex and often confusing path for the conduct of experiments outside the laboratory using genetically modified organisms. The manual, "Agricultural Biotechnology: Introduction to Field Testing," is designed for use by principal investigators and institutional officials, including biosafety committee members.

The scope of regulatory responsibilities within and among the various departments and agencies of the federal government is not fully documented in this publication.

Its emphasis is on the delineation of USDA guidelines that have been established and the identification of pertinent contact points in other agencies of the federal government. However, it does a credible job of documenting the principles and procedures for conducting safe experiments outside the laboratory using genetically modified organisms. As such, it is essential reading for researchers and administrators contemplating field testing of such organisms. This is particularly true for those in the academic community who are just beginning to venture into the scientific arena of testing biotechnology products resulting from laboratory studies.

It is assumed that this is only the first step toward the establishment of a reasonable and practical protocol for delineating policies and procedures pertaining to biotechnology in the U.S. agricultural scientific community.—ROBERT F BARNES, *American Society of Agronomy, 677 South Segoe Road, Madison, WI 53711.*

BOOK

Oil Crops of the World—*Edited by G. Robbelen, R.K. Downey, and A. Ashri.* McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020. 1989. 553 p. Hardcover. $39.95.

Vegetable oils and other economically useful derivatives from oil crops are important in both local and global agricultural trade. As the editors of *Oil Crops of the World* state in the Preface, "Oil crops and their products are the second most valuable commodity moving in world trade." The publication of this book marks the first collection of information in English on general aspects of vegetable oils, as well as specific information on major oilseed crop species.

The first half of the book includes general information on oil crops, and the remainder covers specific crops. The first 12 chapters of the book will be useful to individuals interested in or involved in the vegetable oil industry. The chapters discuss the importance of oil crops and their products, the chemical nature of vegetable oils, biosynthesis of fatty acids, nutritional characteristics and food uses of vegetable oils, industrial and nonfood uses, oilseeds as energy crops, and analytical methods for oil content and fatty acid composition. In addition, chapters contain details of the nature and biosynthesis of storage proteins, the nutritional characteristics and protein uses of oilseed meals, and carbohydrate and fiber content of oilseed crops. The section concludes with chapters on processing and on genetics and breeding of oil crops.

These chapters are uniformly of high quality. The authors are international experts who have provided an excellent, single source of pertinent information of use to scientists working with oilseed crops. The chapters provide enough depth that scientists studying oilcrops will find extensive information on important aspects of the crops. Each chapter contains a bibliography with citations for important research works and reviews. Unfortunately, delays in publication of this book have limited these citations to material published before 1986. Instructors will find these early chapters to contain a wealth of information that can be included as reference information in production courses to show students the chemical and nutritional nature of seed components, as well as the processing and marketing of these important agricultural products.

Sixteen chapters are devoted to specific oil crops of world importance. All the major annual and perennial crops are included, but the addition of two minor crops, poppy and niger, is curious. Each crop is discussed with the same format, including importance and distribution, origin and systematics, mode of reproduction, breeding procedures, breeding objectives, history of cultivar development, and utilization of products. The chapters are well written by highly qualified international scientists. Although the chapters are generally 20 pages, some are much shorter. In several instances, the chapter brevity reflects a lack of information on breeding and cultivar development. Other chapters, such as the seven pages devoted to maize, could have been expanded to match the level of information furnished for other major crops.

The editors have indicated that the book was designed to provide a "major reference work for those interested or involved with any aspect of the vegetable oil industry, as well as providing a text for undergraduate and graduate classes in plant breeding, crop quality and nutrition."

While the editors have achieved the goal of producing a reference book, it is questionable whether the book could be used as a text in plant breeding, crop quality, or crop nutrition courses. None of the principles of these three subject areas are discussed in this book. Crop quality and crop nutrition are not discussed in any of the individual crop species chapters. Mention is given to breeding procedures and objectives for each of the oilseed crops, but the discussion is generally short. Much more extensive coverage is given to details of breeding specific crops in other texts. Although each chapter has a large section devoted to production data, the most recent figures are from 1985, and production levels from some crops have changed considerably since then.

Curiously the chapters on the individual crops have little discussion of the location of oil in the plant, the oil content or composition, the genetic and environmental variation found for content or composition, or specific discussions on the methods or results for improving the oil. Such discussions may have been more useful to oilseed crop researchers than the choices made for this book.

Although the treatment of the 16 oil crops may have limited use for agronomy instructors or researchers, the information contained in the general chapters of *Oil Crops of the World* should make this a good reference book for students and faculty involved in the study or teaching of international oil crops.—DAVID A. KNAUFT, *Department of Agronomy, University of Florida, Gainesville, FL 32611-0311.*

SOFTWARE

ISST—Introductory Soil Science Tutorials. Version 1.1— *Raymond E. Knighton,* Department of Soil Science, North Dakota State University, Fargo, ND. $160.00.

Here is a set of tutorials on some soil science topics written for use on IBM-PC or compatible computers. This is a beginning of something that, I think, will be the wave of the future. Along with textbooks, laboratory manuals, and study guides, computer-assisted instructional material will become a necessary component for teaching. This probably will be particularly the case in the introductory subject matter areas. After well-designed software of this type is commonly available, it has the potential to have a big impact on how lecture time can best be used. Much of the information delivery purpose of lectures today can be done by properly designed, interactive-type programs that utilize all the potential of the electronic technology that is available today. This should free up lecture time for more discussion and problem-solving activities that are often only weakly addressed in undergraduate education.

Computer scientists are *not* going to author this kind of material for us (soil science educators). We are going to have to do it. Dr. Knighton is one of the software pioneers in introductory soil science. The programming language, PC/PILOT, used by Dr. Knighton, is a higher-level language specifically written for preparing instructional software. It is a language that is not overly complex, but is capable of doing rather sophisticated things such as carrying on a type of interactive discourse with a user that is important in the educational process. Graphics, dynamic as well as static, can be part of the program.

The tutorials in the ISST package cover six general topics: soil formation, soil structure and texture, silicate clays, soil water, soil water potential, and soil classification. Each of them come on a separate 5.25-inch disk and costs $25.00. A main operating disk and an instructor, courseware manager disk, at $5.00 each, are also included. In addition to the disks, the package contains a reference manual printed on 5- by 8-inch pages in a three-ring spiral notebook. Use of ISST requires registration (form provided within the manual), which permits use of the program only in accordance with a Specific User License Agreement-Single CPU or Multiple Use Agreement. Registration entitles the purchaser to program updates and support.

Each of the general topics contains a set of subtopics. For example, the general topic Soil Formation has the subtopics weathering, factors, horizon nomenclature, and profile development. In addition, each subtopic contains an introduction and a topic (or choice) titled Question or Questions. All of this is accessed through a menu system.

The Question(s) choice contains 75 multiple choice-type questions that provide a means for a user to check material comprehension. The number of questions presented when this choice is selected is controllable by the course instructor. Any number from 1 to 75 is possible, the default being 10. The program generates a new, randomly selected set of questions from the 75 each time Question(s) is chosen. The Soil Water question set contains quantitative calculations and provides a built-in calculator if wanted.

The Soil Water Potential module contains some graphical representation of water potential that can be very effective in assisting students to comprehend this concept. The Soil Classification module contains a map set showing the distribution of the various soil orders worldwide, in the USA, and in the North Central states. Soil survey maps are also included for parts of North Dakota. A disadvantage with this software is that its encryption, necessary for copyright protection, prevents adapting the material such as map information that is of local interest. The module on Silicate Clays is devoted primarily to presenting crystal structural information about layer silicates. A routine is even provided to build layer silicate structures. As a clay mineralogist, I believe the time spent on this topic could be better used on other things in an introductory course in soil science.

A very attractive feature of this software is the possibility for a course instructor to keep records of individual student use of the tutorials and their performance on the question sets.

Some general comments about this courseware may be pertinent. It is prepared for use on CGA-type monitors. This is no doubt done to reach the largest possible clientele. It does, however, severely limit the use of color combinations and of fonts. This is a serious limitation in terms of the sophistication of the graphics possible. The EGA and VGA monitors are now rather widely used. Good courseware is going to require utilization of EGA/VGA capabilities. One somewhat frustrating feature of ISST is the requirement for identification and a password on entering the program. The ID is certainly necessary if individual use records are to be kept, but a bypass option should be available if desired. Password use to limit access is just not good pedagogy. Material like this should be as readily accessible as possible.

Courseware preparation is a new area for most of us. Not many graduate programs in soil science or agronomy include training in design of instructional material. Along with programming assistance, help is definitely needed in good instructional design. This involves menu systems used, structure of screens, use of help systems to make the ware user-friendly, and effective incorporation of graphics with text. ISST could benefit from some consulting with an instructional designer. A uniformly operating menu system in terms of how choices are made would be desirable, for example. In most places in the program, hitting any key advances the screen—and accidently hitting a key is common. This is confounded by lack of ability to go to the previous screen in many places in the courseware. Accessing the previous screen should be possible on most every screen. It should also be possible to exit the courseware from any screen. In ISST you often get trapped in a subtopic. You can either use CTRL-ALT-DEL or continue to the last screen.

A demonstration disk is available from the author to preview an example of the material that is available. People teaching introductory soil science may find this courseware to be very helpful in their teaching program.—LEON J. JOHNSON, *Department of Agronomy, The Pennsylvania State University, 116 ASI, University Park, PA 16802.*