R E P O R T

WATER PRODUCTION FUNCTIONS AS RELATED TO TIME AND AMOUNT OF IRRIGATION AND RAIN

Crida, Hyderbad, India

May 14-26, 1990

Consultant Report by

R.J. Hanks, Ph.D. & G.E. Bingham, Ph.D.

Agrometeorology Subproject

Agricultural Research Project (386-0470)

Implementation Order No. 70

Contract No. 386-00000-C-00-5039-00

WINROCK INTERNATIONAL
1611 North Kent St.
Arlington, VA 22209

Water Production Functions as Related to Time and Amount of Irrigation and Rain.

May 14-26, 1990

at

CRIDA, HYDERABAD,INDIA

FINAL REPORT

BY

R.J. HANKS AND G.E. BINGHAM
USA INSTRUCTORS

V.U. RAO AND N.N. SRIVASTAVA
INDIA INSTRUCTORS

May 29, 1990

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The support we were given by various organizations and individuals responsible for planning and inplementation of the workshop was excellent.

Planning by ICAR, USAID and Winrock International resulted in the workshop running smoothly throughout the program. Adjustments were accomplished quickly and we were able to concentrate on workshop activities. Particular efforts were made by Dr. Maharaj Singh and others at Winrock International to get the meteorological equipment through customs and to Hyderabad in time for the workshop. Dr. B.V. Ramana Rao, CRIDA then made special effort to provide securuty for the equipment.

Facilities, logistical support and arrangements provided by Dr. B.V. Ramana Rao, CRIDA and Dr. C.K. Ramanatha Chetty, CRIDA and their staff assured smooth running of the workshop. Dr. V.U. Rao, Hissar, and DR. N.N. Srivastava, CRIDA, our India counterparts on this workshop, gave constant advice and feedback throughout the course as well as making numerous arrangements during the course which is much appreciated. Dr. V.U. Rao particularly helped us as a go-between at the hostel that made life there much more agreeable.

The efforts of special lecturers, Dr. S.M. Virmani, Prof. S.K. Sinha, Dr. S.T. Nagaraj and Dr. D.G. Rao are very much appreciated. We also acknowledge the hospitality of Dr. S.M. Virmani for arranging our trip to ICRASAT and hosting us while there.

Considerable work was done at the field site prior to the workshop by Dr. D.G. Rao, Dr. K.C.P. Rao. We especially appreciate their efforts to set up the line source sprinkler and install the neutron access tubes and the use of the neutron probe. This was a significant effort which we acknowledge.

Finally we thank the participants for their support throughout the workshop. Their interest and high energy level helped make the everday training a pleasant experience and provided a stimulating atmosphere for all.

SUMMARY

An INDO-US Workshop on Water Production Functions as Related to Time and Amount of Irrigation and Rain was held at CRIDA in Hyderabad, A.P. The workshop was attended scientists from 12 different institutions and Universities were represented with 14 total participants. Instruction was by Dr. R.J. Hanks and Dr. G.E. Bingham from the Plants, Soils, and Biometeorology Dept., Utah State Univ. Guest speakers were Dr. S.M. Virmani, Prof. S.K. Sinha, Dr. S.T. Nagarag and Dr. D.G. Rao. A line source system and neutron probe soil moisture measuring site was set up at the CRIDA experimental farm under the direction of Dr. D.G. Rao and Dr. K.C.P. Rao.

The workshop had the following objectives:

1. Consider the basic processes that determine crop water use and soil water balance characteristics.
2. Discuss the theoretical and experimental methods for evaluation of evapotranspiration (soil evaporation and transpiration).
3. Consider the effect of inputs and management practices on crop water use.
4. Discuss modeling of crop water use as related to yield and the verification of the models using the line source method.
5. Apply water production functions in solving practical problems in both rainfed and irrigated agriculture.
6. To learn how to use the meteorological data acquisition system (METSYS) and apply the results measured to above objectives.

A pre-workshop questionnaire was used to ascertain the experiencea nd background of the participants. Lectures, discussions hands-on training with computers, METSYS and practical experience in the field were used to meet the objectives. A post-workshop questionnaire was given to measure the degree to which the participant thought the training had been successful. Both instructors and participants thought the workshop was highly successful in providing useful information for their application.

One concept that we adopted early was to be flexible to the needs of the participant. Thus we followed the schedule approximately as outlined the first week. On Saturday of the first week we scheduled a discussion to consider amending the program. The second week was, as a consequence, devoted to getting all participants thouroughly familar with the data system. Seven systems were set up outside of the hostel so work could be done, in pairs, at all hours with no security problem. The second week, therefore, was quite different from the program

originally planned.

A unique feature of the workshop turned out to be the training of the participants on the METSYS all at the same location. Normally this is done on an individual basis for a couple of days with company representative etc. that had limited experience using the system. The advantage of having group training proved incentative, competition and extra help with problems as well as healthy discussions on uses and applications. Housing participants and instructors together also had the advantage of late-night consultation and practice that seldom is achieved. The participants strongly suggested that this procedure be followed whenever complex equipment is handed over to local scientists.

They suggested it would greatly reduce the damage, misuse, and non-use of equipment which has occurred in some instances in past INDO-US projects. They also suggested that longer time is needed to assimulate complex systems.

The main difficulty encountered was the inability of having free access to the microcomputers after official training sessions to allow participants "practice-without-pressure". Frequent power outages were also frequent problems. These problems were partially alleviated by the availability of laptop computers brought by both instructors. However, all concerned agreed for serious instruction on computer usage requires a computer for every 2 to 4 people and non-pressure time to use the computer.

The participants were excellent scientists mainly trained agricultural meteorological meteorologists and related diciplines. After some initial hesitation about their ability to master computers and complicated the METSYS they became enthusiastically involved. They all ended up with a high sense of accomplishment and having had a new experience. Thus, both instructors and participants had a "winning" experience.

OBJECTIVES

The general objectives of this short course were to provide Indian scientists with information and experience in modeling and field verification of water production functions as related to time and amount of water applied.

The specific objectives were:

1. Consider the basic processes that determine crop water use and soil water balance characteristics.

2. Discuss the theoretical and experimental methods for evaluation of evapotranspiration (soil evaporation and transpiration).

3. Consider the effect of inputs and management practices on crop water use.

4. Discuss modeling of crop water use as related to yield and the verification of the models using the line source method.

5. Apply water production functions in solving practical problems in both rainfed and irrigated agriculture.

The participant at the beginning the course was asked to develop a technical program for implimenting course information into a research project to account for site specific factors at his location.

An additional objective of the course that developed, as a result of having the meteorological data acquisitions system (Campbell Scientific Model CR10 and associated sensors) hereafter called "METSYS" was:

6. To learn how to use the METSYS and apply the results to previous objectives.

PARTICIPANTS

The participants with their affiliation are listed in the attachments. They were generally enthusiastic and attentative throughout the workshop even though many of the topics were new to them. Most of them were Agro-meteorologists but two were trained in other closely related dicisplines. Their experience was quite varied especially related to microcomputers (PC)

familarity and programming. However, all adjusted quickly with help as needed so all seemed to profit.

WORKSHOP PROGRAM

A program was drawn up prior to the start of the course based on an outline prepared with our Indian counterparts when they were in the US and at USU. This was amended prior to the meeting after seeing the facilities available. The local people had planned on having the computer instruction in another institute. After inspecting the site and the computers available it was decided to "make do" at CRIDA because of the time needed to transport everyone to the computer facilities and because the computers were old units with 2 disk drives. To be effective for training, at the level being done in these programs, the computers need a hard drive of at least 20 mb memory to be able to use software US consultants are using. Thus two computers were found, that could be spared, and a room found as well. Three other computers in normal use were also allocated for our use at specified times. We also had 2 laptop computers brought with from USA that served well. It turned out that the hands on computer experience was done mainly on the two computers assigned. Most of the participants with little experience did not want to get started without someone else to help. The laptops served to give us some flexibility as well as serving to provide a medium to prepare in the evenings and early in the morning.

One concept that we adopted early was to be flexible to the needs of the participant. Thus we followed the schedule approximately as outlined the first week. On Saturday of the first week we scheduled a discussion to consider amending the next weeks program. We also had our Indian counterparts keep giving us feedback. We also were housed in the same hostel as the participants and ate all of our meals with them. Thus by the end of the first few days there was free interchange. The second week was, as a consequence, devoted to getting all participants thouroughly familar with the data acquisition. Several systems were set up outside of the hostel so work could be done at all hours and there was no security problem. The second week, therefore, was quite different from the program originally planned. The program shown in the attachments is as actually given.

CHANGES SUGGESTED

1. How do you do troubleshooting with METSYS?

2. How can METSYS be used for the maximum advantage? What can

it be used for?

3. How can spare parts be obtained? Once equipment arrives it is very difficult to get spare parts-thus spare parts needs to come as part of the system originally.

4. The lab sessions are not long enough. With 1 1/2 hours time participants just get into a subject and they have to move.

5. We need stepwize instructions on how to get data in and out of the METSYS.

6. We need to know how to use the serial interface on the METSYS.

7. How can PLANTGRO be adapted to local conditions.

8. How can we use the BASIC programming language to our advantage-for example to take the data from the METSYS and use it for some other purpose?

9. Can the METSYS be programmed to measure rainfall intensity?

10. What is the difference between Tables 1,2, and 3 of METSYS.

CRITIQUE

Program

We believe the course was generally successful. It exceeded our expectations when we discovered the wide background of the individual participants. Thus we decided early on that we had to be able to adjust our program and give individual attention to the needs of individual participants.

The partipants probably got most out of the hands-on instruction with the METSYS and the hands on use of the computer. There was an introduction to models as well as some rudimentry instruction in the use of word processor programs, spread sheets and BASIC and QUICKBASIC programming languages. They had fairly detailed instruction on METSYS for measuring meteorologocal parameters. The participants took to this unusual experience (for them) very well and progressed daily. This experience is undoubtedly the highlight of the workshop. Each of them got a chance to set up a system, program it, and use the data in a BASIC program. Very few of them had extensive experience with computers so there was some reluctance to get personally involved at first. About half-way through the course some of the participants caught the idea and this helped other convince themselves that they could do the programming necessary to handle the METSYS.

This confidence also helped with their eagerness to use the other models discussed and to manipulate their METSYS data. They were all provided with a disk with the BASIC programs discussed and became somewhat aware of the other software used and its application. The next step will be for them to continue on with their learning at home.

A unique feature of the course turned out to be the training of the participants on the METSYS all at the same location. Normally this is done on an individual basis for a couple of days with company representative etc. that had limited experience using the system. Thus the company representatives in India got a considerable learning experience also. We believe this is the first time this type of effort has been done with a group before.

The advantage of having group training provided incentative, competition and extra help with problems as well as healthy discussions on uses and applications. Housing participants and instructors together also had the advantage of late-night consultation and practice that seldom is achieved. The participants strongly suggested that this procedure be followed whenever complex equipment is handed over to local scientists. They suggested it would greatly reduce the damage, misuse, and non-use of equipment which has occurred in some instances in past INDO-US projects. They also suggested that longer time is needed to assimulate complex systems.

The main difficulty encountered was the inability of having free access to the microcomputers after official training sessions to allow participants "practice-without-pressure". Frequent power outages were also frequent problems. These problems were partially alleviated by the availability of laptop computers brought by both instructors. However, all concerned agreed for serious instruction on computer usage requires a computer for every 2 to 4 people and non-pressure time to use the computer.

The visit to ICRISAT was unexpectedly rewarding because they had a METSYS installed there and had been using it for quite some time. They were using the software that the particiapnts had been introduced to and thus an additional learning experience occurred. Also one of the ICRISAT people had been using a simple water balance model and the line source system. Thus they gave some different look at the same subjects treated in the course. Fortunately the conclusions were similar so they reinforced each other.

Facilities

We believe the main weakness of the program was the inability to give each of the participants enough time with the PC's to do what they wanted to accomplish. The facilities were locked up about 5pm and could not be used again until next morning. The computers were borrowed from normal use and therefore could only be used on a limited scale. This problem was partially treated by use of our personal laptop computers in the evening at the hostel. However, it would have been much better if the computer facilities were available in the evening.

Another problem was the occurrence of power outages several times each day which effectively terminated many computer sessions. Again this problem was partially treated by use of the laptop computers that were battery powered. Thus we strongly suggest and US consultant to bring a laptop if he is to be involved with computers.

We realize these problems are common to India and the participants have experience living with the situation. Nevertheless it would be very useful if some type of "uninteruptable power supply" were available.

Participant perspective

A post-workshop was handed out to all participants and returned just before the workshop ended. A summary of the results is included in the attachments. Their evaluation was essentially similar to our conception. The overall rating of the workshop was excellent to very good and 100 per cent said they would recommend it to other people of similar background. They were

apply the skills learned.

The participants had some very useful suggestions. They agreed that more time with the computers would have been useful. They suggested that copies of computer programs be handed out to them. This was a problem because we were using software that was not available on the computers available. We were not prepared to give them these packages because of legal requirements.

Other suggestions made about which we stongly agree are:
1. A review of the work done in India in related fields should be done. This means that more advantage could be taken of Indian scientists to.
2. More information on soil plant water relations as related to practical meteorological observations and analysis as well as pests and disease is needed. We agree but it may be unrealistic.
3. Advection-it's influence on water and crop production. This is a topic of more concern in India than elsewhere but never-the-less of concern in many places. This might be a topic of future cooperation.
4. More information on crop production functions. We agree but this part of the program was shortened to allow for more work on METSYS. There are some excellent Indian scientists that have done good work on this topic which we brought to their attention. They also wanted more time on crop production functions. However, a few weeks is too short a time to expect results. We tried to point out that crop production functions are very site specific but apparently did not get this point across well.

RECOMMENDATIONS

We believe that the method used in this workshop could be used as a model for future workshops involving transfer of complicated hardware. It would probably have been best to limit the topic to use of the hardware, and it's applications, rather than try to cover two general topics as we tried to do.

Better computer facilities in terms of number of computers and reliability are needed but their application needs to be tied to computer use to solve problems. Near maximum use of the facilities was done in this workshop but left most participants, and instructors, frustrated. Future workshops need to have computer facilities available, for off hours use at the hostel, that are provided with "uninteruptable" power supplies so programs are not lost when the power fails. They also need a good printer with good paper. We had to find both after we arrived and both paper and printer were marginal.

Better communication needs to developed between the host institution and US consultants before the next workshop. The consultant needs to know what facilities are to be made available including computers, drive capacities, software available (with

version number and date) etc. This information needs to be given by a person that is computer-knowledgable not the administrator who may think he has very fine facilities. We tried to get this information, before coming on this workshop, but only got information that was meaningless.

We believe the flexibility in scheduling, as we attempted, was very satisfactory. It would have been very easy to continue on with the original program and the participants may have thought we knew best. This puts an added burden on US instructors as they need to be prepared for adjustments.

Better communication is needed between Winrock and the US consultants. When we accepted our origin contract we were of the opinion that the India scientists that would come to the US would be trained so they could give the workshop. They never had that idea, however. When we were persuaded to come to India, we assumed we would share instruction with them. But that did not happen either. We were left with all of the decisions and they acted as "gofers" (at which they did a very good job).

Much of the instruction could be done by Indian scientists on such topics as water production functions etc. It was our original conception that the Indian scientists would come to US for training and then go bach home and give the short course. It turned out they never thought they could do it. Maybe a compromise would be to include well known Indian scientists, on equivalent stautus as US scientists. That would help to maintain relevency also.

The participants need to be better prepared for use of computers in future, especially when the training is computer oriented. They need, at the minimum, to be familar with DOS and file manipulation. Many of their institutions have a few computers but are somewhat limited in availability. They also have some people that could train future participants.

Future US consultants should be informed about the computer software that will be provided in the program. It should coincide with the training they will be presenting.

The METSYS purchases should be augmented with a more complete spare parts package. Small items like screws, bolts are excuses given for non-use of equipment. We got the impression that local administrators have very limited funds and will not allow funds to be spent for spare parts etc once the equipment has arrived. Government regulations apparently are a problem. Hence, a more complete list of spare parts should be procured and maintained at some central location in India. Better communication between India representatives of Campbell and participants would prevent sending so many 110 volt equipment and transformers and adaptors that didn't fit India plugs.

LIST OF HAND OUT MATERIALS

1. Pre-workshop questionnaire

2. Physical Properties of Soils
   Unit 1. Water Quantities.
   Unit 4. Soil-Plant-Atmosphere Relations.

3. Micromet Instrumentation.

4. CR 10 Prompt Sheet.

5. Several reprints related to the Line Source System.

6. Measurement of bulk density and soil water content Gravimetric and neutron probe. Soils 566 Lab 1.

7. Measurement of soil water depletion. Soils 566 Lab 2.

8. Adapting model PLANTGRO for other conditions.

9. BASIC program for computing ET by the Penman method using the data collected with METSYS.

10. Reprints from Dr. Singh-an Indian scientists that has published extensively about crop productions etc.

11. Teaching outlines for the CR-10

12. Teaching programs for the CR-10

[1] Campbell METSYS operators manuals (participants only).

[1] Campbell software manual (participants only).

[1]All of the available copies of these items have been distributed to the scientists. No copies are available for the report..

ATTACHMENTS

List of Participants

Dr. S.S. HUNDAL, Agrometeorologist
Dept. Agricultural Meteorology
Punjab Agricultural University
Ludhiana (Punjab) India 141004

Dr. A.A. DASON, Agrometeorologist
Agricultural Research Station
Tamil Nadu Agricultural University
Kovilpatti

Dr. U.S. Victor, Agrometeorologist
CRIDA, Santoshnagar
Hyderabad-500659
A.P. India

Dr. Yogeswara Rao Arja, Agrometeorologist
Agricultural Research Station
Dems Building, Kamalanapar
Anantapur-515001 (A-P)

Dr. Upendra Shanker, Agrometeorologist
Jawahar Lal Nehru University
All India Coordinated Research Project on Agrometeorology
Department of Physics
Jabalpur (M-P) 482004

Dr. S.T. Nagaraj, Agrometeorologist
University of Agricultural Sciences
Bangalore
Karnataka State
India

Dr. Y.S. Ramakrishna, Agrometeorologist
Central Arid Zone Research Institute
Jodhpur
India 342003

Dr. R.D. Singh, Agronomist
I.C.A.R. Research Complex for N.E.H. Region
Barapani, Shillong
(Meghalaya)

Dr. N.S. Murty, Agrometeorologist
G.B. Pant University of Agriculture and Technology
Hill Campus
Ranichauri-249199
Tehri (U.P.)

Dr. A.M. Shekh, Agrometeorologist
Dept. of Agril. Meteorology
Gujarat Agriculturai University
Anand Campus,
Anand-388110
Gujurat

Dr. K.P.C. Rao, Soil Scientist (Physics)
CRIDA
Santoshnagar
Hyderabad-500659

Dr. C.B. Gaikwad, Agronomist
All India Co-ordinated Research Project on Agrometeorology
Krishak Bhavan
Solaphur
(Mahatma Phule Agril. University

Dr. Padmakar Tripathi
N.D. University of Agriculture
I. Tech Kumarginj.
Faizabam D.U.P.

PROGRAM

DAY 1 (Monday, May 14, 1990)

10.30 Inagural Session Chairman Dr. C.U.R. Chetty

Welcome .....Dr. T.V. Murty

Indo-US Project on Agricultural Meteor.....Dr. P.C.Bhatia

Concept of Workshop.....Dr. R.J. Hanks

Address by Chief Guest.....Dr. S.M. Virmani

Remarks.....Dr. C.U.R.Chetty

Vote of Thanks.....Dr. B.V.R. Rao

11.30 Tea and Refreshments

12.00 Introduction of participants and questionnaire

13.00 ===LUNCH===

14.00 Special Speaker - Prof. S.K. Sinha
Moisture stress effects on crop growth and productivity.

15.00 Introduction to the Campbell Data System. Bingham

Introduction to the micromet system.
Measurement principles.
Exercise #1 - Measurement principles.

DAY 2 (Tuesday)

8.30 Basic soil water processes and relation to plant, climate and management factors. Hanks.

11.0 Instrumentation requirements for measuring the necessary soil and climate factors to produce water production functions. (Unit 1 "Applied Soil Physics" and Soils 665 Lab No. 1-2) Hanks

13.00 ===LUNCH===

14.00 Travel to field site. Measure soil water with neutron probe. Calibrate neutron probe. Introduction to line source.

DAY 3 (Wednesday)

8.30 Special Speaker---Dr. S.T. Nagaraj
Computer operations and utilization.

9.30 Discussion of model PLANTGRO.BAS for simulating the influence of soil, climate, crop and management factors. Hanks.

13.00 ===LUNCH===

14.00 CONCURRENT SESSIONS

A. Practical experience using PLANTGRO--as influenced by rainfall and irrigation timing and amount, Epot, soil properties and crop. Hanks

B. Programming the CR-10 Data Collection Module BLOCK #2 Bingham and Rao.

Assembly of the Data Collection Station (Part 1).

Campbell Rep. and Bingham.

DAY 4. (Thursday)

8.30 Line source method. Hanks

11.00 Crop production functions--problems and use. Hanks

13.00 ===Lunch===

14.00 CONCURRENT SESSION

A. Computer simulation of the effect of water applied by line source using PLANTGRO. Rao and Srivastava

B. Programing the CR-10 Data Collection Module - BLOCK #3 Bingham.

Assembly of the Data Collection Station (Part 2).

DAY 5 (Friday)

8.30 Discussion of other models -- CERES wheat -- Hanks

10.00 Special speaker -- Dr. D.G. Rao --
CERES Sorghum

11.00 Data required for Ceres models and format. Dr. D.G. Rao and Hanks

13.00 ===Lunch===

14.00 CONCURRENT SESSION.

A. Experience using wordprocessor and spreadsheet. Manipulating Data files and graphics.

B. Introduction to Edlog and Term and the data collection module. Bingham.

DAY 6. Saturday

8.30 Go to field and measure soil water, irrigation and rain and climatic data.

11.00 Open session for each participant to evaluate direction of course and make suggestions of direction for remainder of sessions.

13.00 ===Lunch===

14.00 Hands on demonstration of the METSYS and beginning of programming fundamentals.

Day 7. Sunday No sessions.
Time to prepare adjusted program for nextweek.

DAY 8. Monday

8.30 Sensor hookup to data logger Bingham

11.00 Output program and installion Bingham

13.00 ===Lunch===

14.00 Output programming Bingham

Get equipment sorted out, assigned and start set-up

DAY 9 (Tuesday)

8.30 Complete instrument setup in the field and checkout

Discussion of problems encountered Bingham
Instrument protection, lightning protection, calibration, etc. Bingham.

13.00 ===Lunch===

14.00 Complete field installation, programming and testing.

DAY 10. (Wednesday)

8.30 Check out of data collection in field

10.00 Data removal from data storage modules and manipulation

13.00 ===Lunch===

14.00 BASIC model for using data from the METSYS to compute ET. Discussion of BASIC programmin using data just collected. Hanks

15.00 Adaptation of model PLANTGRO for local conditions and generating the appropriate model. Hanks

16.00 Example of BASIC programming to manipulate soil water depletion data and compute water balance. Comparison with earlier work done (spreadsheet).

DAY 11. Thursday.

8.30 Field data removal and putting onto a PC.
Manipulation of data recorded.
Print out on a PC and printer.
(Use of SMCON, EDLOG and SPLIT programs)

11.30 Discussion of problems encountered and corrections possible.

Program to be used to measure rainfall intensity.

Discussion of some publications from India related to water production functions and ET-yield relations.

13.00 ===Lunch===

14.00 Picture session showing all met systems together with participants.

Dismantling system and repacking.
Use of METSYS software to analyze data collected as time permitted.

Day 12. Friday

7.30 Visit to ICRISAT of related activities regarding Agrometeorology, plant breeding and water balance relations, use of line source for crop physiology purposes and cropping systems.

12.30 ===Lunch at ICRISAT===

15.30 Presentation of individual project proposals.

Chairman Dr. P.C. Batia ICAR.

Project proposals

Complete final questionnaire.

DAY 13 Saturday

8.30 Final session.