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INDO - U.S. WORKSHOP ON AGROFORESTRY

TREE GERMPLASM AND SPECIES IMPROVEMENT

HELD AT

GUJARAT AGRICULTURAL UNIVERSITY
SARDAR KRUSHINAGAR
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BY

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EXECUTIVE SUMMARY

A forest tree improvement workshop was held at Gujarat Agricultural University from April 15-27. Twenty-five participants from 10 states attended. The workshop stressed the practical rather than the theoretical applications of tree improvement. Emphasis in the workshop was given to the need for exploration of species and provenances from seed collections of phenotypical good trees and testing these in uniform environments so that the best genotypes can be identified.

Implementation of tree improvement programs for agroforestry has the same conceptual basis as do tree improvement programs for industrial forestry; only the objectives differ. In India, however, genetic gains are often hindered because of biological, technical, and administrative limitations. For example, the reproductive biology of the species of interest must be understood before initiating tree improvement programs. In other instances, forest researchers lack basic equipment or reference material to effectively complete their tasks. Coordination of tree improvement activities at different locations across India needs to be improved. Recommendations are given in the report.

A coordinated germ plasm collection is needed immediately for species of both national and regional importance. For species of local interest, improvement does not necessarily need to immediately involve a complex strategy; for species of national interest like *Azadirachta indica* (Neem), *Dalbergia sissoo* and *Gmelina arborea*, more intensive and long-term programs may be warranted.

BACKGROUND

The genetic composition of many forests in India has been altered by loggers, fuelwood cutters, and farmers. Some unique gene pools of native forest species are threatened by extinction. More frequently, however, the predominant situation is the genetic high grading of forest populations in the country to the extent that little useful material remains for incorporation into tree improvement programs.

In an effort to promote forest germ plasm conservation in India, a workshop on "Tree Germ Plasm and Species Improvement", was sponsored by USAID/AGRE through Winrock International and hosted by the Indian Council of Agricultural Research (ICAR) and Gujarat Agricultural University. In preparation for the workshop, two Indian scientists, Dr. V. K. Gupta (Indian Grassland and Fodder Research Institute) and Dr. S.B.S. Tikka (Gujarat Agricultural University), were posted for five months (August-December, 1990) at North Carolina State University, Raleigh, NC where they interacted with faculty, staff and graduate students, and with forest industry and state forest-service personnel in discussing gene conservation and tree breeding strategies. The specific objective of the Indian scientists was to collect sufficient information on germ plasm conservation that would be useful to the participants at the workshop. Dr. R. C. Kellison and Dr. W. S. Dvorak, scientists from North Carolina State University, assisted Drs. Gupta and Tikka at the short course at Gujarat Agricultural

University, Dantiwada on April 15-27, 1991. Both American scientists are trained in tree improvement of industrial forest species. It was thought that such expertise would complement the training of their Indian counterparts who are plant breeders, without forestry experience, working on agroforestry systems.

Prior to their departure from the U.S., the Indian scientists, with the assistance of Drs. Kellison and Dvorak, developed an outline for the Workshop which was subsequently reviewed and approved by Winrock International (Appendix 1). The Workshop outline was amended in India on April 15 once it was found that some Indian scientists would not be able to participate as lecturers as anticipated (Appendix 2). Dr. Kellison and Dr. Dvorak submitted two- to five-page written summaries to Winrock International for each session at the Workshop for which they were responsible; the Indian lecturers with minor exception also provided written summaries of their lectures (Appendix 3A). In addition, brief summaries were prepared by some of the Workshop participants following oral presentations of their research activities (Appendix 3B).

TERMS OF REFERENCE

The two American scientists were contracted by Winrock International to serve as rapporteurs for the Workshop, to present the majority of lectures, to interact with the participants and to provide an outline of a national germplasm conservation strategy for selected species. At the request of Dr. S. Chinnamani (ICAR),

the option remains to also assess introductory provenance/progeny trails of Pinus, especially P.patula, for which the North Carolina scientists have special experience and expertise.

OBJECTIVES

1. To promote interest in germ plasm conservation of forestry and agroforestry species in India through a series of lectures at Gujarat Agricultural University.
2. To make recommendations on how to strengthen and better coordinate tree improvement activities in the country.
3. To outline a national gene conservation strategy in collaboration with Indian scientists.
4. To outline a strategy for provenance/progeny evaluation of an introduced species such as P.patula for which the American scientists have special experience and expertise.

THE WORKSHOP

Twenty-five participants from 10 states attended the workshop (Appendix 4). The facilities at the Agricultural University were excellent. Course organizers, Dr. Tikka and Dr. Gupta, and others at Gujarat Agricultural University - especially Prof. A.T. Patel, should be commended for their great effort to make the program a success. Special mention should also be made of the assistance of Dr. S. Chinnamani, Assistant Director General (Agroforestry) ICAR, who collaborated with the Indian organizers to ensure that the administration of the Workshop was professionally conducted.

Furthermore, Dr. Chinnamani attended the first week of the workshop where he presented several lectures. The lectures of both the Indian and American scientists went smoothly despite occasionally being interrupted by outage of electrical power.

To promote better understanding of the lectures, selected readings were distributed to participants. This useful material was selected by the American scientists prior to their departure from the U.S. and sent express mail to course organizers in India. A list of suggested readings was also made a part of the lectures; many of these references were not made available to the participants because of the cost of shipping and reproducing the referenced books and periodicals.

Discussion questions were distributed to participants for some sessions to further strengthen dialogue and interaction (Appendix 5. Three field trips supported topics that were discussed during the Workshop (Appendix 6).

PROBLEMS ENCOUNTERED AND SOLUTIONS

Related to the Workshop

Interaction and discussions from participants were minimal the first two days of the course with the exception of five or six people who are active plant breeders. Those with less plant breeding experience, or experiences in other disciplines, e.g., soil science, animal nutrition, etc. were hesitant to express their opinions. Course organizers responded to the problem by asking that all participants speak approximately 10 to 30 minutes on their

agroforestry experiences. This forced interaction precipitated much discussion by participants and appeared to get most everyone actively involved in the workshop. By the fourth day, interactions and discussions were commonplace during and after each session.

2 Distribution of the book "Forest Tree Improvement" did not occur until midway of the second week, and therefore, lost much of its value as reference material for the participants. Futhermore, some (not all) of the selected readings for a particular session were not distributed until several days after the lecture was given. Therefore, the selected readings did not have the teaching impact that was intended. It is recommended that such reference material be distributed in a timely fashion to participants at future workshops. Ideally, the selected readings should be bound and distributed to participants at the time of workshop initiation.

Related to the National Plan of Gene Conservation

During the workshop, scientists exchanged views about agroforestry projects and long-term plans for its advancement. It is apparent that some administrative, botanical and technical limitations inhibit long-term development of tree improvement of agroforestry species in India. Solutions to the problem lay outside of the scope of the workshop, but the concerns are documented below with the hope that they be addressed by those formulating policy on such matters.

1. A list sometimes exists for some of the 31 ICAR research units on species priority for tree improvement programs. However, it is

apparent that for some of the priority species, information on the reproductive biology (flower structure, wind or insect pollinated. self fertile or self incompatible, phenology, etc,) is lacking or has not been compiled. Such information is essential for initiation of tree improvement programs because the improvement strategy differs for out-crossing vs. non-outcrossing species, for monoecious vs. dioecious species and for insect vs. wind-pollinated species.

2. In some cases, a scientist is working on a particular forest species without the knowledge that similar activities are being conducted by colleagues at other locations throughout India. A cooperative approach to forestry research and tree breeding is badly needed to maximize progress and minimize duplication of effort. The first step in developing cooperative forestry activities is to determine the tree improvement projects in progress, their status, and the names of the senior scientists responsible for their development.

3. Tree breeders do not have access to many international tree breeding journals which, for the most part, prohibits them from being current on the latest technologies being developed outside of India.

4. There appears to be many situations where the tree improvers do not have access to basic equipment to carry out tree improvement activities. Climbing ladders, grafting knives, increment borers, microcomputers for data analysis, etc. are the types of equipment needed.

NATIONAL GERM PLASM PROJECT

A distinction is made here on agroforestry species that have national importance as opposed to those having regional or local importance. The consensus is that those species of regional or local importance need not be committed to complex mating designs that are not needed or are impractical. To that we agree, but it is to be remembered that a regional program of a wide-ranging species that today has minor value could one day be elevated to major value. Therefore, we do not discourage heavy tree improvement emphasis on a wide-ranging species with local interest. We just think, more is to be initially gained from many scientists working on one or two species than for those same scientists to be relegating their time on a large list of both major and minor species. Further to the point of "minor" species, is the intense breeding work in progress for Leucaena spp. and Casuarina spp. Those intense breeding efforts should be continued regardless of the categorization of "major" or "minor" species.

In the separation of "major" and "minor" species, our recommendation is for the continuation of species testing for biomass production for fuel and fodder, timber, soil conservation and amelioration, tree architecture and complementariness for agriculture, pasture and horticulture crops. The wealth of agroforestry trees in India as well as in species introductions is so vast that decades will be required to ascertain the species

having greatest agroforestry value. We dare say that there will be a shifting of species priority. A species of high importance today will likely be surpassed by a species now having dubious distinction.

In our opinion, much improvement in the quality of agroforestry species in India could be made by simply selecting the best trees in natural stands. Seeds from these trees would be used to establish open pollinated progeny tests from which the best trees of the best families would be used to establish clonal or seedling seed orchards. It is estimated that as much as 20% genetic gain could be obtained by these relatively straightforward practices. For species that can be readily propagated, the alternative would be to establish cutting or hedging banks rather than seed orchards. Genetic gains for such programs would likely be more than double those of sexually reproduced plants because of the capture of nearly all of the genetic variation instead of only the additive portion that is available from sexually reproduced tree improvement programs.

Some species of national interest should be immediately identified for tree improvement efforts. Three forest species in India, Azadirachta indica, Dalbergia sissoo and Gmelina arborea, have such wide geographic distribution and economic importance that they are recommended for inclusion in national tree improvement programs.

PROCEDURES

The classical method of selecting plus trees for inclusion in clonal seed orchards, followed by progeny testing and rouging of the orchard to leave only the best genotypes is not appropriate for the three identified species. The reason is that the trees occur singly or in such small groups that the comparison system of selection is ineffective. The alternative is to select the best "mother trees" -- those producing seeds -- on a systematic basis throughout the species range, or a portion of its range, and from those trees to collect seeds for the open-pollinated progeny tests. Selection of the best families and of the best trees within those families can thus be accomplished because all of the trees within that progeny test are occupying a common environment.

In instances where select trees can be identified, the option exists to establish the trees in a clonal seed orchard. Results from the open-pollinated progeny tests from seeds also originating from the select tree (ortet) could then be used to rogue the inferior genotypes from the clonal orchard. A second generation program would potentially result from selection and breeding of the best families and the best trees in those families. Except, perhaps, for Gmelina arborea, this option does not hold much hope because of the open-grown nature of the trees.

The systematic sampling of "mother trees" for progeny test might be done on a grid basis throughout the range of the species, but most logically it would be done on the agroclimatic zones established for India. The six zones are Himalayan Hills -- two

(East and West), Gangetic Plains, Humid and Sub-Humid, Arid and Semi-Arid, and Tropical. Only the last four zones would have application to the three identified species. The adoption of this principle would allow the agricultural colleges and research stations associated with ICAR, and located within the four zones containing the three species of interest, to each make their own collections.

Progeny Testing

The 20 or so ICAR units located within the four agroclimatic zones would participate in the tree improvement sampling schemes for the three species. That scheme would be common to all participants. It would encompass provenance/progeny testing in which 20 trees per location (provenance), separated form each other by at least 100 mts., would serve as the "mother trees". A quantity of seeds sufficient to produce 72 plantable seedlings will be collected from each tree. Assuming that a 20 sampling-point grid had been established for the zone, the number of "mother trees" would be 400. The work load for collecting seeds from the 20 provenances and the subsequent progeny testing would be proportionately allocated to the ICAR units.

The recommended progeny-test design is 6 replications of 6-tree row plots. Assuming that no more than 3 provenances were to be included in any one progeny test (60 "mother trees" plus 5 checks) the statistical layout would be a randomized complete block (RCB). If more than three provenances were to be included in a

given progeny test, a different kind of design would be required, such as blocks-in-sets, to reduce the environmental variation associated with replications. The American scientists will provide designs for progeny testing after the number of "mother trees" for a test location has been set.

Check Lots

The check lots should be representative of the species in the area of study. Those trees should be perennially good seed producers and they should be located so that their security is reasonably assured for seed production until all phases if the progeny test have been completed. These trees will be in addition to the 400 trees identified for the test. These check lots will be common to all progeny tests in an agroclimatic zone, which will allow a comparison of all 400 "mother trees" within that zone.

Spacing of Test Trees and Surrounds

The 6-tree-row plots, replicated 6 times will be spaced at 3x3 mts., for the 3 identified species. The whole test will be surrounded by 2 rows of trees of the same species. Extra seedlings from the progeny lines can be used for this purpose. For a test of 3 provenances and 20 trees per provenance plus 5 checks, an area of about 2.5 hectares would be required for one test. 5 hectares for two tests.

In instances where the replications are not contiguous they, too, will be surrounded by two border rows of trees which increases test size. For test designs other than RCBs, considerably more land area will be required.

Seedling Production

Seedlings from the "mother trees" of any one species from the defined agroclimatic zone would desirably be grown in a common nursery/shadehouse facility. Barring this recommendation, the seedlings for each progeny test within the zone will be grown in a common nursery. If the latter option is exercised, it will be essential for seeds from the check lots to be grown in the same nurseries where the test seedlings are to be grown. Considerable coordination will be required to collect and distribute seeds from the 5 check lots.

The same size container, soil medium and cultural care will be afforded all lots of the target species at the nursery at which they are grown. The timing of seed sowing will be such that the seedlings are of optimum size at the beginning of the rainy season.

Site Location and Preparation

Two complete tests on contrasting but species-adaptable sites will be installed in the same year. The species-adaptable sites will be site prepared and cultivated to assure -- as far as practical -- optimum survival and growth of the seedlings. Care will also be given to protect the plants from grazing animals and

from insects, diseases and other pests, inclusive of fire. In case of plantation failure in the first year, plans should be made to repeat the planting in the second year.

Traits for Selection of "Mother Trees" & for Progeny Evaluation

"Mother trees" of average or above phenotype, that are more than 20 years old will be chosen based on tree height, acceptable tree-height to tree-diameter ratio, stem form (straightness and relative freedom from forking), crown form and leaf retention during the dry season. Trees with infectious diseases and insect infestations will be rejected.

The progeny of *Azadirachta indica* and *Dalbergia sissoo* will be evaluated on survival after the first growing season, for total height and foliage retention after 3 and 5 years, and for total height, stem diameter, stem form, crown form and foliar retention after 8 and 10 years. Initial selections for clonal and seedling seed orchards will be made at 8 years, and will be verified at age 10. For *Gmelina arborea*, the measurement and trait evaluations will be: year 1 -- survival, year 3 -- total height and foliage retention, and year 5 -- total height, stem diameter, stem form, crown form and foliage retention. Selections will be made at year 6, based upon measurements and evaluations at both years 5 and 6.

SUMMARY AND CONCLUSIONS FOR ESTABLISHING TREE IMPROVEMENT PROGRAMS OF *AZADIRACHTA INDICA*, *DELBERGIA SISSOO* AND *GMELINA ARBOREA* IN INDIA

In addition to the procedures described for the three species for which a long term tree improvement program can be justified, other considerations are emphasized for optimizing the genetic gain to be realized. Among these considerations are :

1. Form working groups of tree breeders in India that have specific interest in the tree improvement of *Azadirachta indica*, *Delbergia Sissoo*, *Gmelina arborea* and other valuable agroforestry species. Charge each of these groups with the development of an action plan, the needs and results of which would be submitted to the Assistant Director General (Agroforestry).

2. Compile information on breeding efforts for these species in other countries to identify current technologies that have proven successful. For example, for *Gmelina arborea*, Brazil, Costa Rica, Guatemala, Indonesia, Nigeria and Venezuela all have active Gmelina plantation programs. Some also have very active tree improvement programs. It would be useful to determine if any provenances from India have been tested in these countries and to ascertain their performance.

3. Begin a coordinated exploration and plus tree selection of all three species in India. Such activities would take approximately 3 to 4 years depending on the number of people and institutions involved.

4. Establish clonal orchards and perhaps seedlings seed orchards from open-pollinated progeny tests.

5. Distribute seeds from the orchards.

6. Begin a practical and usable mating scheme to produce rapid gains in the next generation.

At the least, 1000 trees should be selected country-wide for each species to begin the testing and orchard programs. Several hundred hectares of land will be needed to test progeny and establish seed orchards on a country-wide basis per species. Sites at agricultural universities would serve this purpose well.

RECOMMENDATIONS

During the final session of the Workshop, participants provided the American consultants with a list of recommendations to strengthen tree improvement efforts in India. These have been combined with recommendations by Dr. Kellison and Dr. Dvorak and are summarized in the following list.

1. Most of the advances in tree improvement activities in India are the result of an individual scientist working alone at a particular institution. Much greater progress could be made if groups of scientists from different institutions interested in the same species could do collaborative research. Top priority must be given to generate a list of scientists interested in and working on tree improvement in India with summaries of their current projects so that the activities of all researchers is better known and could be better coordinated. Such a list would not only include

those trained in plant breeding but would also include the names of any scientist whose work furthers the understanding and development of agroforestry species. For example, much good work has been conducted on soils, animal nutrition, etc., that is extremely valuable to further improvement on agroforestry species. It is essential that a survey be completed on the scientists doing tree improvement work. The responsibility for conducting the survey needs to be that of a high ranking administrator in Delhi rather than an individual scientist working at a remote agricultural station.

2. A tree improvement association should be formed in India after the survey has been conducted and names of interested scientists has been compiled. Initially a newsletter will be distributed to keep association members informed. As the association grows, a tree improvement journal should be published.

3. In order for tree improvement scientists to be abreast of the latest research, it is essential that they have access to international journals like Silvae Genetica, Forest Science, Commonwealth Forestry Review, Agroforestry News, etc..

4. Working groups of tree improvers should be formed to work on breeding strategy for species of national and local interest. Choice of species for improvement should not be chosen alone by administrators but in collaboration with biological and social scientists who understand the biology of the species and the farmer's needs.

5. Indian scientists trained in tree improvement abroad should be placed in tree improvement positions upon their return to India whenever possible.

6. To strengthen the network of tree improvement staff in India, at least one tree breeding position should be made available at each of the 27 agricultural universities in the country. Furthermore, efforts should be made to initiate tree breeding courses at all of the agricultural universities as part of the agroforestry curriculum. Professors with backgrounds in forestry rather than agriculture are needed for such courses. Initially, professors from the U.S. with experience in the Tropics and Subtropics could be a good source of talent.

7. Efforts need intensified to send students abroad for graduate training in forest tree improvement. Good institutions exist in the U.S., U.K., Brazil, Australia and elsewhere. Dozens of Indian students, rather than just one or two, need to be cross-trained to form the next generation of tree improvement workers for the 21st century.

8. Exchange of forest scientists between the U.S. and India should continue to further both group's knowledge of agroforestry systems and breeding. It is also essential that experienced Indian scientists be given the opportunity to attend and interact at international tree breeding conferences.

9. As part of no. 7 above, the Government of India, ICAR, and U.S. AID should host an international symposium on breeding of agroforestry species in India in 1992-93. A number of symposia

have been held on agro-forestry systems, but few have emphasized tree improvement. Such a conference, if organized properly, would generate much interest in gene conservation and breeding in India, and give foreign scientist some idea of what has already been accomplished in India on the development of agroforestry species.

10. Additional tree improvement workshops should be given in India but participants should have the option of attending an "intensive track" or "general track" depending on their interest and tree improvement experience.

11. Sizeable improvement of agroforestry species in India could be made by selection of "mother trees" in natural stands, establishment of progeny tests, and establishment of clonal or perhaps seedling seed orchards. Progeny tests are important because it is one of the means of selecting superior phenotypes from a population of open-ground "mother trees". On a national level, at least 1000 "mother trees" from 40 to 50 provenances should be initially screened. On a regional level, fewer provenances and "mother trees" need to be tested. For those species of only local interest, intensive, multi-generation breeding programs should not be initially contemplated. For species of great economic interest throughout the country, larger, more intensive breeding programs may be warranted. Such a program would require a coordinated effort backed by substantial long-term funding.

PROVENANCE/PROGENY TRIALS OF PINUS PATULA

North Carolina State University has a long history of conducting applied tree improvement programs including the evaluation of provenance/progeny tests. The latest efforts was creation of the Central American and Mexico Conference Resources Cooperative (CAMCORE) in 1980. The purpose of that cooperative which is primarily supported by private industry, is gene conservation of endangered species in Central America and Mexico. A further benefit from the 19-member organization representation Mexico, Central America, South America and Southern Africa is the identification of species that had never been recognized. Among those species are Pinus tecunumanii, once considered to be a sub-species of both P. patula and P. oocarpa. In the tests established, P. tecunumanii significantly out performs both of its "parent" species. The result is that P. patula is being replaced by the new species on a large scale in the exotic environments of Columbia, Brazil, South Africa and Zimbabwe, where P. patula was once exclusively planted. The replacement is resulting in a volume gain of 25% in large areas of the tropics and sub-tropics.

Even though P. petula is being restrictively planted in India, because of lack of markets, areas exist in the Western and Eastern Ghats where it is the premier plantation species. Further, it is considered only a matter of time before commercial use is found for the extensive plantations. To that eventuality, plans would be made to assess P. tecunumanii and other promising plants such as, P. maximinoii on sites that formally only supported P. patula.

In addition to the relatively cold insensitive species of P. patula, P. tecunumanii, and P. maximinoii, high-altitude species from Central America and Mexico such as P. gregii, P. hartewegii, P. leiophylla, have great cold tolerance. The potential exists to extend the pine plantation range in India to the lowlands of the Himalayas, to connect with the range of the natural P. roxburgii.

With the expertise and the plant material possessed by CAMCORE, it would appear logical for India to become a part of the consortium.

ACKNOWLEDGEMENTS

The American consultants would like to thank the staff of Winrock International in both Washington DC and Delhi for their support during trip preparation in the U.S. and on-site activities in India. We are especially grateful to Christine Knight for typing the drafts and final copy of the report.

Our stay in India was very productive. We were impressed with the large amount of agroforestry research in progress, with the diverse and harsh climatic conditions and, most noticeably, with the friendliness of the people. We hope this trip is the beginning of a lasting collaboration.

POSTSCRIPT

Coimbatore

Following the conclusion of the Workshop on April 27, I (R. C. Kellison) travelled to Coimbatore, Tamil Nadu to see agroforestry and industrial forestry at Coimbatore, Mettupalayam

and Ooty. I was accompanied by Dr. G. Kumaravelu, Dean, College of Forestry and Dr. M. G. Dasthager, Professor of Forestry, Tamil Nadu Agricultural University, and by Dr. R. Narayanan, Assistant Professor of Microbiology, TNAU Horticultural Research Station. At the Forestry Research Station, Dr. C. Surendran, Professor and Head, had each of his scientists give me a brief summary of their research work -- both in the field and in laboratory. The visit concluded with a stop at the research laboratory at TNAU where contact was made with scientists working in soil microbiology and biotechnology. At TNAU, a fruitful discussion was held with Dr. S. Jayaraj, Vice Chancellor, on the ways and means to develop formal interaction between TNAU and North Carolina State University (NCSU).

The research work in progress at Coimbatore and Mettupalayam is indeed impressive. The scientists at those stations are current with forest research in other parts of the world, and they are among the leaders in agroforestry research, so far as I could tell, in India or perhaps in the world.

The industrial forest plantations of Pinus patula and Eucalyptus globulus and, to some extent, Acacia mearnsii at Ooty are well established. The less-than-outstanding growth rates could almost surely be improved by using superior seed sources, such as would be available through CAMCORE for Pinus patula, P. tecunumanii, and P. maximinoii. The latter two species, of recent nomenclature often perform better than P. patula even in areas were P. patula has been widely planted.

A great variation in tree size in the Eucalyptus globulus plantations could be greatly reduced by use of vegetative propagules in the place of seedlings. The limitation to this concept is the poor rooting success of the species, about 32% with a range among clones of 22% to 42%. This low percentage is counter-productive for inclusion in a tree improvement program because the gain obtained from breeding is lost from rejection of the non-rooting trees. Clones with more than 60% rooting ability are needed for vegetative propagation to be an integral part of a tree improvement program.

The future of vegetative propagation of E. globulus does offer promise. Research being conducted in Portugal and Chile, under controlled conditions, is offering much better rooting success than in India -- 50 to 60%. Similar results can be obtained in India by using improved rooting facilities and paying more attention to detail.

Jhansi

The trip to Jhansi on May 01, was to interact with scientists at the National Research Center on Agroforestry, especially Dr. Deb Roy, Director, NRCC, and at the Indian Grassland and Fodder Research Institute (IGFRI). The contacts at the Institute were Dr. V.K. Gupta, Senior Scientists for Leucaena breeding, Dr. P.S. Pathak, Principal Scientists and Head, Agro Silvipasture Division, and Dr. Panjab Singh, Director, IGFRI. The progress being made in all phases of agroforestry at these two facilities

is also very impressive for the harsh conditions of the area. The breeding of Leucaena is probably second only to that of Dr. Brewbaker -- the father of Leucaena in Pan-tropic areas -- in Hawaii.

Because of the short time spent at Jhansi, I made very few observations for critique. The one point to be made is for the Leucaena project to settle on a long-term breeding strategy; some caution should be exercised in the species hybridization program. Crossing the various species to Lucanea leucocephala will likely not give added biomass production unless the parent of the other species has inheritance for insect, disease and other pest resistance.

In the harsh environment of Jhansi, it was revealing that a separate list of agroforestry trees are favored as opposed to other research stations with which I have made contact. The species of importance to IGFRI are Hardwickia binata, Acacia nilotica and Albezzia amara. This difference emphasizes the need for local evaluation of tree species for Indian agroforestry.

New Delhi

A brief meeting was held with Dr. I.P. Abrol, Deputy Director General, (SAE), Indian Council of Agricultural Research (ICAR). The point of discussion was the exchange of scientists and graduate students between ICAR institutions in India and North Carolina State University. I lamented to Dr. Abrol as I did to Dr. Jayaraj (TNAU) about the exclusion of North Carolina State University from

accepting Indian graduate students under the Winrock International guidelines in which only 18 months are allowed for matriculating at the Ph.D level. The administration at North Carolina State University is willing to compromise their program, insisting instead that a maximum of 30 months be spent in residence for the degree.