# R E P O R T

## WORKSHOP ON TREE AND CROP NUTRIENT CYCLING

Central Arid Zone Research Institute
Jodhpur, India

March 23-April 5, 1990

Consultant Report by

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Agroforestry Subproject

Agricultural Research Project (386-0470)

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WINROCK INTERNATIONAL
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# FINAL REPORT

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CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR

## EXECUTIVE SUMMARY

An Indo-US workshop on tree-crop nutrient cycling was conducted at the Central Arid Zone Research Institute (CAZRI) in Jodhpur, Rajasthan from March 21 to April 5, 1990. Dr. J.P. Gupta, CAZRI, was the Coordinator for the workshop. Twenty-three scientists from throughout India participated in the workshop.

Material for the workshop was prepared by Drs. A.K. Srivastava and S.A. Khan from India and Drs. L.E. Nelson, A.L. Friend and J.D. Hodges of the U.S. These five scientists presented most of the lectures and laboratory exercises, but additional lectures were presented by Dr. S. Chinnamani and local scientists at CAZRI. Lectures and laboratory exercises emphasized basic information on plant and soil processes involved in nutrient cycling as well as practical information on soil and vegetation management as it relates to nutrient cycling. Participation by those attending the workshop was exceptionally good.

Most of the major objectives of the workshop were accomplished and the intended material was covered. However, much of the planned field work on methods for soil and plant analysis could not be accomplished because of insufficient time before the workshop to locate suitable areas and plan the exercises.

Recommendations are separated into those for future Indo-US workshops sponsored by USAID and those for subsequent Indian tree/crop nutrient cycling workshops. The recommendations for USAID-sponsored workshops, especially where field methods are to be taught, emphasize the need for advanced planning and coordination between U.S. scientists and their counterparts where the workshop will be held. For future regional workshops to be handled within the country, it is the recommendation of the consultants that a single person within The All India Coordinated Research Project on Agroforestry be designated as the person responsible for such training. This person would be responsible for obtaining competent instructors and assuring that the proper material is presented.

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# INTRODUCTION

In India the national needs for increased forest areas to reduce wood product imports and to ameliorate local environments have been clearly expressed. At the same time, demands for fodder, fuel, timber and other wood products have greatly exceeded the supply and additional markets exist for other agroforestry products such as certain fruits and specialty items. Thus, agroforestry provides an opportunity for additional cash income and capital formation for farmers and could be particularly appropriate for those with small holdings on rainfed and marginal lands.

The above considerations led to the initiation of the All India Coordinated Research Project on Agroforestry (AICRPA) by the Indian Council of Agricultural Research (ICAR) during the sixth 5-year Plan of the Government of India and its strengthening at 31 centers during the seventh 5-year Plan.

Since the Indo-US subcommission on Agriculture also identified agroforestry as an important area of mutual interest, ICAR and USAID developed a subproject on agroforestry under the USAID Agricultural Research Project. This subproject assists activities of AICRPA by developing and implementing workshops on agroforestry topics, supplying equipment, and facilitating collaborative research between Indian and U.S. scientists and institutions.

## Background

In August, 1989 two Indian scientists (Dr. A.K. Srivastava and Dr. S.A. Khan) came to Mississippi State University to participate in a special five-month training program in forest tree/crop nutrient cycling. While at Mississippi State they collaborated with Drs. L.E. Nelson, A.L. Friend and J.D. Hodges to develop a syllabus and put together necessary teaching materials for a proposed workshop on nutrient cycling to be presented in India.

Subsequently, Mississippi State University was selected by Winrock International as the American institution which would participate with their Indian counterparts to conduct the workshop. Drs. Nelson, Friend and Hodges were invited to participate in the workshop to be hosted by the Central Arid Zone Research Institute in Jodhpur, India.

## Objectives

The objectives of the subcontract between Winrock International Institute for Agricultural Development and Mississippi State University were:

1. To develop and present a two-week (12 days) workshop on tree/crop nutrient cycling to 25 participants at Jodhpur, Rajasthan, India;

2. To enhance the development of a nucleus of Indian expertise in tree/crop nutrient cycling; and

3. To provide, by way of the workshop, a forum for initiating longer-term scientific collaboration between Indian and U.S. scientists and Institutions.

## EXECUTION OF WORKSHOP

### Circumstances

This was the second course taught by scientists from Mississippi State University in a series of short courses sponsored under the ICAR/USAID-India agroforestry program. The first was the Workshop on Tree Seed Technology given at Coimbatore on May 22 to June 3, 1939. The circumstances under which the nutrient cycling short course was presented and recommendations resulting from it should be of value in the preparation of future short courses. None of the U.S. scientists had prior experience in India. They were not familiar with Indian methods of operation, even though all had experience working with Indian scientists in the U.S. In addition, all of the U.S. scientists had previous experience outside the U.S.

### Conduct of Course

#### Execution

The course was held at Central Arid Zone Research Institute (CAZRI) in Jodhpur, Rajasthan. The principal liaison person was Dr. J.P. Gupta, Principal Scientist, who not only attended to the day-to-day problems involved in the conduct of the course but also to the needs of the participants. He operated under the handicap of not having participated in the planning of the short course. This problem was due to a lack of communication during the planning of the course by the three U.S. and two Indian scientists in the U.S. None of the U.S. or Indian scientists were familiar with the resources available at CAZRI. The course design and training schedule were modified upon the arrival of the U.S. participants. The U.S. participants found that instead of the scheduled three days for orientation and local planning, the course was scheduled to begin on the day of arrival. Lecturers by several members of the CAZRI staff were incorporated into the schedule as well as an all-day field trip. Due to an accident which delayed his arrival, one of the Indian scientists who had participated in the planning in the U.S., Dr. A.K. Srivastava of the Central Soil and Water Research and Training Institute, Dehra Dun could not present his opening lectures. Fortunately, Dr. Chinnamani, Assistant Director for Agriculture and Forestry, ICAR was in attendance and gave the opening lectures. The other Indian scientist who participated in the planning in the U.S., Dr. S.A. Khan of the C.S. Azad University of Agriculture and Technology, Kanpur arrived only on the first day of the course. Overall, the unanticipated changes in the course schedule strengthened the course and broadened the horizons of the Indian scientists not familiar with the problems

of the arid zone. The cooperation of Dr. Gupta and his staff were exemplary. Although, the Director of CAZRI, Dr. J. Venkateswarlu had to be out of town during much of the time the course was in session, his lecture gave an added dimension to the arid zone problems. In addition, Dr. Maharaj Singh of Winrock International, India was in attendance from the beginning until March 27, 1990 and made numerous contributions throughout the opening sessions.

The facility for the lectures was excellent, being air-conditioned and equipped with both overhead, slide and movie projectors. Due to lack of knowledge of laboratory facilities and time for preparation, the planned laboratory exercises were generally reduced to demonstrations rather than being the planned hands-on exercises. Transportation was somewhat inadequate, and although the field exercises were accommodated, it was with some difficulty and no doubt interfered with the normal Institute activities. One of the more positive aspects of the course was the quality of the participants. This was demonstrated by their contributions to lecture discussions, informal out-of-class discussions, and the keen interest displayed in acquiring further information on agroforestry research and methodology. The level of experience, interest, and enthusiasm of these individuals contributed greatly to the course (as also noted in the evaluation by participants).

## Content of Course and Responsible Scientists

The course outline was completed by the Indian and U.S. scientists before the Indian scientists returned to their respective stations in mid-January of 1990. The course outline was subsequently modified after being reviewed by Winrock-India. Two copies of the final course outline were forwarded to Winrock-India on March 16, 1990 by express mail. Additional revisions in the schedule were made upon arrival in Jodhpur; the changes resulted in only minor deletions of planned lecture material and presentation time may have been shortened in some cases. Lectures were given by both U.S. and Indian scientists, the former having more experience in nutrient cycling in forest ecosystems, the latter having experience in agroforestry systems in general. Unfortunately, neither of the two Indian scientists were able to visit the proposed site of the short course after their return from the U.S. and prior to the beginning of the short course. The final schedule and responsible scientists for each activity are given in the 'Training Schedule' which follows.

The instructional material presented at the workshop is found in Appendix E which is filed with Winrock/Delhi. Each participant was provided a copy.

## Training Schedule and Responsible Scientists

| Date | Time | Activity | Responsible Scientist(s) (affiliation) | |
|---|---|---|---|---|
| March 23 | 10:00 - 12:00 am | Registration of Participants | Dr. J.P. Gupta | (1) |
| | 02:30 - 04:30 pm | Inaugural Session | Dr. Y.S. Ramakrishna | (1) |
| | | | Dr. S. Chinnamani | (2) |
| | | | Mr. M. Singh | (3) |
| | | | Dr. J.D. Hodges | (4) |
| | | | Dr. J. Venkateswarlu | (1) |
| | | | Dr. J.P. Gupta | |
| March 24 | 09:00 - 10:00 am | Background Information | Dr. S. Chinnamani | |
| | | | Dr. J.D. Hodges | |
| | 10:00 - 11:00 am | Problem Appraisal | Dr. S. Chinnamani | |
| | | | Dr. A.K. Srivastava | (5) |
| | | | Dr. J.D. Hodges | |
| | 11:00 - 12:00 am | Review of Progress in Agroforestry | Dr. S. Chinnamani | |
| | | | Dr. A.K. Srivastava | |
| | | | Dr. A.L. Friend | (3) |
| | 02:00 - 05:30 pm | Field tour of Agroforestry Experiments at Jodhpur Station | Dr. J.P. Gupta | |
| | | | Dr. K.C. Singh | (1) |
| | | | Dr. S.K. Sharma | (1) |
| | | | Dr. J.D. Hodges | |
| | | | Dr. S.A. Khan | (6) |
| March 25 | 09:00 - 12:30 pm | Plant Mineral Nutrition | Dr. L.E. Nelson | (4) |
| | 02:00 - 05:00 pm | Sight Seeing Tour of Jodhpur | Support Personnel | (1) |
| March 26 | 09:00am- 01:00 pm | Plant Growth Quantification Pre-Lab Instruction and Field Exercise | Dr. A.L. Friend | |
| | | | Dr. S.A. Khan | |
| | | | Dr. J.P. Gupta | |
| | 02:00 - 05:00 pm | Administrative Housekeeping (Travel reimbursement) | Dr. J.P. Gupta | |

| | | | |
|---|---|---|---|
| March 27 | 09:00 - 10:30 am | Plant Water Relations | Dr. A.L. Friend |
| | 10:30am- 12:30 pm | Hydrology | Dr. A.L. Friend |
| | 02:00 - 04:00 pm | Roots and Root Systems Lecture and Pre-Lab Instruction | Dr. A.L. Friend |
| | 04:00 - 05:30 pm | Root Quantification Field Laboratory Exercise | Dr. A.L. Friend<br>Dr. J.P. Gupta |
| | 05:30pm- 06:30 pm | Plant Root Interactions | Dr. A.L. Friend |
| March 28 | 09:00 - 10:00 am | Review of Plant Mineral Nutrition | Dr. L.E. Nelson |
| | 10:00 - 11:30 am | Litter and Soil Sampling and Analysis Pre-Lab Instruction | Dr. L.E. Nelson<br>Dr. S.A. Khan |
| | 11:30am- 01:00 pm | Litter and Soil Sampling Field Exercise | Dr. L.E. Nelson<br>Dr. S.A. Khan |
| | 02:00 - 03:00 pm | Climatology in Relation to Agro-forestry | Dr. Ramakrishna |
| | 03:00 - 04:30 pm | General Principles of Nutrient Cycling | Dr. L.E. Nelson |
| | 04:30 - 05:00 pm | Film: "Wildlife of the Desert" | Dr. J.P. Gupta |
| March 29 | 09:00 - 10:30 am | Use of Instruments | Dr. S.A. Khan |
| | 10:30 - 11:00 am | General Principles of Nutrient Cycling | Dr. L.E. Nelson |
| | 11:00am- 12:15 pm | Nutrient Cycling in Agroforestry | Dr. L.E. Nelson<br>Dr. A.K. Srivastava |

| | | | |
|---|---|---|---|
| | 12:15 - 01:30 pm | Soil and Water Conservation | Dr. J.P. Gupta |
| | 02:30 - 03:30 pm | Site Maintenance in Agroforestry | Dr. J.D. Hodges |
| | 03:30 - 05:00 pm | Nutrient Cycling in Agroforestry | Dr. A.K. Srivastava<br>Dr. L.E. Nelson |
| March 30 | 09:00 - 10:30 am | Arid Water Use by Desert Trees | Dr. Lehiri (1) |
| | 10:30 - 11:30 am | Maximizing Productivity and Nutrient Use | Dr. L.E. Nelson |
| | 11:30am- 06:30 pm | Field Tour of Beriganga Research Station and Sand Dunes of Osiyan | Dr. J.P. Gupta<br>Dr. K.C. Singh<br>Dr. S.S. Rathore (1) |
| March 31 | 09:00 - 10:30 am | Conservation and Loss Prevention | Dr. A.K. Srivastava |
| | 10:30 - 11:30 am | Dryland Agriculture and Agroforestry | Dr. J. Venkateswarlu |
| | 11:30am- 12:20 pm | Nutrient Cycling and Systems Management | Dr. A.K. Srivastava |
| | 02:00 - 03:00 pm | Allocation of Vegetation | Dr. A.K. Srivastava<br>Dr. J.D. Hodges |
| | 03:00 - 03:45 pm | Trainees present brief Summaries of their ongoing research and activities | Dr. J.D. Hodges<br>Dr. L.E. Nelson<br>Dr. A.L. Friend |
| | 04:00 - 04:45 pm | Case Studies and Research Strategies | Dr. J.D. Hodges<br>Dr. L.E. Nelson |
| | 04:45 - 05:30 pm | Trainee Presentations (continued) | Dr. J.D. Hodges<br>Dr. L.E. Nelson<br>Dr. A.L. Friend |
| April 1 | All day | Open for trainees to begin work on group projects | |

| | | | |
|---|---|---|---|
| April 2 | 08:00am-<br>08:00 pm | Field Tour of Pali Research Station and Ranakpur | Dr. J.P. Gupta<br>Dr. J.C. Tewari<br>Dr. S.K. Sharma |
| April 3 | 09:00 -<br>09:30 am | Follow-up questionnaire | Dr. A.L. Friend<br>Dr. J.D. Hodges<br>Dr. L.E. Nelson |
| | 09:30 -<br>10:00 am | Laboratory Data Analysis and Interpretation | Dr. A.L. Friend<br>Dr. L.E. Nelson<br>Dr. J.D. Hodges |
| | 10:00 -<br>10:30 am | Review of Nutrient Cycling | Dr. L.E. Nelson<br>Dr. J.D. Hodges<br>Dr. A.L. Friend |
| | 10:30 -<br>12:00 am | Trainee Presentations (continued) | Dr. A.K. Srivastava<br>Dr. J.D. Hodges<br>Dr. L.E. Nelson<br>Dr. A.L. Friend |
| | 12:00am-<br>05:00 pm | Supervised Work on Group Projects | Dr. L.E. Nelson<br>Dr. J.D. Hodges<br>Dr. A.L. Friend |
| April 4 | 08:00 -<br>11:00 am | Group Presentations | Dr. L.E. Nelson<br>Dr. J.D. Hodges<br>Dr. A.L. Friend<br>Dr. A.K. Srivastava |
| | 11:00am-<br>01:00 pm | Valedictory | Dr. J.P. Gupta<br>Dr. J. Venkateswarlu<br>Dr. J.D. Hodges<br>Dr. L.E. Nelson<br>Dr. A.L. Friend |

Affiliations:

(1) CAZRI
(2) ICAR
(3) WINROCK
(4) Mississippi State University
(5) CSWRTI
(6) C.S. Azad Univ. Agric. and Tech.

## Participants

Twenty-three participants attended the workshop (Table 2 and Appendix C). These participants came from 14 states throughout India (Table 3). All participants had advanced degrees with thirteen having a masters and ten having a Ph.D. There was a wide range of background, experience and knowledge among the participants. Over one-half had training in either soils or agronomy, but the fields of forestry, horticulture, animal nutrition and organic chemistry were also represented. It is expected that all participants will be able to utilize the information presented in their teaching, research and extension efforts. Some should be able to either lead or participate in training sessions on nutrient cycling. All participants received copies of lecture outlines and other training materials used in the workshop.

Table 2 - List of participants attending the workshop on tree/crop nutrient cycling

Indo-US Workshop-cum-Training on Tree Crop Nutrient Cycling held at Central Arid Zone Research Institute, Jodhpur from March 23 to April 6, 1990

| S.# | Name & Designation | Institutional full address |
|---|---|---|
| 1. | Dr. K.S. Bhatia<br>Associate Professor<br>(Forestry) | Department of Soil Conservation and Water Management, C.S.A.<br>Univ. of Agric. & Tech.<br>Kanpur - 208 002 (U.P.) |
| 2. | Mr. S.K. Dhyani<br>Scientist S-2(Eco.Bot.) | I.C.A.R. Research Complex for NEH for NEH Region<br>Shillong 793003 (Maeghalaya) |
| 3. | Mr. L.G. Giri Rao<br>Agronomist (Agro-forestry) | APAU, Rajendranagar<br>Hyderabad - 30 (A.P.) |
| 4. | Mr. S.K. Gupta<br>Scientist | Agro-Silvipasture Division<br>Indian Grassland & Fodder Research Institute, Jhansi (U.P.) |
| 5. | Mr. S.I. Hanamashetti<br>Scientist S-1<br>ACRP on Agroforestry | University of Agril.Science<br>Dharwad-580005 (Karnataka) |
| 6. | Mr. Kailash Kumar<br>Scientist (Ag.Chem) | ICAR Research Complex for NEH Region Manipur Center<br>Imphal-795001 (Manipur) |
| 7. | Mr. S.K. Majhi<br>Lecturer<br>AICRP on Agroforestry | Regional Research Station<br>B.C.K.V., Jhargram<br>Midnapore (W.B.) |
| 8. | Dr. M. Murugan<br>Associate Professor | Sheep Research Station<br>TNVASU, Kattuppakkam-603203<br>Chingelpet Dt (Tamilnadu) |
| 9. | Dr. M. Achuthaw Nair<br>Associate Prof. KAU | College of Agriculture<br>Trivandrum-695522 (Kerala) |
| 10. | Mr. N.N. Nimbole<br>Scientist (S.Gr.)<br>(Agronomy) | CRIDA, Hyderabad (A.P.) |

| | | |
|---|---|---|
| 11. | Mr. B.B. Patel<br>Scientist (Soil Conservation) | AICRP on Agroforestry<br>Gujarat Agril. University<br>Sardar Krushinaotar-385506<br>Distt. S.K. (Gujarat) |
| 12. | Mr. B.N. Patil<br>Asstt. Prof.<br>O/I Agroforestry Project | College of Agriculture<br>Nagpur (Maharashtra) |
| 13. | Mr. P.K. Ralhan<br>Asstt. Prof. of Forestry | Deptt. Forestry & N.R. Punjab Agricultural University<br>Ludhiana - 141004 (Punjab) |
| 14. | Mr. S.S. Rathore<br>Scientist | Central Arid Zone Research Institute, Jodhpur-342003<br>(Rajasthan) |
| 15. | Mr. M. Saleem<br>Asstt.Prof.Agroforestry | Dry Land Research Station<br>Rakh Dhiansar, Bari.Brahmna<br>Jammu Tawi - 181 133<br>(Jammu & Kashmir) India |
| 16. | Mr. M. Shanmugam<br>Associate Professor<br>(Soil Science) | Forestry Research Station<br>(TNAU) Mettupalayam-641301<br>(Tamil Nadu) |
| 17. | Dr. B.D. Sharma<br>Scientist | CAZRI, Regional Research Station, Bikaner-334002<br>(Rajasthan) |
| 18. | Dr. B.M. Sharma<br>Scientist (Sel.Gr.) | Central Arid Zone Research Institute, Jodhpur-342003<br>(Rajasthan) |
| 19. | Dr. K.L. Sharma<br>Scientist (Soil Chem/ Fert.) | CRIDA, Hyderabad - 500659<br>(A.P.) |
| 20. | Mr. Gurpreet Singh<br>Asst.Scientist<br>(Agronomy) | Kandi Research Station<br>Balachaur Distt. Hosiapur<br>(Punjab) - 144521 |
| 21. | Mr. K.N. Tambi<br>Asstt. Prof.(Senior Grade) (Horticulture) | Department of Forestry<br>J.N.K.V.V., Jnbalpur<br>482 004 (M.P.) |
| 22. | Dr. S. Thirumalai,Ph.D.<br>Associate Professor | Livestock Research Station<br>TNVASU, Kattuppakkam-603203<br>Chingelpet Dt (Tamilnadu) |
| 23. | Mr. V.P.S. Tomar<br>Scientist (S.Gr.) (Forestry) | C.S.W.C.R.T.I., Dehradun (U.P.) |

Table 3 - Summary statistics on home-state, highest degree, and degree specialization of participants

| | State | No. of Participants |
|---|---|---|
| 1. | Rajasthan | 3 |
| 2. | Tamil Nadu | 3 |
| 3. | Hyderabad | 3 |
| 4. | Maharashtra | 2 |
| 5. | Punjab | 2 |
| 6. | Uttar Pradesh | 2 |
| 7. | Kanpur | 1 |
| 8. | Karnataka | 1 |
| 9. | Kashmir | 1 |
| 10. | Kerala | 1 |
| 11. | Madhya Pradesh | 1 |
| 12. | Meghalaya | 1 |
| 13. | Manipur | 1 |
| 14. | West Bengal | 1 |
| | Total | 23 |

| Highest Degree | # Attendees |
|---|---|
| M.S. | 13 |
| Ph.D. | 10 |

| Training | # Attendees |
|---|---|
| Agronomy | 5 |
| Forestry | 5 |
| Soil Science | 5 |
| Horticulture | 3 |
| Animal Nutrition | 2 |
| Soil & Water Conservation | 2 |
| Organic Chemistry | 1 |

## ANALYSIS OF WORKSHOP

### Evaluation by Participants

Responses received on the post-workshop evaluation questionnaire (Appendix D) indicated that the overall-rating of the course was very good (10 responses) and ranged from excellent (3 responses) to good (8 responses). In the evaluation of the strengths and weaknesses, the lectures and group discussions were rated high (4 on a scale of 1 to 5, 5 being high) while the field laboratory and field trips were rated average or below average (Table 5). The low ratings can be attributed to a lack of knowledge on the part of the short course planning group about the facilities available for use during the short course and lack of time at the institute prior to the beginning to prepare for the field exercises. For example, none of the three U.S. or two Indian scientists in the planning group had ever visited CAZRI.

The participants were asked to make specific comments and naturally there was considerable diversity in their expressions about the workshop. In general, they indicated the most useful aspect of the course was learning about nutrient cycling and its role in the nutrition of the species employed in agroforestry systems. The most negative aspects were the field exercises and field trips. It was also suggested that there should have been less background material and more discussion of nutrient cycling. Another suggestion included the need for more source material (reprints, books, etc).

Table 5. Summary of the Course Evaluation by the participants

1. Overall rating of the course (number of responses).

| | | | |
|---|---|---|---|
| Excellent | (3) | Very good | (10) |
| Good | (8) | Average | (0) |
| Poor | (0) | Very poor | (0) |

2. Strengths and weaknesses

| Item | Rating * | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 | No ans. | Average |
| | ---- number of responses ---- | | | | | | |
| Basic background lectures | 10 | 8 | 2 | 0 | 0 | 1 | 4.4 |
| Applied agroforestry lectures | 5 | 9 | 3 | 1 | 0 | 3 | 4.0 |
| Field laboratory exercises | 1 | 3 | 6 | 5 | 4 | 2 | 2.6 |
| Field trips and tours | 1 | 5 | 10 | 1 | 3 | 1 | 3.0 |
| Group discussion and exercises | 6 | 12 | 2 | 0 | 0 | 1 | 4.2 |
| Informal out-of-class discussions among participants | 3 | 11 | 5 | 1 | 0 | 1 | 3.8 |
| Lectures by local experts | 1 | 11 | 5 | 2 | 1 | 1 | 3.4 |

*Rating: 5=strong to 1=weak.

## Pre-and Post-Workshop Testing

The Pre-workshop Test (Appendix B) was a useful tool in evaluating the level and pace appropriate for teaching the workshop. It indicated a weakness in fundamental training of some of the participants (Average Score 49%).

The same test was repeated as a post-workshop test. The results from the post-workshop test showed a 20% increase in average score. Surprisingly, some individuals' scores changed only slightly, or decreased after the workshop. This was apparently due to lucky and unlucky guessing in the pre-and post-workshop tests, respectively. The minor improvement group comprised one third of the total. Another one third of the group showed substantial improvement (40% increase in score), while the remaining third showed average (20%) improvement in score.

The absolute scores of the post-test were not high (final average 58%). We attribute this primarily to differences in educational testing between the US and India. Furthermore, the participants did not see their exam papers after the first exam, although we reviewed most of the answers in our lectures. This may have also contributed to the low absolute scores.

In summary, the results of the analyses showed improvement in exam scores after the workshop. Many of the strongest improvements were those of the better students. It may be concluded that the workshop improved the knowledge of the participants, especially for those with prior training.

## Consultants' Evaluation

A number of very favorable impressions were obtained from the workshop, but the consultants feel that the highlight of the workshop was the keen interest, enthusiasm and participation of the scientists enrolled in the workshop. It was obvious that they were dedicated to their research and were anxious for information which would help them in that research. The participants were very open in discussing their research projects and that exchange of information was a major benefit of the workshop. The fact that the participants were from a wide range of backgrounds and locations made this exchange especially useful.

The hospitality, assistance and facilities provided by the people at CAZRI were outstanding. Dr. Gupta, in addition to providing one lecture, was always available to see that all needs were met and that the workshop ran smoothly. There were some problems with planning and the way the workshop had to be conducted, but these were not the fault of the people at CAZRI. Other scientists at CAZRI, Drs. J. Venkateswarlu, K.C. Singh,

S.K. Sharma, Y.S. Ramakrishna, A.N. Lehiri, B.M. Sharma, S.S. Rathore and J.C. Tewari made invaluable contributions to the workshop serving as lecturers and by interacting with the participants.

Although there were interruptions and changes in the planned schedule, the "flow" of the workshop was very good. There was ample opportunity for discussion and exchange of ideas between the instructors and participants. The field trips were especially useful in this respect.

The major short-coming of the workshop was that we could not spend enough time on field (practical) exercises. This "hands on" experience would be invaluable to the participants. Things can be presented which are impossible to cover in a classroom. These field exercises were planned,. but were shortened or cancelled either because of the lack of a suitable site or the lack of time for proper planning as noted below. Again, this was not the fault of the people at CAZRI.

The Indian liaison at the host institution should participate in the planning of short course activities. His familiarity with the facilities and resources of the host institution will ensure that field and laboratory exercises can be adequately managed. Also, the host institution should be provided ample time to prepare for field and laboratory exercises. In addition, the short courses should be scheduled so that the vegetation is at the developmental stage required by the field exercises.

Material presented at this short course using the overhead projector would have been improved by larger type and inclusion of only the material referred to during the lecture.

Each instructor should have prepared and brought to the first session sufficient copies of his lecture material to supply each participant with a copy. This would eliminate problems involved ir the use of copy machines.

A typewriter or word processor should be available for the exclusive use of the instructors for making last minute changes in course material and preparation of reports.

Sufficient copies of basic reference material should be provided for the participants. In some cases, this might be one copy per participant, in other cases fewer copies might suffice. Those planning a course should be provided information about library facilities at the host institution. Unfortunately, at this workshop, recataloging was being done and much of the material was unavailable. Also, library hours coincided with workshop hours and the library was unavailable during the participants free time.

The case studies scheduled for this short course would have been of greater value had the participants been aware of nutrient cycling activities and brought pertinent data and information from their home institutions.

Final determination of the effectiveness of the workshop will be how well the material presented is used by the participants in their research work and teaching efforts, including the preparation and presentation of short courses for other interested scientists. An effort should be made by ICAR to determine how the material is used.

Although the participants benefitted substantially from the workshop, more training in nutrient cycling may be needed before they can adequately conduct teaching and/or research in nutrient cycling. In this context, the workshop provided only a survey of pertinent topics.

## RECOMMENDATIONS

### Future Indo-US Workshops

Overall, the workshop on Tree and Crop Nutrient Cycling was effective. Nevertheless, there are several areas that can be improved for future workshops. More advance communication between the host institution in India and the US consultants is essential. It is recommended that at least one of the instructors from the host institution be sent to the U.S. for training. This is most critical for workshops having a strong practical field component, such as the present one. By having this link with the host institution, internal expertise may be best used and planned for, and field and laboratory practicals may be designed to fit the available resources. Another recommendation would be for future US scientists to import all handouts and teaching materials. This would avoid delays in photoduplication and ensure that the quality of materials is adequate. Even with the above measures, one or all of the US instructors should arrive at the workshop location two days in advance to make final arrangements. This allows the consultants to devote their full energies to teaching and not mechanical details. Finally, it would be most useful to provide the US consultants with some briefing on what to expect in the way of local customs and administrative structures. To this end, it would be advisable to provide future consultants with copies of previous consultants' final reports.

### Future Nutrient Cycling Workshops in India

Of utmost importance to the success of future workshops will be the careful selection and identification of an Indian Scientist who can coordinate and act as a resource person for nutrient cycling workshops. This individual should have qualifications that allow him to identify qualified instructors and recommend supplementary training if necessary. Although the present workshop achieved its goals of improving the knowledge base in nutrient cycling, few participants emerged qualified to conduct a workshop themselves. In this context, it would be advisable for selected instructors to receive supplemental training, especially in basic soils, mineral nutrition, and ecosystems ecology. Future workshops should emphasize basic terms and principles of nutrient cycling. For example terms such as "leaching" and "nutrient cycling" had different meanings for different participants. The need for consistency in terminology as well as methodology is great if coordinated research is to be conducted. On a practical level, the geographic location of future workshops will be essential to their success. For example, if litter and soil sampling is to be demonstrated, temperate areas during moist seasons should be used. Finally,

future workshops should emphasize basic methodology. In fact, it may be desirable to devote an entire workshop to methods in nutrient cycling research for agroforestry systems. It is not enough to demonstrate techniques. Individual scientists should collect and actually analyze data to be adequately trained to conduct future research.

## APPENDIX A

### Scope of Services

An agroforestry workshop activity is to be carried out under the Agriculture Research Project in accord with the two-year work plan for this subproject.

#### Workshop Rationale

As the agroforestry programs of India continue to develop, those responsible for intensively utilized tree-crop production systems will become increasingly concerned about the sustainability of those systems. The relative impact over time on site productivity from growing differing combinations of forest tree species with agricultural crops is not sufficiently well understood to support reasonable decisions on sustainable agroforestry. More specifically, the impact or the nutrient-moisture balance of the soil following intensive cropping of forest and agricultural crops is poorly understood across the many diverse combinations of soil/site/species in the aggregated agroforestry production system. Program efforts to understand the tree-crop/nutrient-moisture relationships in intensively utilized systems are essential components of any strategy to define and implement practices to sustain production from these systems.

To this end, a workshop on tree/crop nutrient cycling is proposed. The workshop will serve as the core activity around which other subproject activities can be clustered. The intent of this strategy is to enhance the development of a nucleus of Indian expertise in tree/crop nutrient cycling, the workshop subject area. Upon completion of this proposed activity, there should be in place Indian scientists who can continue and sustain the program efforts initiated by the workshop. The workshop associations also provide a forum for initiating longer-term scientific collaboration between Indian and U.S. scientists and institutions.

#### Workshop Structure

A two-week workshop for 25 Indian scientists will be held in Jodhpur, Rajasthan, India during March-April 1990. U.S. scientists, in collaboration with Indian scientists, will be jointly responsible for developing the technical content of the workshop and for presenting the material to workshop participants. The scientists from the U.S. and the scientists from India will be the workshop's instructors.

## Appendix B

Workshop on Tree and Crop Nutrient Cycling
Central Arid Zone Research Institute, Jodhpur
March 26 - April 7, 1990

A. Personal Information

1. Name _____

2. Designation _____

3. Last qualification _____

4. Specialization _____

5. Name of institution or organization _____

6. Name of Agroforestry project _____

_____

_____

7. What do you hope to gain from this workshop?

_____

_____

8. Type of Agroforestry System(s) in which you work:

_____

_____

B. Pretest: In order to learn something of the background of the workshop participants so that the lectures and discussions will be more meaningful and useful, please answer the following questions:

## Pretest Questions

Instructions: Circle correct response or provide brief answer in the space provided.

1. Circle the element or elements in the following list that is (are) not macronutrients. (a) Ca (b) Al (c) Si (d) B (e) S (f) K (g) Mo (h) N (i) P (j) Cu.

2. Potassium is usually applied to soils deficient in this nutrient as muriate of potash (KCl) which is 60 percent $K_2O$. It would be absorbed by the plant roots as (a) KCl (b) $K^+$ (c) $K_2O$.

3. Which one of the following statements does <u>not</u> refer to the Law of Limiting Factors?

   (a) The level of crop production can be no greater than that allowed by the most limiting of the essential growth factors.

   (b) This is also known as Liebig's "Law of the Minimum."

   (c) If one nutrient deficiency is corrected, another factor will limit growth.

   (d) This law applies only to the essential elements.

4. The conversion of the unavailable organic S compounds found in organic residues added to soils to the available $SO_4^=$ is the result of microbial activity and is called mineralization. (a) true (b) false

5. The loss of water from plant leaves by transpiration results in the movement of the $SO_4^=$ ion from the bulk soil to the surface of the plant root. This is called (1) contact exchange (2) mass flow (3) diffusion

---

Given the following characteristics of the Ap horizon of two soils:

| Soil | Textural Class | B. D. | pH |
|---|---|---|---|
| A | Clay loam | 1.10 | 6.0 |
| B | Sandy loam | 1.50 | 5.0 |

6. The total pore space will be greater in (a) Soil A or (b) Soil B. Assume well-aggregated surface soils and similar particle densities.

7. The capacity to absorb and hold nutrient cations in the available form will be greatest in (a) Soil A or (b) Soil B.

8. The availability of Fe and Mn will be greater in (a) Soil A or (b) Soil B.

9. Percolation rates will be greater in (a) Soil A or (b) Soil B.

10. The organic matter will be highest in (a) Soil A or (b) Soil B. Assume same climate and vegetative type.

11. Nutrient cycling in the soil-plant-atmospheric system is said to consist of three subcycles. Which of the following is one of these?

    (a) The Kreb's cycle

    (b) Hydrologic cycle

    (c) Biogeochemical cycle

    (d) Crop cycle within rotations

12. When it is said that a nutrient cycle is tight, losses from the system are at a minimum. (a) true (b) false

13. The nutrient, N, P, K, Ca, and Mg, is most readily leached (by precipitation) from crop and forest canopies.

14. Resorption (also called retranslocation or biochemical cycling) refers to (a) movement of nutrients from roots to soil, (b) movement of nutrients out of foliar tissue during senescence, or (c) absorption of nutrients from precipitation by foliage and bark.

15. Nutrient cycling does not occur when agronomic crops are grown each year on the same area. (a) true (b) false.

16. What is most efficient in terms of labor input, shifting agriculture of classical agricultural (row crop) systems?

7. It has been well established by research that trees (forests) can alter local rainfall patterns.

True
False

8. In semi-arid regions there are usually two main reasons for management of runoff. What are these two reasons?

9. Inclusion of trees in an agroforestry system may aid in a number of ways to improve soil conservation and reduce soil erosion. In that respect, which of the following is <u>not</u> accomplished by having trees present?

(1) Breaking the force of raindrops hitting the soil
(2) Decreasing losses by evapotranspiration
(3) Improving infiltration
(4) Modifying the physical properties of the soil.

). The terms "soil conservation" and "nutrient conservation" are synonymous terms.

True
False

.. Which is more limited by water stress, photosynthesis or growth?

!. Does plant water potential increase or decrease from root to leaf?

23. The viscosity of water is the principal factor limiting plant water uptake from cold soils (circle one):
True
False

24. The drought-deciduous growth habit is an example of (circle one): (a) bioengineering, (b) water stress tolerance, (c) water stress avoidance, (d) water stress resistance.

25. Rank the water-use efficiencies of species which utilize the (a) C3, (b) C4, and (c) CAM photosynthetic pathways.

_____
most ---- to ---- least

26. "Hydraulic lift" as reported by Richards and Caldwell (1987) is the upward movement of water in the soil driven by: (a) temperature, (b) gravity, (c) transpiration, (d) plant water potential gradients, (e) soil capillary forces.

27. Dew is a source of precipitation (circle one):
True
False

28. In most systems, the dominant pathway for water loss through evapotranspiration is (circle one): (a) evaporation, (b) transpiration.

29. The greatest water holding capacity per unit volume is found in (circle one): (a) dead wood, (b) clay-sized particles, (c) silt-sized particles, (d) sand-sized particles.

30. The greatest water-infiltration rate (saturated flow) per unit area is found in (circle one): (a) dead wood, (b) clay-sized particles, (c) silt-sized particles, (d) sand-sized particles.

31. On a unit area basis in the same climatic region, more water is lost to water vapor by (circle one): (a) continuous crop canopy, (b) continuous tree canopy, (c) same for (a) or (b), (d) soil without tree cover,

32. What type of root utilizes or accounts for the largest proportion of net primary production in mature temperate forest ecosystems (circle one): (a) coarse >5 mm diameter roots, (b) small 2-5 mm diameter roots, (c) fine <2 mm diameter roots, (d) structural roots.

33. Root systems may be visualized as the mirror image of the above-ground crown (circle one):
True
False

34. Roots may impart strength to soil and prevent mass movements. Which roots are more important for this function (circle one): (a) live roots, (b) dead roots, live and dead are equally important.

35. Caldwell et al. (1985) found increased below-ground competitiveness to be associated with (circle one): (a) high total root mass, (b) high rooting densities, (c) the presence of mycorrhizae, (d) symbiotic nitrogen fixation.

36. Shelterbelts and windbreaks have been shown to reduce evapotranspirational losses by crop plants. This reduction is due entirely to the reduction in wind speed over the crop plant.

True
False

37. If nutrient use and output through harvesting is the same in an agroforestry system as in a normal agricultural crop system then the agroforestry system is no more efficient than the crop system at nutrient conservation.

True
False

APPENDIX C

## EQUIPMENT LIST FOR WORKSHOP IN INDIA

I. Laboratory: A laboratory space and the use of the following items will be necessary for the workshop.

1. IBM PC/AT or equivalent microcomputer
   a. PC DOS software
   b. PC SAS and/or Minitab software
   c. Dot-Matrix printer
2. Two Blue M (or equivalent) forced air laboratory drying ovens 50-125°C Range
   a. One for Soils (105°C)
   b. One for plant tissues (70°C)--large size
3. Analytical balance, range: 0.01-1000g
4. Muffle furnace 450-500°C
5. Waring blender
6. Binocular dissecting microscope
7. Dissecting forceps with very fine points for sorting roots from soil
8. 20 glass petri dishes
9. Li-Cor (or equivalent) leaf area meter

II. Field: The following items will need to be available for field trips and labs:

1. Three soil augers,
   a. Slotted soil probe
   b. Soil screw auger
   c. Post-hole digger
2. Soil core sampler with hammer attachment including
   a. 5cm dia. X 5cm ht. corer with 24 retaining cups for collecting soil bulk density samples

b. 5cm dia. X 15cm ht. corer with 24 retaining cups for collecting root samples

3. 24 Sample holding cans or containers greater than 5cm dia. and 5cm ht. for drying soil samples

4. 50 1-liter volume and 50 3-liter volume paper bags or boxes for sample drying

5. Two 25cm X 25cm aluminum sampling frames

6. Five permanent felt-tip marking pens

7. One 10m telescoping height measuring rod

8. Haga Altimeter (or equivalent) for tree height measurements

9. Five wooden meter sticks

10. One small 33cm head pick mattock with 42.5cm handle

11. Five 50cm X 50cm square wooden frames (15cm in height) with aluminum or nylon screen bottom; 2mm mesh size

12. Five porus cup lysimeters with vacuum pump

13. Stainless steel 20cm bread knife with scalloped or serrated edges for sampling plant litter

14. Anvil pruners (20cm; Hand clipper for woody materials)

15. Heavy duty lopping shears; 60cm

16. Pruning saw; 25cm curved blade; 3 points/cm

17. 50m Lufkin fiberglass tape

18. 244cm dia. diameter tape

19. Mantax aluminum calipers; up to 127cm diameter capacity

20. 17cm vernier calipers

21. Round blade soil spade 44 X 13cm blade; 120cm overall length

22. Round point shovel 20 X 30cm steel blade; 120cm handle

23. Hanging dial scale w/hook; 30kg capacity

II. Field (cont'd)



24. Plastic funnels and plastic tubing of assorted sizes
25. Burlap bags of various sizes for weighing samples in the field
26. Assorted sizes of wash bottles for wetting soil in the field
27. Bow saw with 76cm blade
28. Single-bit axe 1kg head
29. Machete with 55cm blade

III. The following plant and soil analysis will be desired:

1. Soil pH
2. Available P; Available K
3. Total N for soil and vegetation (samples will need grinding)
4. Total carbon for soil

IV. Useful Equipment

1. Porometer (leaf conductance)
2. Pressure chamber apparatus (leaf water potential)
3. Environmental sensing equipment; Omnidata weather station or equivalent to measure:
   a. Photosynthetically active radiation (PAR)
   b. Relative humidity
   c. Air temperature (°C)
   d. Soil temperature (°C)
   e. Soil moisture
4. Li-Cor LI6200 photosynthesis system

APPENDIX D

Workshop on Tree and Crop Nutrient Cycling
( March 23 - April 4, 1990 )

Central Arid Zone Research Institute (CAZRI), Jodhpur

## COURSE EVALUATION

Do not sign your name, this is anonymous.
We thank you for your participation and comments.

Comments may be continued on reverse

1. Overall rating of the course. ( )

(a) Excellent
(b) Very Good
(c) Good
(d) Average
(e) Poor
(f) Very poor

2. What were the strengths and weaknesses of the course ? (Rate 5 = Strong to 1 = Weak)

(a) Basic background lectures (mineral nutrition, water relations, hydrology, nutrient cycling, root systems) :

(b) Applied agroforestry lectures (conservation, allocation of vegetation, maximizing productivity) :

(c) Field laboratory exercises :

(d) Field trips and tours :

(e) Group exercises and discussions :

(f) Informal out-of-class discussions among participants (information exchange) :

(g) Lectures by local experts :

NOTE : Strength will be interpreted as useful and well presented; while weakneses will be interpreted as either inappropriate or not adequately presented (please specify).

3. What were the specific aspect of this Workshop that you found most useful and positive :

4. What wer the specific aspects of this Workshop that you found least useful, or negative.

5. Other comments.