IBSRAM

International Board for Soil Research and Management

Report of the Inaugural Workshop on

Management of Vertisols for Improved Agricultural Production

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at
ICRISAT Center
Patancheru, India

18-22 February 1985

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Sponsoring Organizations

ACIAR	Australian Centre for International Agricultural Research
ADAB	Australian Development Assistance Bureau
AID	Agency for International Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
SMSS	Soil Management Support Services

Foreword

The Workshop on the Management of Vertisols for Improved Agricultural Production, an IBSRAM inaugural workshop, was held at ICRISAT Center, Patancheru, India, from 18 to 22 February 1985. It was attended by 60 delegates from 26 countries, and by several members of ICRISAT.

A large part of the funds for the Workshop were donated by the International Crops Research Institute for the Semi-Arid Tropics and the Soil Management Support Services, but many other donors supported the Workshop, including the Australian Centre for International Agricultural Research, the Australian Development Assistance Bureau, the Agency for International Development, the International Development Research Centre, and the Office de la Recherche Scientifique et Technique Outre-Mer. Several national governments and international agencies assisted by sponsoring attendance of their delegates. IBSRAM is pleased to express its gratitude to all of them.

Thanks are also due to the Workshop Organizing Committee, the Advisory Committee, and the Local Arrangements Committee at ICRISAT. Their names are listed on the inside front cover of this report.

This booklet contains the workshop program, the names and addresses of participants, a summary of the paper presentations, the recommendations of the working group discussions, and suggested procedures for participation in the Vertisols Soil Management Network. ICRISAT will publish proceedings of the Workshop later this year.

C. F. Bentley
Chairman, IBSRAM

Executive Summary

Participants in the Inaugural Workshop on the Management of Vertisols for Improved Agricultural Production strongly endorsed the establishment of a Vertisols Soil Management Network to promote agricultural development and use of these potentially highly productive, dark clay soils.

The workshop was attended by more than 60 participants from 26 countries. Twenty-two invited presentations were followed by a field trip to farmers' fields in India, where improved management of Vertisols has already been introduced. Four working groups presented reports setting priorities for research and evaluation. Countries in which Vertisols contribute significantly to food production were identified, and procedures for participation as Network Cooperators were drafted.

Delegates were urged to prepare draft proposals for research on Vertisols using national program resources and to submit these proposals to IBSRAM for assistance in obtaining additional funding, as required. Network Cooperator proposals should be submitted to IBSRAM by mid-1985 and via IBSRAM to potential donors by the end of the year. The implementation of such proposals would mark the active initiation of a Vertisols Soil Management Network, with IBSRAM's guidance and assistance.

A high level of interest in joining the network was indicated by delegates from 19 countries represented at the workshop. Several others expressed a desire to be kept informed with a view to joining later. An outline for preparation of project proposals by Network Cooperators was compiled by the participants for use in developing national program support for network research activities, and a tentative proposal for a Mediterranean Region Vertisol Network was offered by the delegate from ICARDA. It was evident that cooperation with the international centers would benefit the work of the network of individual countries.

It is estimated that there are at least 310 million hectares of Vertisols and associated vertic soils throughout the world, most of them either currently uncultivated or underutilized but with a high potential for improvement. The largest areas are 79 million hectares in India, 70 million in Australia, and an estimated 60 million in the Sudan. The Vertisol area in the Sudan, for instance, is estimated to have a production potential equal to that of the major grain-producing prairie provinces of Canada. In many

Executive Summary

other countries, including Venezuela, Ethiopia, Egypt, and Syria, these soils are an important resource.

Vertisols have unique physical properties that affect their manipulation for use: the clayey texture causes deep, wide cracks when the soil is dry and stickiness when it is wet. These soils occur in climates with high temperature and variability in rainfall. All this creates difficulties in crop, land, and water management that need to be specifically addressed by research. Already, soil management and cropping practices have demonstrated the capability of these soils for expanded food production: Indian national programs, in cooperation with ICRISAT, have developed a system of farming Vertisols that can produce two crops a year on land that formerly produced only one.

The Workshop was concerned with endeavoring to assist national agricultural research programs in applied research and adaptive testing to enable them to adopt some of the technology that has been developed elsewhere for successful use by farmers in their own countries.

Through the network that is to be formed as a result of this workshop, and with the assistance of IBSRAM and donors, the national scientists in the countries concerned will be assisted in planning, executing, evaluating, and applying research aimed at improving the productivity of the Vertisols in their area. That assistance will also be valuable to national agricultural research programs in developing their capability and confidence in doing any other kind of agricultural research they may wish to undertake in the future.

The net effect foreseen from the Vertisol network will be improvement of national agricultural research capabilities, improved use of Vertisols, and, most important of all, increased food production to meet the needs of growing populations.

It was the consensus of the Workshop that there is a genuine need for a network to assist in achieving those objectives and to assist and speed the compilation and dissemination of both existing and new knowledge to be gained from research to be undertaken. Both objectives will contribute to the continuing increase of effective utilization of Vertisols.

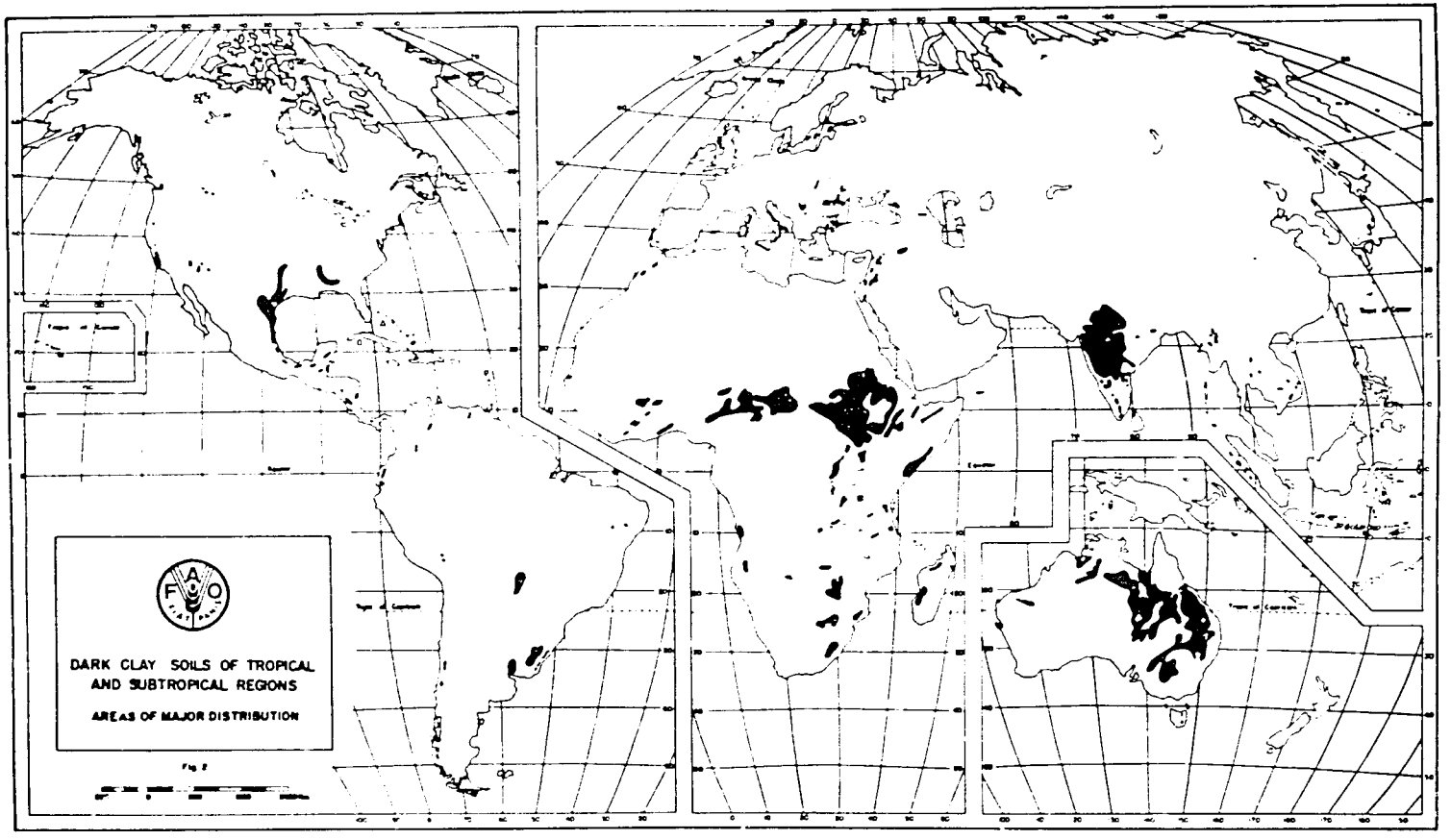

Fig. 1. Areas of major distribution of the dark clay soils of the tropical and subtropical regions (FAO 1965).

The Inaugural Workshop for a Vertisol SMN

Introduction

Vertisols, which occur extensively in humid and subhumid, semi-arid, and arid climates, have potentials for food production well above their present level of use. There are approximately 310 million ha of these soils in India, Australia, Sudan, Ethiopia, Chad, Venezuela, Argentina, and other countries of Asia, Africa, and the Americas. They contain at least 30% clay, and the dominant clay mineral is usually one of the montmorillonite group. These properties give rise to the primary attributes of Vertisols that affect their management by man. These include high moisture retention and high shrinking and swelling, resulting in the concomitant mechanical difficulties in handling.

The Vertisols belong to four suborders, as defined in *Soil Taxonomy*:

1. Torrerts—Vertisols of deserts.
2. Uderts—Vertisols in humid areas.
3. Usterts—Vertisols in areas with essentially summer rains.
4. Xererts—Vertisols in areas with mean annual soil temperatures of less than 22°C and having winter rains.

Figure 1 shows the distribution of Vertisol and vertic regions of the world. The Vertisols with xeric soil moisture regimes—in Mediterranean climates—are mainly in northern Africa (Algeria, Libya, Morocco, Tunisia), the United States (California), and southern Australia. Uderts are found in Trinidad and Venezuela, among many other countries, and Usterts are located in Ethiopia, India, northern Australia, and the Sudan, among others. Torrerts occur mainly in the Sudan, the Sahel, and the U.S.

Table 1 lists some countries considered to have Vertisols or vertic subgroups, by climatic regions, as prepared by the Workshop participants.

Purpose

The purpose of this Inaugural Workshop on Management of Vertisols for Improved Agricultural Production was to launch a Soil Management Network (SMN) for Vertisols.

Table 1. Partial list of countries with Vertisols and vertic subgroups, by climatic zones.

Humid & subhumid (udic) (8% of area)	Semi-arid (ustic) (70% of area)	Arid (torric) (18% of area)	Mediterranean (xeric) (4% of area)	High altitudes
Argentina	Argentina	Australia	Algeria	Colombia
Australia	Australia	Chad	Canary Islands	Ethiopia
Cameroon	Botswana	Colombia	Chile	Kenya
Canada	Brazil	Egypt	Cyprus	Tanzania
Colombia	Burkina Faso	India	Greece	
Commonwealth of the Caribbean	Burundi	Jordan	Iran	
Cuba	Chad	Pakistan	Iraq	
Dominican Republic	Colombia	Somalia	Israel	
	Commonwealth of the Caribbean	Spain	Italy	
		Sudan	Jordan	
Ecuador	Cuba	Syria	Lebanon	
El Salvador	Ethiopia	United States	Libya	
Ethiopia	India	Venezuela	Morocco	
Fiji	Kenya		Portugal	
France	Malawi		Spain	
Guatemala	Mexico		Syria	
Guayana	Niger		Tunisia	
Haiti	Nigeria		Turkey	
Hungary	South Africa		United States	
India	Sudan			
Indonesia	United States			
Mexico	Venezuela			
Nicaragua	Zambia			
Philippines	Zimbabwe			
Rumania				
Solomon Islands				
Sri Lanka				
Sudan				
Thailand				
Trinidad				
United States				
Uruguay				
Venezuela				
Vietnam				
Yugoslavia				
Zaire				

Source Vertisol Workshop participants

Workshop Objectives

The workshop reviewed the important principles of improved Vertisol management technology and their applications for increasing production under diverse farming systems. The specific objectives were:

1. To review the present knowledge of both traditional and improved farming systems on Vertisols under rainfed and irrigated conditions.
2. To review the present knowledge of the characterization and classification of Vertisols.
3. To evaluate the data-base and analytical techniques needed to assess the applicability of current advanced Vertisol management techniques.
4. Based on the previous objectives, by involving national and international operational and research institutions in exchanging ideas and collaborative work, to:
   a. Investigate the feasibility of an effective network for adaptive research and testing to introduce improved Vertisol management technology;
   b. Develop linkages between institutions involved in characterization surveys and management of Vertisols to improve interpretations for their more efficient use; and
   c. Identify areas of Vertisols that need further research for better evaluation and use.

Program Outline

The workshop was held over 5 working days. The first 2 days were devoted to reviewing and determining the state-of-the-art. A mid-workshop field tour of sites of operational and on-farm research provided a basis for discussion of ICRISAT's experiences in the development of improved management technologies. The fourth day was devoted to group discussions for determining the research and management needs of the network. The last day of the workshop was used to formulate the outline of a network.

Summary of Symposium Sessions

The opening session was chaired by L.D. Swindale, Director General, ICRISAT. C.F. Bentley, Chairman of the governing board of IBSRAM, first introduced IBSRAM and the purpose of the meeting, then discussed various aspects of the proposed Vertisol Soil Management Network. S.M. Virmani, Leader of the Farming Systems Research Program at ICRISAT, presented an approach to the management of Vertisols in the semi-arid tropics, based on the experience gained by ICRISAT over the last decade of research on these soils. Virmani pointed out that, through the application of improved methods of management of Vertisols, crop yields of over 4000 kg/ha per year have been harvested in the last 9 years at ICRISAT watersheds. In on-farm tests, the improved technology showed two to five times higher gross profits than the traditional technology.

M.A. Rasheed, Head, Soils Department, National Research Centre of Egypt, chaired the second session, in which participants discussed properties, use, and management of Vertisols in different agroecological zones of the world. The four presentations in this session described characterization of Vertisols in the semi-arid, arid, subhumid and humid, and the Mediterranean regions. Speakers presented the role of physical properties of Vertisols in relation to their management. R. Dudal, Professor, University of Leuven, Belgium, delineated the Vertisols and vertic soil areas of the world. In reviewing his 1965 map on the global distribution of Vertisols, Dudal said, he now tentatively estimates this group of soils to occupy about 300 million hectares.

The research needs and constraints to improved use of Vertisols was the topic of four papers presented in the third session, chaired by J.S. Kanwar, Director of Research, ICRISAT. Examples of dryland, irrigated use of Vertisols in Australia, the United States, and the Sudan were reviewed. Pedological research needs of Vertisols were assessed. B.A. Stewart, Laboratory Director, USDA Conservation and Production Research Laboratory, U.S, presented an interesting concept on a system of limited irrigation for dryland Vertisols.

In session four, participants discussed the components of the available technologies for the improved management of Vertisols. The following aspects were reviewed: crops and cropping systems, land and water management practices, soil fertility management, and tillage practices for soil and water conservation on Vertisols. It was observed that the effective surface drainage of excess water is critical for efficient management of these soils. Responses of crops to applied fertilizers were discussed, because these soils are generally deficient in nitrogen, phosphorus, and zinc. B.A. Stewart chaired this session.

The fifth and final session of paper presentations, chaired by R.Dudal, discussed methods for transfer of improved Vertisol management technologies from the research institutes through national agricultural development systems. L.D. Swindale outlined some available approaches to agrotechnology transfer, including analogue and soil family transfer. Other approaches for transfer using classification and soil survey interpretations were discussed, and a case study of the environmental characteristics of Vertisols in Syria was presented. Finally, the

socioeconomic aspects of technology transfer to farmers' fields were reviewed, and some IDRC experiences with networks were used to present some principles for network success.

Working Group Discussions and Recommendations

Workshop delegates separated into four working groups to discuss and recommend future research priorities for improved management of Vertisols that would increase agricultural production. The groups focused on the following general topics:

1. Evaluation of the properties, survey, and classification of Vertisols,
2. Management of Vertisols under rainfed conditions,
3. Management of Vertisols under irrigated conditions, and
4. Validation of technologies.

Group 1 discussed the questions of guidelines for characterization of representative research sites and whether to recommend lines of research for better and more transferable results. It was suggested that it will be necessary to have information on soils, climate, topography, cropping systems, and previous research results of the area under question. In case there is no previous adequate information on the area, at least a reconnaissance soil map at 1:250 000 should be made. Landsat imagery was suggested as a base map. A description of the occurrence and distribution of natural vegetation in the area can help to indirectly determine climatic and moisture regimes.

The group presented two alternatives for site selection: one is to plant experiments in farmers' fields; the other is to select a site on an experiment station. Some of the basic items to consider if experiments are planted in farmers' fields include: proximity of the field to an agrometeorological station, accessibility to the site and availability of farm machinery and equipment, a highly motivated and collaborative farmer, and, naturally, an area with the representative soil. For an experiment station, the following should be considered: accessibility of the area, proximity to a source of labor, availability of water for the station and for potential irrigation, and the existence of large areas of the representative soil plus other representative soils considered on a regional basis.

In the site selected for research, it is important to make a more detailed study of the soil(s) under question. A convenient scale is probably 1:500 or 1:1000. The aim is a clearer understanding of the local variability for improved site selection for research plots. Suggestions were listed for sample analysis in the field and laboratory, and a list of land qualities and deficiencies in their evaluation was prepared. General priorities for research on poorly drained, acid, and sodic Vertisols were drafted. Finally, the group recommended a training workshop session and a document describing the methodology for physical characterization in the field and in the laboratory.

Group 2 discussed research priorities for the management of Vertisols in the drylands. It was noted that food production is generally low in the major Vertisol areas under rainfed conditions. This is true for both high- and low-rainfall areas. Although the very large Vertisol areas of the Sudan, India, and Ethiopia have rainfall between 500 and 1500 mm per year, crop production is still low. The reasons for this are many, but the most obvious are surface drainage problems, lack of water in the dry season, and inadequate plant nutrients. Initial efforts should be focused on putting into place the low-input changes that can increase yields and that will also serve as a foundation for additional technological steps. At the same time, however, some studies should be carried out to determine maximum production potential by integrating all components of a production system.

The group recommended that IBSRAM, in collaboration with the international centers, including ICARDA, ICRISAT, and ILCA, among others, should identify specific research locations and document existing data bases, which would serve as a basis for the formation of the network.

Several priorities for research were listed under the following categories: tillage and land configuration, water conservation and use, nutrient management, cropping systems, and integrated component technology.

Countries indicating a desire to participate in a rainfed Vertisols network include the Caribbean countries, Ethiopia, India, and the Sudan. Botswana, Zambia, and Zimbabwe expressed various levels of interest, but perhaps cannot be immediately included.

Group 3 discussed research priorities for irrigated use of Vertisols. They stated that soil- and water-management requirements of irrigated Vertisols are different in many respects from the dryland Vertisols and other irrigated soils. To date, in many parts of the world, irrigated Vertisols have not received the special attention warranted by the problems peculiar to them. Therefore, there is an urgent need to identify and evaluate the problems of irrigated Vertisols. The group listed current activity areas, and each individual country submitted its own priority. Egypt, Nigeria, Pakistan, the Sudan, Tunisia, and ICARDA expressed great interest in participating in an Irrigated Vertisols Network.

Research priority areas were identified as follows: drainage, salinization and/or sodicity, including alkalinity; irrigation scheduling; crops and cropping systems, soil and land management; weed control; soil testing and crop yield responses under irrigation; and standardized methods for evaluating nutrient deficiencies, as by soil testing, foliar analysis, and field trials.

Group 4 discussed the verification, testing, and validation of improved technologies developed by various institutions. They considered it essential to select the components suitable to local needs. Rather than concentrating on a given technology, components should be identified from the various improved technologies available.

It was suggested that the Vertisol Soil Management Network should include the following principles for Network Cooperators:

* Establish a common objective and then set priorities.
* Allocate resources by the national research programs for the network.

* Identify the comparative advantages and leadership capabilities of the various organizations having improved technologies.
* Supply coordination and logistics, such as identification of a coordinator and the necessary infrastructure.
* Look at the levels of interaction desired.
* Link national cells with international, regional, and other related institutions.
* Establish principles for selection of areas of activity.

The full group reports are included in the proceedings of the workshop, to be published by ICRISAT later this year.

Outline for Preparation of an IBSRAM-Sponsored Project Proposal by a Network Cooperator

After the concluding session of the workshop, many participants remained and met on Friday night and Saturday morning. They developed the following outline for use in preparing IBSRAM-sponsored project proposals for participation in the Vertisol Soil Management Network.

1. Brief statement of sociological setting, extant agriculture, etc.
2. Statement of the problems (*emphasize*)
3. Objectives of the project (*emphasize*)
4. Program of work
   a. Applied research and/or on-farm testing—Phase 1, 3 to 5 years
   b. Validation, if necessary—Phase 2, up to 10 years
5. National component
   a. Location and personnel
      i. Institutions and agencies—executing agency; director of project; responsible officer; etc.
      ii. Personnel resources—number of scientists, type and level of expertise; percentage of time to be spent on project
      iii. Technicians—number and roles
      iv. Administrative and office support
   b. Physical resources
      i. Laboratory facilities and equipment
      ii. Field facilities, such as experimental sites and equipment

iii. Transport
iv. Other facilities, including housing; other infrastrucutural facilities, such as possible collaborating institutions; etc.

6. International component

   a. Personnel

      i. Visiting scientists—number, expertise, duration needed, and at which stage of project needed.
      ii. Technologists (if any)—number and specific needs

   b. Field work support

      i. Equipment, machinery, and supplies
      ii. Field operations

   c. Consultancies

7. Budgets

   a. National component
   b. Donor component
      Administrative costs—IBSRAM

8. Names, titles, addresses (including telex or cable), official channels of communication.

Project proposals should be sent to:

Mr. G.B. Gresford
IBSRAM Interim Administrator
ACIAR
G.P.O. 1571
Canberra 2601, Australia

Program

SUNDAY, 17 FEBRUARY

1900 Cocktail party, hosted by J.S. Kanwar, Director of Research, and C.R. Jackson, Director for International Cooperation, ICRISAT.

MONDAY, 18 FEBRUARY

0830-0945	Registration

Session 1: Introductory Session

Chairman: L.D. Swindale
Rapporteurs: R.P. Singh, J.R. Burford

0945-1000	Welcome: L.D. Swindale
1000-1030	Introduction to IBSRAM and purpose of the workshop: C.F. Bentley
1030-1100	Tea/coffee
1100-1145	The concept of a Vertisol Soil Management Network: C.F. Bentley
1145-1230	Approaches to the management of Vertisols in the semi-arid tropics—the ICRISAT experience: S.M. Virmani, M.R. Rao, K.L. Srivastava
1230-1255	General discussion
1255-1300	Remarks by the Chairman
1300-1400	Lunch

Session 2: Properties, Uses, and Management of Vertisols in Different Agroecological Zones

Chairman: M.A. Rasheed
Rapporteurs: Piara Singh, J.C. Bhattacharjee

1400-1445	Vertisols of semi-arid tropics: W.A. Blokhuis
1445-1530	Vertisols of the dry tropics of Sudan: H.H. Abdulla Mohammed
1530-1600	Tea/coffee
1600-1645	Vertisols of subhumid and humid zones: R. Dudal
1645-1730	Vertisols of the Mediterranean region: A.Y. Taimeh
1730-1735	Remarks by the Chairman

TUESDAY, 19 FEBRUARY

Session 3:
Research Needs and Constraints to Improved Usages

Chairman: J.S. Kanwar
Rapporteurs: C.W. Hong, K.L. Sahrawat

0830-0915	Pedological research needs: D. Tessier, A. Ruellan
0915-0930	Dryland use of Vertisols: K. Coughlan, G.D. Smith, D.F. Yule
1000-1030	Tea/coffee
1030-1115	Limited-irrigation/dryland farming systems: B.A. Stewart
1115-1200	Irrigated use of Vertisols: I.A. Babiker
1200-1215	Discussion

Session 4:
Technologies Available and Their Components

Chairman: B.A. Stewart
Rapporteurs: C.K. Ong, M.R. Rao

1215-1300	Cropping systems for Vertisols in different rainfall regimes in the semi-arid tropics: R.W. Willey, R.P. Singh, M.S. Reddy.
1300-1400	Lunch
1400-1445	Vertisol land and water management practices: E. Burnett
1445-1530	Soil fertility management: J.R. Burford, K.L. Sahrawat, R.P. Singh
1530-1545	Tea/coffee
1545-1600	Group photograph
1600-1645	Conservation-effective tillage: P. Unger, O.R. Jones
1645-1700	Audiovisual on adoption of technology on Vertisols: S.M. Virmani
1700-1705	Remarks by the Chairman
1705	Group discussions Coordinator: H. Eswaran Formation of working groups.

1930	Workshop Dinner at Secunderabad Club, hosted by C.F. Bentley, Chairman, IBSRAM, and L.D.Swindale, Director General, ICRISAT.

WEDNESDAY, 20 FEBRUARY

Session 5: Field Trip

0800-0830	Audiovisual on Introduction to ICRISAT
0830-1000	Visit to ICRISAT Vertisol watersheds and soil profile: S.M. Virmani, J.C. Bhattacharjee, J.R. Burford, Sardar Singh
1000-1035	Adoption of Vertisol management technology in Karnataka State, India—a case study: T.V. Sampath
1035-1045	Tea/coffee
1045-1130	Drive to Shankarpally plateau
1130-1200	Discussion of soil and geomorphology
1200-1300	Drive to Rest House at Sangareddy
1300-1400	Lunch
1400-1440	Drive to Aroor village
1440-1600	Visit to farmers' fields—research results and adoption studies: M.S. Reddy, M. von Oppen, D. Sharma
1600-1700	Return to ICRISAT Center

THURSDAY, 21 FEBRUARY

Session 6: Methods and Transfer of Technology

Chairman:	R. Dudal
Rapporteurs:	R.D. Ghodake, Sardar Singh

0830-0915	Approaches to agrotechnology transfer: L.D. Swindale
0915-1000	Environmental characteristics of Vertisols in Syria—a case study of their influence on the management and productivity of

	cereals at Jinderiss: P.J.M. Cooper, J.D.H. Keatinge, S. Kukule, I.K. Somel
1000-1030	Tea/coffee
1030-1115	New approaches to Vertisol classification and their influence on the transfer of technology: J.A. Comerma
1115-1200	Soil survey interpretations for Vertisols: J.D. Nichols
1200-1245	Socioeconomic aspects of technology transfer: M. von Oppen, R.D. Ghodake, K.G. Kshirsagar, R.P. Singh
1300-1400	Lunch
1400-1500	Research networks—some IDRC experiences: A.D.R. Ker
1500-1530	Tea/coffee
1530-1730	Group discussions (continued)
1730	Group leaders and rapporteurs meet and prepare reports

FRIDAY, 22 FEBRUARY

Session 7: Presentation of Group Reports

Chairman: H. Eswaran
Rapporteur: T. Hawando

0800-1030	Group leaders present their reports
1030-1100	Tea/coffee
1100-1200	Discussion
1200-1300	Audiovisual on SMSS: H. Eswaran
1300-1400	Lunch

Session 8: Concluding Session

Chairman: C.F. Bentley
Rapporteurs: R.A.E. Mueller, M. von Oppen

1400-1600	Conclusions and Consensus Statement

Participants

Invited Participants

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