NEW DIRECTIONS AND PROBLEMS FOR TREE BREEDING IN THE TROPICS

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ABSTRACT

American southern forests and foresters have been basic resources for the establishment of industrial plantations in many tropical countries and for the development of tree breeding in several. Now, however, national priorities are changing towards rural and social forestry, with new opportunities and new constraints. The opportunities include new species (particularly multipurpose species) and unfamiliar environments (especially arid, semi—arid and degraded lands) while the problems include large populations of humans and cattle (with consequent excessive demands for fuel and fodder), uncertain land tenure (with limits on resource inputs) and inadequate professional and technical staff.

Traditional research steps are still required (choice of species and provenance; selection, progeny testing and propagation; seed or other propagule production) but appropriate breeding strategies must be simpler than those now adopted with industrial species. Continuing international support is required to increase national capability.

INTRODUCTION

It is 20 years since I earned my first dollar as a student tree breeder, 30 m up a slash pine tree at Harrison Experimental Forest, Gulfport, Mississippi, under the watchful and amused eyes of E.B. Snyder and F. Mergen. At that time few tree breeders were working in the tropics (Queensland, Kenya, the Rhodesias and South Africa) and industrial plantations (excluding Australia) occupied a few thousand hectares. Now there are 11.5 million ha of tropical plantations (pine, eucalypts, teak, *Gmelina* mainly), the planting rate is 1 million ha per year and some types Df tree breeding programmes exist in at].east 30 countries. Many of these activities are based on southern pines and American nationals or foreign tree breeders trained in the US. One example is the Zimbabwe pine breeding programme which includes *inter alia* 8 x 8 full diallel crosses without selfs and 8 x 24 or 8 x 27 factorial crosses of *Pinus elliottii* and *P. taeda* on 6 — 8 trial sites, now 7 — 10 years old (Barnes,* pers. comm.).

The International Union of Forestry Research Organizations Working Party S2.03-01 (Breeding tropical and subtropical species) has 280 members in 75 countries of which 50 are in the geographic tropics. The Working Party has held several meetings at which many tropical breeders 3articipated (Florida, USA, 1971; Nairobi, Kenya, 1973; Brisbane,

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Australia, 1977; Aguas Sao Pedro, Brazil, 1980). The bulk of the work has concerned survival, growth rate, form and occasionally wood properties; breeding strategies have tended to follow the classical pattern of species and provenance trials, selection of superior phenotypes (plus trees, often only 20-50), creation of primary seed orchards, progeny testing (mainly open-pollinated) and restructuring of seed orchards (to form the so-called 1.5 generation). Working Party S2.03-13 (Breeding southern pines) has recently been established, led by Dr. F. Bridgwater; this will have many tropical members.

Latterly some countries have entered phases of advanced generation breeding (e.. Australia, Fiji, Zimbabwe with tropical pines); others have developed more advanced operational techniques such as rooted cuttings to capture specific combining ability superiority (e.g. Brazil, Congo, with tropical eucalypts) while some, usually twinned with an institution in a temperate country, are examining tissue culture as a means of propagation and genetic conservation (India, teak; Malaysia, oil palm; Nigeria, obeche - Triplochiton scleroxylon.) Opportunities for further improvement clearly exist in these approaches to commercial plantation species. However, in most tropical countries plantation forestry has given way to rural development forestry as a priority subject of investigation and investment; the object of this paper is to review the part that tree breeding may play and the problems that will be encountered.

The use of the one word "tropics" implies a uniformity that does not exist. The belt around the earth between 23.5' north and south of the equator contains ranges of vegetated altitudes (0-4,000 m a s 1), vegetation types (evergreen rain forests to desert scrub), annual rainfall totals (0-10,000 mm), annual rainfall distributions (continuous to 1-2 months per year), soils (pH 3-9), densities of populations of humans and domestic animals, availabilities of professional and technical staff, skills and experience, and commitments by Governments to forestry.

RECENT TRENDS OF FORESTRY IN TROPICAL DEVELOPMENT

The importance of commercial plantations as contributors to economic development will of course continue in many tropical countries. However, it has recently been realised that these do not necessarily provide benefits that trickle down to rural populations. The World Bank (1978) revised its forestry sector policy to place investment in rural welfare ahead of industrial investments and most other development hanks, multilateral agencies, bilateral donors and non-governmental organizations now follow similar policies.

In 1980-81, together with J. Spears and J.E.M. Arnold, I conducted a review of .forestry research needs in developing countries for the preparation of a statement by World Bank and FAO (1981) to the 17th IUFRO Congress and the priorities have been widely accepted by donor and recipient organizations; they have led to the appointment by IUFRO of a special coordinator for developing countries. The broad subject priorities are:-

(i) Forestry in relation to agriculture and rural development
(ii) Forestry in relation to energy production and use
(iii) Management and conservation of existing resources
(iv) Industrial forestry

Tree breeding is identified in (i.), (ii) and (iv) while genetics is implicit in (iii) so tree breeders can be assured of gainful employment in increasing numbers during the foreseeable future but their objectives will be very different from those encountered in industrial, temperate forestry

BENEFITS OF NON-INDUSTRIAL TREES AND FORESTS

In the rural situation the products and services obtained from trees are commonly in the reverse order of priorities compared with industrial plantations, namely site improvement, habitat improvement and production.

Site improvement includes soil or sand dune stabilization, protection of soil and water supplies, soil improvement (stucture, chemistry, water balance), and control of weeds.

Habitat improvement includes the provision of shade and shelter for humans, domestic animals and wild animals, and shelter for crops. In some countries amenity, tourism and recreation may be legitimate national objectives though they are less important at the level of local communities.

Products required rurally include poles, saw timber, fuel (mainly wood and charcoal), food for humans and domestic animals, other animal products (e.g. honey, silk) and chemical derivatives essential oils, drugs, soaps).

The urgent need for these benefits can be seen from the following selection of global estimates based on various FAO and World Bank studies and on the report by Wood, Burley and Grainger (1982) for the US Congress)ffice of Technology Assessment:-

World area of closed forests	2860 million ha
Tropical area of closed forests	1160 million ha
Tropical area of moist forests	1060 million ha
Tropical humid deforestation	6 million ha per year
Arid/semi-arid deforestation	20 million ha per year agricultural lands and 4 million ha per year open woodlands
Desertification	affects 3000 million ha, 67% of the world's countries, and 17% of the world's population

Soil erosion following deforestation cost approximately US $ 1 million in India alone over the last three years and soil is Nepal's major export (1 billion tons annually). Forests moderate water flow and deforestation has contributed to shortages of drinking water in many large cities (e.. Bogota, Jakarta, Kuala Lumpur, Lagos, Manaus, San Jose) while Bangkok is sinking faster than Venice as ground water is being pumped up to meet dry season needs that were formerly met by monsoonal rain water released slowly by upland forest areas. Reforestation rates approach 1 million ha per year of which half are industrial, the remainder meeting less than one fiftieth part of rural needs (<u>inter alia</u> the fuelwood deficit in arid and semi-arid lands requires the equivalent of 26 million ha of pure plantations, although the needs must be met by single trees in farm boundaries as much as by village woodlots). USAID is currently helping many countries with fuelwood projects (for some of which expatriate experts are required) and it is co-sponsoring fuelwood workshops with IUFRO in Africa and Asia.

SPECIES AND LANDUSE SYSTEMS TO PROVIDE THE BENEFITS

For any given site a wide range of species could possibly provide a given benefit. However, it is unlikely that trees or forests will be grown for a single benefit in rural locations. Both individual farmers and village communities, particularly those in areas of severe land pressure, require several benefits from one tree or plot. This introduces the recent (jargon) concepts of multipurpose trees and agroforestry systems.

Virtually all trees can be used for at least two purposes since they can be burned as well as used in solid form but multipurpose trees are difficult to define exactly; in common opinion they are species that can provide several products and benefits from the one tree, *Azadirachta indica* (Meliaceae) which can supply wood, fuel, chemicals, cattle fodder and shade (see Radwanski, 1977; Schmutterer, Ascher and Rembold, 1981), or *Leucaena leucocephala* (Leguminoseae) which can fix nitrogen, stabilise soil, and provide fodder, fuel and shade (NAS, 1977). Although recent attention has been concentrated on a few outstanding species such as the two above and several *Acacia* and *Prosopis* species many others have potential for different sites; the ICRAF/IBPGR/CFI/NAS workshop that preceded this meeting identified some 2000 species that have been recommended by someone for somewhere (see Burley, 1983) and the USDA Plant Genetic Resources Laboratory at Beltsville, Maryland, maintains a computer-based data bank on 1000 woody legumes most of which have at least nitrogen fixation and wood or fodder production as multipurpose attributes (see e.g. Duke, 1981). These large numbers immediately pose the problems of seed sources (exploration, taxonomy, supplies and certification) and comparative field trials. Agencies such as CFI, NAS and USAID that conduct exploration, conservation and evaluation of multipurpose trees were described in Burley (1983) and the workshop attempted to identify mechanisms for stimulating and coordinating internationally the necessary research and development of these species.

With increasing populations land pressure becomes intolerable and man's needs to have to be met from smaller areas of Land. Agricultural crops, domestic animals and trees may be raised on the same plot, either in intimate spatial mixture or in temporal sequence. Such combinations are collectively called agroforestry (Lundgren, 1982) which is a land use system well suited to meet social and community forestry objectives (Burley and Wood, 1983). Agroforestry imposes unfamiliar constraints on the silviculturist. Experiments must be designed to include mixtures of annual and perennial crops, various spacings, unusual silvicultural treatments such as coppicing and pollarding, and the determination of yields and qualities of products other than the familiar stem wood leaves, thorns, branches, extractives, palatability, burnability, *etc.)* A manual of methods for agroforestry research is in preparation by ICRAF and CFI with NAS support to amplify the manual on species and provenance testing for tropical plantation crops (Burley and Wood, 1976).

PROVENANCE

Many of the participants at this meeting deal with selective breeding of indigenous species for which either local origins are best or the stage of provenance trials is long past. It would be interesting to count how many here have actually designed or assessed a provenance trial. No doubt many work in cooperative organizations that exchange improved genetic material from a range of natural origins and I wonder if I dare ask if origin records are maintained for such material even though the natural range and variation are well known.

In contrast, for the species of use in the tropical rural scene, little is known about the natural range nor about the degree of genetic change caused by human activities such as selective or complete logging. Where trees have been planted the local source has usually been used and considerable land race differentiation has occurred. The importance of genetic history of both natural and derived provenances is well known (see Jones and Burley, 1973) and the place of provenance material in breeding strategies will be discussed in detail at the meeting of IUFRO Working Parties S2.02-08, S2.03-0I and S2.03-13 in Zimbabwe during April, 1984.

OBJECTIVES OF BREEDING

As introduced above, for many aspects of rural development multipurpose trees will be used and the principal objectives of breeding will be to increase the yield of their particular benefits or products. This will entail development of rapid assessment techniques for characters as diverse as nitrogen-fixation capacity, leaf palatability or alkaloid content, shade/shelter microclimatic effects, or soil holding ability in addition to standard wood or total biomass production.

The second set of objectives will be to yield seed or propagules that can be managed in small nurseries or by individual land owners who have little skill, resources or time for tree planting and maintenance or who often have little appreciation of the benefits likely to accrue. Since the individual farmer himself is not likely to practise tree breeding, particularly if his first plantings flower and seed early and prolifically, any improved planting stock must be provided cheaply by governmental and non-governmental organizations. It must obviously be backed up with agri-silvicultural research to determine crop mixtures and managerial practices and by extension services to publicise the benefits of using improved material and the methods of growing it.

A third set of objectives for many species may be the conservation of genetic variation by representatives of both natural populations and local land races, At present in forestry there is no equivalent of the international agricultural research institutes and other centres that maintain gene banks of many thousands of agricultural crop selections. Although some international agencies maintain samples of seed from several populations of some species, it is necessary for individual national organizations to create and maintain local gene pools for breeding for future changes of site, management, market, pests and diseases. Few have done this for species used in smallholder and community forestry.

CONSTRAINTS ON BREEDING

To meet rural land use objectives there are several constraints on breeding even a single species, assuming that information is available on the optimum species and provenance for each of the major products or benefits.

The first is the multiplicity of benefits itself which requires the derivation of selection indices and possibly the maintenance of multiple populations (see Namkoong, Barnes and Burley, 1980).

The second is the existence of genotype-environment interactions in which environment includes different sites, managerial methods, and agricultural crops if used in an agroforestry mixture. The range of contributing factors is large and the reduction of overall heritability and gain could also support the need for multiple populations.

The third is simply the cost of the research necessary to examine all combinations of site, species, management and benefit, and to develop appropriate populations. In many countries forestry has a low governmental priority within forest departments. This situation may be improved if donor funding supports research in rural forestry specifically and extension work generally.

Fourthly, tree breeding in tropical regions is constrained by inadequate staff numbers and skills. Many professional breeders have been trained in US universities but too often they are diverted to administrative or political office in national or international organizations. Until the market is saturated with qualified personnel one approach is the intensive specialised short courses such as those offerred periodically at CFI, Oxford or NC State University, Raleigh, and possibly in future by the South-East Consortium for International Development (Chapel Hill, NC). Further, donor agencies such as USAID can support the provision of American nationals either as Peace Corps volunteers or specialists on regular assistance projects in developing countries. A major factor in the success of all such projects is continuity and follow-up; rarely does a 2- or 3- year assignment achieve significant results and nowhere is this more apparent than in long-term activities such as tree breeding. An extended commitment of staff and institutional support is desirable and this can be obtained through the concept of twinning between institutions in developed and developing countries.

The first two of these constraints lead towards complexity of breeding strategy; the last two impose simplicity. Clearly a balance has to be struck for each country but in general appropriate strategies will be simpler than those currently operated in temperate regions.

REFERENCES

BURLEY, J. (1983). Background document for ICRAF/IBPGR/CFI/NAS workshop on multipurpose tree germplasm, Washington, DC, USA. ICRAF, Nairobi, Kenya, 70p and 18 appces.

BURLEY, J. and WOOD, P.J. (1976). A manual on species and provenance research with particular reference to the tropics. Trop. For. Pap. Commonw. For. Inst., Oxford, England, No. 10, 226p.

BURLEY, J. and WOOD, P.J. (1983). Development of curricula for community forestry. Pap. Twelfth Sess., FAO Adv. Cttee. For Educ., Nairobi, Kenya. FO: ACFE - 83/12, FAO, Rome, Italy, 6p.

DUKE J.A. (1981). Handbook of legumes of world economic importance. Plenum Press, New York, USA, 345p.

JONES, N. and BURLEY, J. (1973). Seed certification, provenance nomenclature and genetic history in forestry. Silvae Genetica 22(3), 53-8.

LUNDGREN, B. (1982). The use of agroforestry to improve the productivity of converted tropical land. Rept. US Congr. Office of Technology Assessment, Washington, DC, USA, 81p.

NAMKOONG, G., BARNES, R.D. and BURLEY, J. (1980). A philosophy of breeding strategy for tropical forest trees. Trop. For. Pap. Commonw. For. Inst., Oxford, England, No. 16, 67p.

NAS. (1977). Leucaena - promising forage and tree crop for the tropics. National Academy of Sciences, Washington, DC, USA, 115p.

RADWANSKI, S. (1977). Neem tree. I. Commercial potential, characteristics and distribution. World Crops and Livestock, March/April, 62-6.

SCHMUTTERER, H., ASCHER, K.R.S. and REMBOLD, H. (eds). (1981). Natural pesticides from the neem tree (Azadirachta indica A. Juss). Proc. First Intl. Neem Conf., Rottach-Egern, Germany. GTZ, Eschborn, Germany, 295p.

WOOD, P.J., BURLEY, J. and GRAINGER, A. (1982). Technologies and technology systems for deforestation of degraded tropical lands. Rept. US Congr. Office of Technology Assessment, Washington, DC, USA, 114p.

WORLD BANK.. (1978). Forestry: sector policy paper. World Bank, Washington, 68p.

WORLD BANK and FAO. (1981). Forestry research needs in developing countries - time for a reappraisal? Spec. Pap. 17th IUFRO Congr., Kyoto, Japan, 56p.