**Allelopathy**

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# REVIEWS

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## ALLELOPATHY

Putnam, Alan R., and Chung-Shih Tang (eds.). 1986. **The science of allelopathy.** Wiley-Interscience Publications, John Wiley and Sons, New York. xi + 317 p. $52.50.
Rice, Elroy L. 1984. **Allelopathy.** Second Edition. Academic Press, New York. xi + 422 p. $71.00.

The field of allelopathy research has engendered much controversy. Two books that have appeared recently attempt to summarize the findings; do they also provide a much-needed critical evaluation of the work?

Putnam and Tang have assembled a diverse collection of papers with a view to developing a "science of allelopathy," which they define as the study of chemical interactions, both inhibitory and stimulatory, among plants. The strengths of this book lie in the exhaustive lists of species putatively shown to have allelopathic effects, the thorough coverage of the range of possible allelopathic interactions, and the detailed descriptions of bioassay methodology.

The book consists of 17 chapters written by an international collection of scientists. In the introductory chapter the editors provide an overview of the history, the "state of the art," and the future potential of allelopathy research. One chapter deals with "allelopathic growth stimulation"; some readers may object to using the term allelopathy (literally translated as "mutual suffering") in this sense. Besides higher plant studies, many chapters deal with chemical interactions involving bacteria, fungi, and algae. A third of the chapters give good documentation of methodologies utilized in isolating and testing potential allelochemicals, and many pages are devoted to illustrating the chemical structure of the gamut of potential allelochemicals. Several chapters provide detailed descriptions of the possible subcellular mechanisms effecting allelopathic responses.

For scientists already convinced of the global ubiquitousness of allelopathy, this book will prove to be a useful reference. For ecologists who view allelopathy as one of many factors in the environmental complex, one that requires careful and critical analysis, this book will be unsatisfactory. The prevalent approach is to note a pattern in nature, or in an agriculture setting, of limited plant growth in proximity to another plant, and then to collect various plant parts and demonstrate that water extracts or leachates or vapors inhibit germination or radical growth of some target species, usually sown on filter paper in petri dishes. Bioassay procedures vary from study to study, but generally the concentration of plant matter to be assayed is not decided upon *a priori*. It would appear that the only criterion is that the material must be concentrated to the level necessary to inhibit growth or germination of the test species. Stowe's (1979. Journal of Ecology **67**:1065–1085) contention "that perhaps any species can be shown to have allelopathic properties in bioassays" would seem to be borne out by the hundreds of accounts of allelopathy in this book.

This book fails miserably to develop the framework for "a science of allelopathy" on three grounds. One is the blatant failure to evaluate critically other components of the environmental complex that could play a role in the zone of inhibition; in most instances I had the impression that studies were designed to prove the role of allelopathy rather than critically test allelopathy. Field studies contrary to the test cases being discussed are ignored. For example, the notorious bare zones around California shrub communities are referred to in several chapters, but studies by Bartholomew (1970), Halligan (1974), and Christensen and Muller (1975), demonstrating the very significant role played by animals, are not even cited in this book.

Second is the failure to evaluate whether or not laboratory bioassay conditions are ever encountered under field conditions. In most cases no attempt was made to determine this, In isolated instances soil concentrations of inhibitory compounds were determined, but this is far short of what is required. The role of soil particles in absorbing chemical compounds, or the potential for breakdown of allelochemicals, or the potential for climate and phenology patterns interacting to produce conditions that would modify bioassay conclusions, were not given due consideration. In the case of the often-cited chaparral allelopathy story, Kaminsky's (1981) finding that allelochemical levels in the field are insufficient to support the conclusion of allelopathy is never cited.

Thirdly, studies such as those by Landers, 1962; Heisey, 1982; or many cited in Stowe, 1979 that have failed to show correlation between distribution patterns of species in the field with bioassay results were ignored.

Elroy Rice also fails to develop a satisfactory response to criticism of his earlier book. In a few instances data contradictory to the role of allelopathy have begrudgingly been mentioned, but with no elaboration. Most of the papers critical of allelopathy which Putnam and Tang failed to cite are likewise missing from this volume. The failure by Stowe (1979) and others to show correlation between lab bioassay results and field patterns are summarily dismissed, whereas papers with favorable conclusions are elaborately presented. I see no excuse for ignoring Stowe's elegantly-designed experiments while presenting four tables and one figure from a study which provides questionable evidence showing that field results are "highly correlated with results of laboratory tests of allelopathic effects of the sunflower plant." Rice is careful to note that other aspects of the environment play a role in vegetation patterning. However, convincing evidence that these other factors are not causally linked to putative allelopathic patterns is missing for most examples.

Despite these shortcomings, this book represents an important collection of literature useful to anyone interested in the study of allelopathy. This second edition represents a major reorganization of the first edition with more than 70 pages and double the number of citations. Unfortunately the print is lighter than in the earlier edition and the photographic quality is poor.

In presentation, the book is encyclopedic and the style is

repetitious. Half of the 14 chapters report on the myriad of organisms putatively showing allelopathic effects. Other chapters include summaries of information on factors affecting production, movement, absorption, action, and effectiveness of putative allelopathic agents.

In summary, both of these books will prove to be useful references for scientists interested in the study of patterns and processes in ecological systems. However, the authors could have done more than accumulate voluminous amounts of literature on chemical interactions between plants. A critical evaluation of this literature would have gone far in putting allelopathy in its proper ecological perspective.

I can think of no more appropriate conclusion than the following excerpt from John Harper's 1975 review (*Quarterly Review of Biology* **50**:493–495) of Rice's first edition of *Allelopathy* (1974. Academic Press, New York):

> *It would not have been difficult to transform this into an extremely valuable textbook. If more doubts had been sown where doubts will grow and a difficult problem critically displayed in all its difficulty, ecologists would have reason to be grateful. There is always room for some scepticism in science.*

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## AN ECOSYSTEM WORTHY OF STUDY

Francis, Charles A. (ed.). 1986. **Multiple cropping systems.** Macmillan Publishing Company, New York. xiv + 383 p. $37.50.

Multiple cropping, in its various guises, is the most common form of agricultural production, at least from an historical perspective. The multiple cropping ecosystem as such should thus arouse the interest of the ecologist, both as a system of study in its own right, and as a system with which much current ecological theory might be tested. As a system of study in its own right we might simply invoke the Everest argument (we study because it is there), or we might also note that improvement of peasant agriculture in the Third World is a felt imperative at many levels, and that ecological approaches could (and probably should) form the basis of their improvement. As a system within which ecological theories might be critically examined and tested, it is difficult to imagine a better one involving terrestrial animals and plants. By their very nature, intercropping systems are highly manipulatable, involve at least two species, and ususally include well-characterized genetic material.

The literature on multiple cropping is enormous. A steady stream of literature reviews has followed the pioneering one of Kass in 1978, and it is thus easy to gain an understanding and appreciation of the field as it stands. But what is remarkable is that the field has changed little since Kass's review, and, despite the large amount of research devoted to the subject, every new review retains something of the flavor of those that preceded it. Perhaps because of the complexity of the subject, it does not seem that much progress is being made. The questions: How do we evaluate multiple crops (or, equivalently, what is the advantage of multiple cropping over monocultures)? If advantageous, why? How can multiple crops be improved? The answers: equivocal. The book edited by Francis is clearly within this tradition. While it breaks no new ground, it nevertheless is one of the best collections on multiple cropping to appear to date.

The 15 chapters to some extent reflect the eclectic nature of the field, ranging from an unusual geographically-biased historical perspective to the typical plant interaction chapter, from an entire chapter on legume-rootcrop combinations to the mandatory chapter on statistical problems. As in other intercropping (or multiple cropping) reviews, the lack of a central theoretical formulation or focus leaves us with a collection of empirical results that hold together only loosely, if at all. While most of the chapters individually are excellent elaborations of the assigned topic, they do not fit together to form an organic whole. In this respect the present work is similar to earlier attempts.

Two chapters form something of a theoretical basis for the book, at least from an ecological point of view. As usual, Brian Trenbath provides a remarkably insightful analysis, this time with respect to nutrient utilization. He proposes the use of a "resource utilization efficiency (RUE)" (the efficiency of resource capture times the efficiency of conversion), and shows how it can be related to the traditional Land Equivalent Ratio (LER), eventually proposing a partitioning of the LER into four additive numerical components. This method is then applied to general resource use and specifically to light as a resource. How his method relates to the techniques used by ecologists to analyze resource use in plant competition, and whether his method represents something of more general ecological interest, are interesting questions. The subsequent chapter by Steve Gliessman is an excellent analysis of plant interactions, but from a disappointingly narrow focus. He chooses to focus on interference (competition) with only token reference to positive interactions, entirely restricted to mutualisms. In light of the many examples of facilitation in the intercropping literature, this omission is unfortunate. But from the point of view he chose, his presentation is excellent, dividing interference into removal interactions (more-or-less resource competition) and addition interactions (mainly allelopathy). It would have been interesting to include references to the more classical notions of ecological interactions, such as the competitive exclusion principle, changes in plant quality, facilitation (direct and indirect), and effect and response in competition.

A later chapter is perhaps the best general treatment of pests in intercrops to appear to date. Altieri and Liebman present detailed summaries of research on both insects and weeds, two of the most often cited factors contributing to intercrop