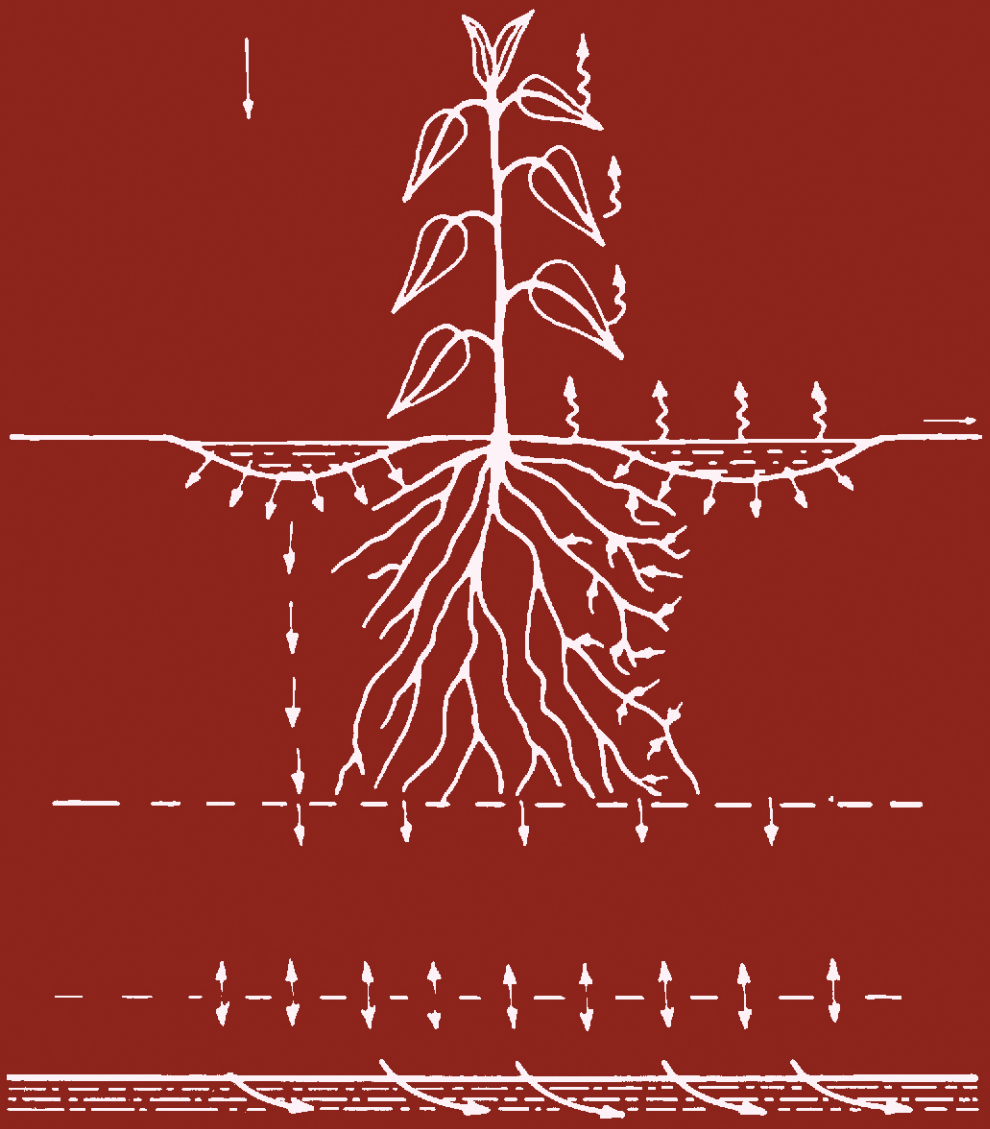
Introduction to Soil Physics

DANIEL HILLEL



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ACADEMIC PRESS 1982
A Subsidiary of Harcourt Brace Jovanovich, Publishers

New York London
Paris San Diego San Francisco São Paulo Sydney Tokyo Toronto

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Hillel, Daniel.
Introduction to soil physics.

Based on the author's Applications of soil physics and Fundamentals of soil physics.
Bibliography: p.
Includes index.
1. Soil physics. I. Title
S592.3.H55 631.4'3 81-10848
ISBN 0-12-348520-7 AACR2

PRINTED IN THE UNITED STATES OF AMERICA

82 83 84 85 9 8 7 6 5 4 3 2 1

This book is only a small clearing at the edge of the woods
where students might observe a few of the trees
as they prepare to set out independently
to explore the great forest which yet lies beyond.

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Preface

This book is a unified, condensed, and simplified version of the recently issued twin volumes, "Fundamentals of Soil Physics" and "Applications of Soil Physics." It is meant to serve as a textbook for undergraduate students in the agronomic, horticultural, silvicultural, environmental, and engineering sciences. Nonessential topics and complexities have been deleted, and little prior knowledge of the subject is assumed. An effort has been made to provide an elementary, readable, and self-sustaining description of the soil's physical properties and of the manner in which these properties govern the processes taking place in the field. Consideration is given to the ways in which the soil's processes can be influenced, for better or for worse, by man. Sample problems are provided in an attempt to illustrate how the abstract principles embodied in mathematical equations can be applied in practice. The author hopes that the present version will be still more accessible to students than its precursors and that it might serve to arouse their interest in the vital science of soil physics.

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Part I BASIC RELATIONSHIPS

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1 *The Task of Soil Physics*

The soil beneath our feet is the basic substrate of all terrestrial life. The intricate and fertile mix composing the soil, with its special life-giving attributes, is a most intriguing field of study. The soil serves not only as a medium for plant growth and for microbiological activity per se but also as a sink and recycling factory for numerous waste products which might otherwise accumulate to poison our environment. Moreover, the soil supports our buildings and provides material for the construction of earthen structures such as dams and roadbeds.

The attempt to understand what constitutes the soil and how it operates within the overall biosphere, which is the essential task of soil science, derives both from the fundamental curiosity of man, which is his main creative impulse, and from urgent necessity. Soil and water are, after all, the two fundamental resources of our agriculture, as well as of our natural environment. The increasing pressure of population has made these resources scarce or has led to their abuse in many parts of the world. Indeed, the necessity to manage these resources efficiently on a sustained basis is one of the most vital tasks of our age.

That knowledge of the soil is imperative to ensure the future of civilization has been proven repeatedly in the past, at times disastrously. In many regions we find shocking examples of once-thriving agricultural fields reduced to desolation by man-induced erosion or salinization resulting from injudicious management of the soil–water system. Add to that the shortsighted depletion of unreplenished water resources as well as the dumping of poisonous wastes—and indeed we see a consistent pattern of mismanagement. In view of the population–environment–food crisis facing the world, we can ill afford to continue squandering and abusing such precious resources.

The soil itself is of the utmost complexity. It consists of numerous solid components (mineral and organic) irregularly fragmented and variously associated and arranged in an intricate geometric pattern that is almost indefinably complicated. Some of the solid material consists of crystalline particles, while some consists of amorphous gels which may coat the crystals and modify their behavior. The adhering amorphous material may be iron oxide or a complex of organic compounds which attaches itself to soil particles and binds them together. The solid phase further interacts with the fluids, water and air, which permeate soil pores. The whole system is hardly ever in a state of equilibrium, as it alternately wets and dries, swells and shrinks, disperses and flocculates, compacts and cracks, exchanges ions, precipitates and redissolves salts, and occasionally freezes and thaws.

To serve as a favorable medium for plant growth, the soil must store and supply water and nutrients and be free of excessive concentrations of toxic factors. The soil–water–plant system is further complicated by the facts that plant roots must respire constantly and that most terrestrial plants cannot transfer oxygen from their aerial parts to their roots at a rate sufficient to provide for root respiration. Hence the soil itself must be well aerated, by the continuous exchange of oxygen and carbon dioxide between the air-filled pores and the external atmosphere. An excessively wet soil will stifle roots just as surely as an excessively dry soil will desiccate them.

These are but a few of the issues confronting the relatively new science of soil physics, a field of study which has really come into its own only in the last generation. Definable as the study of the state and transport of all forms of matter and energy in the soil, soil physics is an inherently complex subject, a fact which may account for its rather late development.

Our present-day knowledge of the soil physical system is still rather fragmentary. Hence, we continue to search and re-search for answers to the numerous newly arising questions. The business, and fun, and occasional agony of science is the continuing endeavor to achieve a coordinated understanding and explanation of observable phenomena without ever resting on yesterday's conclusions. Consequently a valid book on soil physics should reflect the complexity of the system even while attempting to present a coordinated and logical description of what is admittedly only a partial knowledge of it.