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Optimizing soil moisture for plant production

The significance of soil porosity

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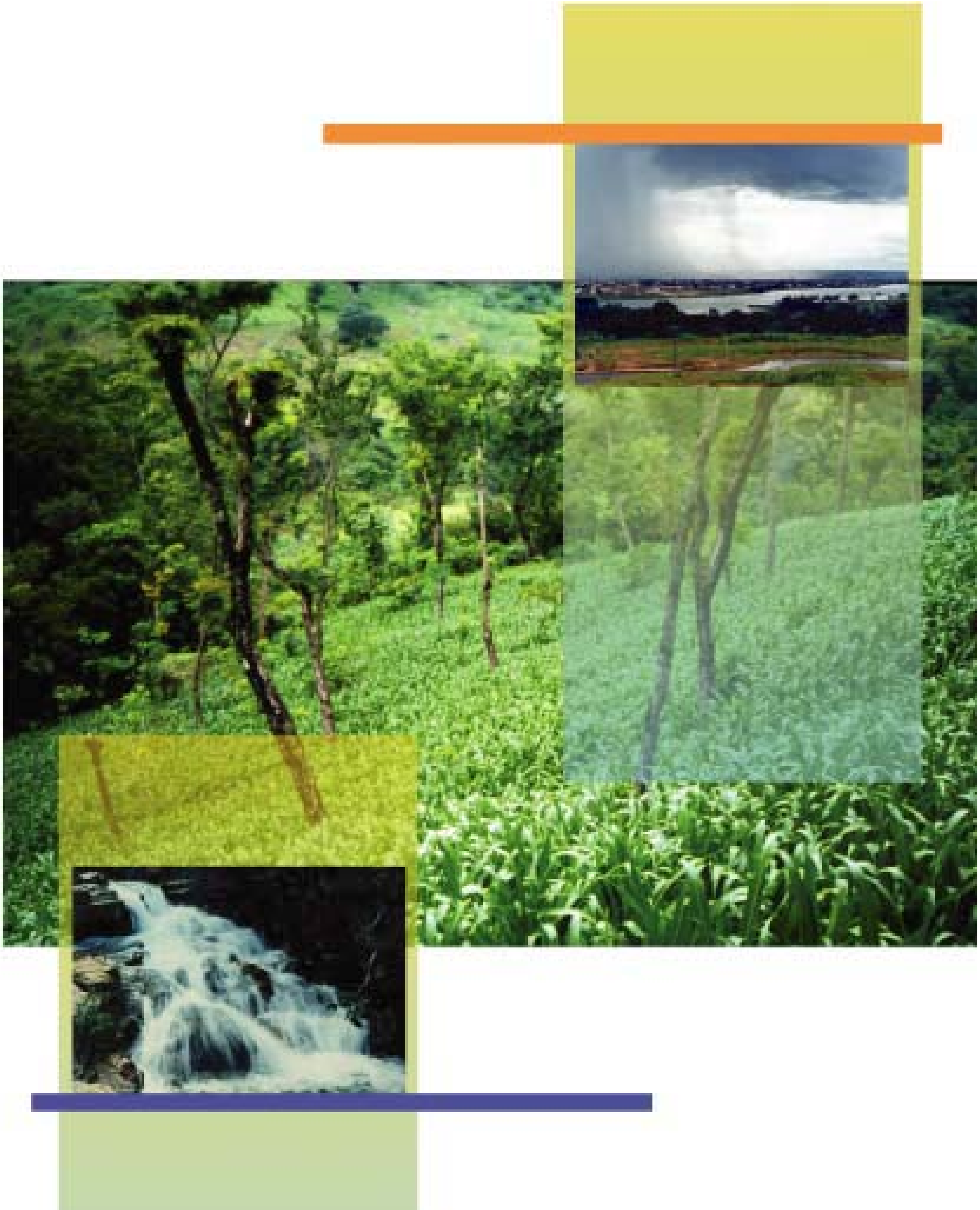

Preface

As the human population grows, notably in the tropics and subtropics (where many rural people live in poverty), the difficulties of increasing food production also increase. In these areas, average crop yields are in gradual decline. In spite of improved plant breeding, the rates of rise in potential yield are slowing down. Problems caused by erosion and lowland flooding are more frequent, providing evidence of ecological instability in upland areas. Water tables are falling as a result not only from drought, but also from overuse. People without formal land rights cultivate ever-larger areas of steep slopes and other marginal land.

As good land for the lateral expansion of agriculture becomes scarcer, there will be increasing need to intensify land use without causing a decline in productive potential.

There are experiences in a growing number of countries indicating that an agricultural revolution based on principles of better soil management can have a significant positive impact on the sustainability and productivity of agriculture.

Soil moisture is often neglected, but improved soil moisture management is crucial for sustainable improvement of food production and water supply. A wider perception of soil productivity and the reasons for soil erosion and runoff will contribute to achieving higher, profitable and sustainable plant production and to improve the regularity of streamflow.

Reduction of a soil's capacity to accept, retain, release and transmit water reduces biomass productivity, whether of crops, pasture species, shrubs or trees. Soil porosity is closely linked with yields, with the economics of farming and with the sustainability of farm families' livelihoods. Farmers are aware that land cleared from previously undisturbed vegetation provides "free fertility" from which the first crops benefit. But they also know that after a few seasons, productivity declines and that part of this decline is associated with the degradation of soil physical conditions. It is less commonly recognized that this soil damage and the loss of organic matter results in increased surface runoff and reduced soil moisture status.

People are aware of problems of water shortage and soil loss, but despite continued efforts, effective means of overcoming them have not become widespread. However, there are examples in parts of Brazil, Niger and Kenya where better understanding and care of the land are avoiding or reducing water shortages. This is being achieved by increasing rainwater infiltration into the soil, where it is retained for plant use or moved below the root zone to the groundwater.

Where surface runoff is a problem, it can indicate that the soil has become unreceptive, less porous and that much of the rainfall is ineffective in supporting plant growth and regular streamflow. The challenge is to enable the entry of as much rainfall into the soil as possible by promoting conditions that simulate an absorptive forest floor. Such conditions will stabilize the landscape, limit erosion and maximize the usefulness of rainfall. It is important to stress that while inadequate soil water supply is a major cause of low crop productivity, the nutritional aspects of crop productivity are also important. Consequently, an integrated approach to solving low crop productivity should always aim at an adequate supply of both soil water and nutrients.

Scientific endeavour will continue to increase our knowledge of the components of these problems and offer partial solutions. However, unravelling details of problems will not automatically result in workable means of solving them. This is because there is too little understanding of some key ecological and ever-changing linkages. For example, it is the complex set of interactions among weather, plants, soils, water and landscape that results in the crop yields each season. Conventional approaches to crop production offer limited scope for future progress. There is a need to think laterally, to see if there are other ways of looking at old assumptions to identify new ways forward.

This book, intended for extension staff and other technicians, as well as farmer leaders, aims to provide a solid basis for sound, sustainable soil moisture management.

This document has been made more user-friendly by presenting a guide for field workers with activities, exercises and discussion topics in non-technical language, and by interspersing the text with illustrations and diagrams. The complete materials of this guide are included on the CD-ROM that accompanies this document. The emphasis in this CD-ROM is on the use of careful field observations of soil and plant indicators to identify soil water problems.

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Acronyms

ABLH	Association for Better Land Husbandry
ABRACOS	Anglo-Brazilian Amazonian Climate Observation Study
AWC	Available Water Capacity
CA	Conservation Agriculture
FAO	Food and Agriculture Organization of the United Nations
FC	Field Capacity
FEBRAPDP	Federação Brasileira do Plantio Direto na Palha
IAPAR	Paraná State's agricultural research station, Brazil
Instituto CEPA/SC	Santa Catarina State's Institute for Planning and Agricultural Economics, Brazil
MAI	Moisture Availability Index
NGO	Non-Governmental Organization
PWP	Permanent Wilting Point
SUREHMA	Paraná State's agency for water resources and the Environment, Brazil
SWC	Soil and Water Conservation
TRIEA	Tea Research Institute of East Africa
WSC	Water and Soil Conservation
ZT	Zero Tillage

Glossary of soil moisture terms

Field Capacity (FC) – refers to the relatively constant soil water content reached after 48 hours drainage of water from a saturated soil. Drainage occurs through the transmission pores (greater than about 0.05 mm diameter; but note that field capacity can correspond to pores ranging from 0.03 to 0.1 mm diameter). The FC concept only applies to well-structured soils where drainage of excess water is relatively rapid; if drainage occurs in poorly structured soils, it will often continue for several weeks, and so poorly structured soils seldom possess a clearly defined FC. FC is best determined in the field by saturating the soil and measuring its water content after 48 hours of drainage have elapsed. Soil at field capacity feels very moist to the hands.

Permanent Wilting Point (PWP) – refers to the water content of a soil that has been exhausted of its available water by a crop, such that only non-available water remains. The crop then becomes permanently wilted and cannot be revived when placed in a water-saturated atmosphere. At this point the soil feels nearly dry or only very slightly moist.

Available Water Capacity (AWC) is the water available for plant growth held between Field Capacity and Permanent Wilting Point.

Saturation – refers to a soil's water content when practically all pore spaces are filled with water. This is a temporary state for well-drained soils, as the excess water quickly drains out of the larger pores under the influence of gravity, to be replaced by air.

List of background documents (available on CD-ROM)

1. Preliminary activities: community maps and transect walks
2. Activities: exploring soil hydrology, biology, porosity, etc.
3. Discussion topics for farmers' groups
4. Assessing project success: the significance of farm families' comments
5. Reinterpreting reports
6. An example of how to begin the steps of improvement
7. Soil moisture use under different land uses and vegetation
8. "The soil maker of Chile"
9. List of publications about cover crops
10. Demonstrating the importance of soil porosity

System requirements to use the CD-ROM:

- IBM compatible with Microsoft® Windows 95 / 98 / 2000 / Me / NT / XP
- 64 MB of RAM
- 50 MB of available hard-disk space
- Internet browser such as Netscape® Navigator or Microsoft® Internet Explorer
- Adobe Acrobat® Reader 5.0 (included on CD-ROM); to be installed in case of problems with previous versions of Adobe Acrobat® Reader