LIFE SUPPORT PLANT
SPECIES
DIVERSITY AND CONSERVATION

Proceedings of CSC/ICAR International Workshop on Maintenance
and Evaluation of Life Support Species in Asia and the Pacific
Region held at NBPGR, New Delhi
April 4-7, 1987

Edited by
R. S. Paroda
Promila Kapoor
R. K. Arora
Bhag Mal

NATIONAL BUREAU OF PLANT GENETIC RESOURCES
NEW DELHI, INDIA
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The dependence of mankind on plant resources is inevitable. Though only 20-25 species provide 90 percent of the world's food and over 3,000 the rest of the potential needs, the global wealth at large, is still being exploited more and more to find out newer sources of foods, fodder, fuel, fibre, medicine and industrial use. In this context, more important is the hunt to exploit plants occurring in extreme environmental conditions such as drought, arid hot and cold deserts, flood prone and soil stress habitats etc. The vast natural expanses of geographical areas in such habitats support scanty vegetation, and in such scarcity zones, the plants on which we get dependent constitute the life support species.

The role such species can play in the developing countries, in particular, in the Asia and the Pacific region, where traditional agriculture prevails in diverse habitats and socio-economy and daily needs are met by the natives from such plants, need not be over emphasised. Thus, it was extremely thoughtful on the part of the Commonwealth Science Council London (UK) and the Indian Council of Agricultural Research, New Delhi (India) to have conducted an International Workshop on the Maintenance and Evaluation of Life Support Species in Asia and the Pacific Region from April 4-7, 1987 at the National Bureau of Plant Genetic Resources, New Delhi, India-an organisation where already a strong national programme on the improvement of under-utilised and under-exploited plants is operating.

This Regional Workshop highlighted the role of life support/emergency plant species in stress prone environments. Thirty three papers were presented and these covered all relevant topics. Over 55 scientists representing different countries from Asia and the Pacific region, as also from Europe and with the international organisations such as UNESCO, participated. These proceedings, are the outcome of the technical programme conducted during the four day deliberations at NBPGR.

I am extremely happy that Drs. R. S. Paroda, Promila Kapoor, R. K. Arora and Bhag Mal have brought out these proceedings, edited jointly by them. Such a synthesis of useful plants at international level from different geographical areas of plant diversity is in fact required. The efforts put in jointly by the Commonwealth Science Council (UK) and the Indian Council of Agricultural Research (ICAR), thus, have been suitably rewarded through this publication.
I am sure this book would generate the desired concern which is still required particularly in developing countries on such life support plant species. In this context, the recommendations of this Workshop will go a long way in drawing out an action oriented programme on the collection, evaluation, utilisation, domestication and conservation of such global genetic resources. I congratulate the authors of this book which is not only meant for a large scientific community, but could equally be used as a reference material by planners in research and development endeavours in a national, regional and international perspective.

N. S. RANDHAWA
Director General, ICAR
New Delhi, India
In spite of the recent advances in agriculture, man is by and large dependent on 20-25 plant species for his daily needs. Many of us are still unaware of the potential which other less known plants could offer in the different geographical/floristic regions of the world. Important new products such as oil, gum and wax for industry, protein for food and feed and chemicals for pest control are likely to result from such plants. New raw materials will also be required in future to meet the growing needs of mankind owing to increasing population pressure and social needs. As we are already aware, improved scientific knowledge on adverse effects of certain products has created demands for new products such as unsaturated fats, low calorie sweeteners and biodegradable pesticides. New industrial processes have stimulated the need for larger supplies of materials such as lubricating oils, drug precursors and waxes.

The region of Asia and the Pacific is blessed with an enormous diversity of such plants. Equally important is the need for utilising these plant resources in stress prone habitats under temperature, soil and water stress and in emergency situations. These life support species are expected to provide new sources of food, fibre, fuel, fodder, hydrocarbon and industrial products. In view of this background, the Commonwealth Science Council, London (UK) and the Indian Council of Agricultural Research, New Delhi (India) jointly organised an International Workshop on Maintenance and Evaluation of Life Support Species in Asia and the Pacific Region from April 4 to 7, 1987 at the National Bureau of Plant Genetic Resources, New Delhi. The objective of this Workshop was to create greater awareness about the usefulness of new potential plants which can support life during emergency/extreme environmental conditions and to highlight the work being done in this direction particularly in different countries of Asia and the Pacific region.

The Workshop was inaugurated by the Hon'ble Minister of State for Agriculture Shri Yogendra Makwana. Dr. M.V. Rao, Special Director General ICAR presided. Fifty five experts from 14 countries, namely, India, Bangladesh, Pakistan, Sri Lanka, Czechoslovakia, Nepal, New Zealand, Thailand, Philippines, Malaysia, Australia, Italy, Sweden and UK participated in the Workshop. The Technical Programme of the Workshop during the four days deliberations consisted of eight sessions. The proceedings included 33 invited papers and gave a comprehensive picture regarding the status of life
support species in Asia and the Pacific Region, and their future prospects in terms of collection, evaluation, utilisation, documentation and conservation. Major recommendations of the Workshop were presented in the Plenary Session chaired by Dr. N.S. Randhawa, Director General, ICAR.

In bringing out these proceedings, we owe our gratitude to Dr. N.S. Randhawa, Director General, ICAR, New Delhi for his guidance and encouragement and also for writing a 'Foreword'. We are equally thankful to the Commonwealth Secretariat, Commonwealth Science Council, London (UK) and the Indian Council of Agricultural Research for jointly sponsoring the Workshop. The help received from the staff of NBPGR, particularly Miss Anjula Pandey, Mr. S. Mauria and Mr. Rakesh Singh is also gratefully acknowledged.

We sincerely hope that these proceedings will be of particular interest to all the researchers and planners concerned with plant diversity and its utilisation and conservation. Also the recommendations would help in generating the required awareness on life support species among all concerned so that these valuable resources do not hitherto remain unattended and get required attention for necessary scientific pursuits in different countries.

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WORKSHOP RECOMMENDATIONS

The programme of the workshop during its four-day deliberations was organised in seven technical sessions. The presentations by the delegates covered overall perspective of life support species in international, regional and national context, laying emphasis on the role of these species in various exacting environments viz., water, soil and temperature stress situations.

Technical Session I dealt with an overview of life support species and was chaired by Dr. N. S. Randhawa, Director General, Indian Council of Agricultural Research, wherein the concept and importance of life support plant species was discussed in global perspective. The importance of diversity in life support species, their collection, utilisation and conservation was highlighted on an international basis by the Commonwealth Science Council, London. The three sessions that followed (Session II to IV) analysed the role of life support species in specific habitats. Technical Session II was chaired by Dr. J. V. Possingham from CSIRO, Australia and dealt with the diversity of such species and its importance in water stress conditions, while Dr. W Harris, Director, Botany Division, DSIR, New Zealand, chaired Technical Session III, dealing with species adapted to temperature stress situations. Dr. I. P. Abrol, Deputy Director General (Soils), chaired Technical Session IV, which stressed on species for the soil stress conditions. The importance of various species for emergency situations was highlighted by the delegates from different countries in Technical Session V chaired by Dr. D. B. Sumithraarachchi, from Royal Botanical Gardens, Peradeniya, Sri Lanka, and Malaysia country reports were presented by the delegates from New Zealand, Sri Lanka, Nepal, Bangladesh, Thailand and Pakistan. Technical Session VI, chaired by Dr. M. P. Nayar, Director, Botanical Survey of India, Calcutta dealt with national programme and efforts put forth by India in this direction.

The working groups met in the Technical Session VII to identify priorities and work out a mechanism for cooperative action on the part of the countries represented from Asia and the Pacific. The convenors of these groups were the respective chairmen of different sessions with one more working group added, namely, new frontiers of science and life support species which was convened by Prof. A. M. Zakri from the University of Kebangsaan, Selangor, Malaysia. One such group chaired by Dr. R. S. Paroda, Deputy Director General (Crop Sciences) and the then Director, National Bureau of Plant Genetic Resources, New Delhi, also
deliberated regarding identity of specific species for temperature and other stress situations.

The Plenary Session was chaired by Dr. N. S. Randhawa, Director General, ICAR. The major recommendations which emerged out of the workshop are as follows:

A. General

1. Life support species have an important role to play for the betterment of mankind, especially under situations of abiotic stresses related to soil, water, nutrients and energy, particularly in view of increased human and livestock population. Therefore, these species are required to be given due importance as far as scientific and technological inputs are concerned.

2. Steps need to be taken to establish a network on life support species among participating countries. Countries such as India might consider establishing an Institute or the national network involving different organisations engaged in life support species. Also, national and regional coordinators be identified so as to coordinate these activities in a well planned manner.

3. The nodal agencies for each country for crop and wild plant genetic resources need to be identified for work on plant germplasm and long-term storage, evaluation, documentation, utilisation and conservation of such species, several of which being endemic or rare, are threatened due to habitat loss etc.

4. An efficient information system for Asia and the Pacific Region needs to be developed for more effective linkage and for the dissemination of knowledge as well as documented material.

5. An inventory of active research scientists working on life support species be prepared and circulated to all concerned for better interaction and exchange of ideas.

6. The training of scientists with emphasis on study of different life support species including their collection, evaluation, utilisation, conservation, taxonomy, ethnobotany etc. will be most essential as well as rewarding. Necessary facilities in this field are available in India at the National Bureau of Plant Genetic Resources, New Delhi and the National Botanical Research Institute, Lucknow as well as at the Botanical Survey of India, Calcutta, which may profitably be utilised for this region.

7. Symposia/Seminars/Conferences on life support species should be organised periodically so as to exchange information, review the
progress and to formulate future strategies. A regional workshop be convened after every two years preferably by the Commonwealth Science Council (CSC) in collaboration with other agencies concerned so as to provide an opportunity to the scientists to know the latest developments and to plan their future research and development efforts.

8. Concerted efforts to give momentum to the work on life support species should be made by involving postgraduate students, using life support species as subjects of their studies for thesis/dissertation and also the concerned institutions. The work on life support species could also be spread by holding seminars for students and teachers and by having discussions at the appropriate level with administrators and politicians.

9. Films, books, brochures, research journals and newsletters on life support species be brought out for quick dissemination and exchange of information and for generating public awareness.

10. A suitable funding mechanism at the international level through possible support of CSC, FAO, IBPGR, UNEP, UNDP, UNESCO, IUCN etc. need to be developed so as to meet the financial requirements for funding the exchange of personnel and the experts, and also for organising the training programmes.

B. Technical

1. It is extremely important to generate information on the origin, distribution, habitat, agro-climatic requirements, benefits as well as scientific utilisation of life support plant species and, therefore, study of these economically important plants need to be given major emphasis. Inventories of all life support species need to be prepared and made available to all concerned in the region.

2. A few important species having economic potential for use as food, forage, fuel, energy, medicine, industrial and other uses for specified stress and emergency situations be selected for in depth studies as per the specific needs of the respective countries/regions. The priority species identified included multipurpose bamboos, canes, *Artocarpus* species, pulses like rice bean, a few minor millets, pseudo-cereals for hills, tuber crops like *Colocasia*, floating species like *Trapa bispinosa*, and a few potential medicinal plants depending on regional needs.

3. Collection, evaluation, documentation and cataloguing of the prioritised life support species be taken up systematically so as to ensure their efficient utilisation.
4. The germplasm of various life support species, including those which are threatened with extinction due to habitat loss, be conserved on top priority basis through *in situ* and *ex situ* conservation methods. Also, as *in situ* measure, the biosphere reserves need to be established and the information on various aspects such as population dynamics etc. needs to be generated.

5. Bio-technological approaches such as *in vitro* preservation of germplasm, maintenance of genomic libraries of important but threatened species and studies on variation in cultures, were recommended for conservation as well as utilisation of life support species.
CONCEPT OF LIFE SUPPORT SPECIES FOR EMERGENCY AND EXTREME ENVIRONMENTAL CONDITIONS

N. S. RANDHAWA

Indian Council of Agricultural Research, New Delhi, India

INTRODUCTION

It is estimated that so far man has used about 3,000 plant species for food and other purposes of which only 150 have been commercially exploited all over the world. However, over the centuries, the tendency had been to concentrate on fewer and fewer species and today, we depend largely on only 20 crop species. Hence, in spite of rich flora that offers great promise, we seem to have depended only on a very small fraction of the plant wealth. These data underscore the narrow base of plant species on which the sustenance of food chain has been dependent and practised by mankind over centuries. The need for producing more food and other basic necessities for rapidly increasing human and livestock population in the second half of the current century necessitated bringing under the plough of more and more ‘marginal lands’ on the one hand and acceleration of degraded soils’ rehabilitation processes on the other. This has posed a serious question to the concept of ‘adopting native plants suited to the environment’ and has kindled interest in agricultural scientists to collect, introduce and evaluate the vast array of under-utilised plant species and also to breed for varieties which can well ‘adapt themselves to the harsh environmental and degraded soil conditions’.

Considering the potential usefulness of such under-utilised types, it was considered appropriate by the Indian Council of Agricultural Research and other co-sponsors of this regional workshop to share the experience on such life support species. This paper lays emphasis on the collection and study vis-a-vis utilisation of such useful species adapted to the harsh environmental and specific soil conditions.

EXTENT OF SOIL CONDITIONS

Dent (1980), based on the data compiled from FAO/UNESCO soil map of the world, indicated the extent of stress conditions for agriculture in different regions as given in Table 1. The data indicated that 88 per cent of total land area in South Asia suffers with some kind of stress and
Table 1. Extent of stress conditions in different regions

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<th>Region</th>
<th>Percent of total land area with limitation of</th>
<th>No serious limitation</th>
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<td></td>
<td>Drought</td>
<td>Mineral stress</td>
</tr>
<tr>
<td>South Asia</td>
<td>43</td>
<td>5</td>
</tr>
<tr>
<td>North &amp; Central Asia</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>2</td>
<td>59</td>
</tr>
<tr>
<td>Australia</td>
<td>55</td>
<td>6</td>
</tr>
<tr>
<td>World</td>
<td>28</td>
<td>23</td>
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only 18 per cent area is free from any serious limitation. This situation warrants the need for searching new potential plant species that can thrive well and can give economic yields under the particular stress conditions.

Soil related constraints

These constraints comprise of those which are of inherent nature such as excessively limiting physical and chemical characters of the soils and those which are brought about by man’s intervention, such as salinity, alkalinity, water logging, lands under shifting cultivation, highly eroded and degraded soils. The broad class of mineral stress constraints are, however, related to both parent material and to man’s soil management practices.

The world soil map and the soil classification system for this purpose by FAO/UNESCO have identified the various mineral stress constraints which are associated with major soil associations (Dudal, 1976). Table 2 indicates the major soil association and the related mineral stress conditions.

Rehabilitation of degraded soils

Multi-disciplinary research efforts by plant breeders, physiologists and soil scientists, particularly in the last two decades, has enlarged the scope of breeding, screening and fitting in suitable varieties of plants to various mineral stress conditions. This approach is of great significance for farming on soils with constraints of toxicity of element(s). In soils developed from alluvial deposits in active flood plains which become excessively acidic on drainage (fluvisols) and develop toxicity of Al, Mn, Fe, it has been established that oil palm and punk tree (*Malapensa leucodendron*) stand these extreme conditions. The examples of (1) Al tolerant wheat varieties in Brazil and USA; (2) rice varieties adapted to deficiency
Table 2. Major soil associations and related mineral stress conditions

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<th>Soil association</th>
<th>Chief feature</th>
<th>Mineral stress condition</th>
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<tr>
<td>1. Acrisols</td>
<td>Strong acidity</td>
<td>Toxicity of Al, Mn, Fe; Deficiency of Co</td>
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<tr>
<td>2. Andosols</td>
<td>Soils developed from volcanic ash deposits</td>
<td>High fixing capacity for P, B, Mo; Al toxicity</td>
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<tr>
<td>3. Arenosols</td>
<td>Soils derived from sands with a large proportion of shartz</td>
<td>Deficiency of Zn, Mn, Cu, Fe</td>
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<td>4. Ferralsols</td>
<td>Strongly weathered soil of tropics</td>
<td>Deficiency of bases, Fe; High fixation of P; Toxicity of Al, Fe, Mn</td>
</tr>
<tr>
<td>5. Fluvisols</td>
<td>Soils developed from alluvial deposits; on drainage they become excessively acidic</td>
<td>Toxicity of Al, Fe, Mn</td>
</tr>
<tr>
<td>6. Glyesols</td>
<td>Poorly drained soil</td>
<td>Toxicity of Fe, Me, Se</td>
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<td>7. Histosols</td>
<td>Soils restricted with water for prolonged periods of the year</td>
<td>Deficiency of Cu, Zn, Mo, Se</td>
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<td>8. Kastanozome</td>
<td>Soils with high base status, often calcareous throughout</td>
<td>Deficiency of P, Zn, Cu</td>
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<td>9. Nitesols</td>
<td>Strongly weathered soils with clay accumulation in the subsurface horizon</td>
<td>Toxicity of Mn</td>
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<td>10. Planesols</td>
<td>Soils subjected to seasonal waterlogging</td>
<td>Toxicity of Al</td>
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<td>11. Solonetz</td>
<td>Alkali soils</td>
<td>Excess Na; Deficiency of Zn, Cu, Fe, Mn</td>
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<td>12. Vertisols</td>
<td>Soils developed from swelling clays</td>
<td>P deficiency</td>
</tr>
<tr>
<td>13. Xerosols</td>
<td>Strongly saline and Na saturated soils</td>
<td>Deficiency of P, Fe, Zn</td>
</tr>
</tbody>
</table>

of Zn, P, Fe and toxicity of Fe, Mn, Al and H₂S; (3) metal tolerant ecotypes of grasses for use in the reclamation of heavy metal contaminated land; and (4) grafting desirable citrus and grapefruit scions on to Fe efficient rootstocks to control Fe chlorosis are noteworthy achievements made in this field of studies through national and international research efforts.
In tuber crops, cassava is adaptable to soils of low fertility and is able to tolerate low Ca, N and K. These edaphic tolerances give cassava an advantage over many other crops in acid infertile soils. Sweet potato is fairly tolerant to Al and Mn and less tolerant to soil acidity. Yams are also less tolerant to soil acidity. Salinity tolerant types are known in *Eucalyptus, Acacia, Salvadora* and *Prosopis* species while several of the temperate soft, pome and stone fruits, and nut crops are adapted to acidic soils, i.e. chilgoza pine *Pinus Gerardiana, Pyrus, Prunus, Armeniaca, Rubus* and *Ribes* species. Water logged soils constitute the natural habitat of the non-cereal energy crops in the tropics viz., *Xanthosoma, Alocasia* and *Colocasia* species. Brackish water habitats support rich populations of *Oryza coarctata*, apart from a rich diversity of mangrove species in India, the nipa palm and the sago palm (*Metroxylon sago* and *M. rumphii*) in the Indo-Malayan region. The laterite soils of the humid tropics which are acidic support rich species diversity of hard seeds—*Xylia xylocarpa, Hopea parviflora* and other dipterocarps; and several of the less known edible fruit trees—*Syzygium, Artocarpus* and *Garcinia* species. Several of the forest plantations/plants of agro-forestry species flourish well on acidic soils, i.e. *Cryptomeria japonica* in Eastern Himalayas and *Populus* and *Salix* species in the Western Himalayas.

Soil reaction preference of some crop plants indicating their optimum pH range are given in Table 3.

**Research Efforts in India**

The Indian Council of Agricultural Research is operating an All India Coordinated Research Project on Under-utilised and Under-exploited Plants. This project was initiated in 1982 with its Headquarters at National Bureau of Plant Genetic Resources, New Delhi and has 15 regular and 10 voluntary centres in different agro-climatic zones of the country. The project aims at conducting studies on the utilisation of less known food and other economic plants, both of indigenous and exotic origin. These include food plants, fodder and energy plants, and industrial and hydrocarbon plants. Rich genetic diversity has been built up in rice bean, winged bean, amaranth, chenopods and buckwheat. Based on the coordinated efforts at different centres promising varieties have been identified in a few species within a very short period, viz., Arizona 2, and HG 8 of guayule, EC 33198 in jojoba, grain amaranth variety “Annapurna” possessing high yield potential and protein content for hilly regions in the Himalayas, and selections in winged bean.

The National Bureau of Plant Genetic Resources, as a national organisation, is equally concerned with the enrichment of genetic resources in less known plants of economic importance. Useful information has
Table 3. The soil reaction preferences of crop plants indicating their optimum pH ranges

<table>
<thead>
<tr>
<th>Crops</th>
<th>Optimum pH range</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cereals</td>
<td></td>
</tr>
<tr>
<td>Maize (Zea mays)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Millets (Pennisetum spp.)</td>
<td>5.0-6.5</td>
</tr>
<tr>
<td>Rice (Oryza sativa)</td>
<td>4.0-6.0</td>
</tr>
<tr>
<td>Sorghum (Sorghum bicolor)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Wheat (Triticum aestivum)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Barley (Hordeum vulgare)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Oats (Avena sativa)</td>
<td>5.0-7.7</td>
</tr>
<tr>
<td>b. Legumes</td>
<td></td>
</tr>
<tr>
<td>Beans (Phaseolus vulgaris)</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Berseem (Trifolium alexandrinum)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Groundnut (Arachis hypogaea)</td>
<td>5.3-6.6</td>
</tr>
<tr>
<td>Soybean (Glycine max)</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Pea (Pisum sativum)</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Lentil, gram, etc.</td>
<td></td>
</tr>
<tr>
<td>c. Miscellaneous field crops</td>
<td></td>
</tr>
<tr>
<td>Sugarcane (Saccharum officinarum)</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Cotton (Gossypium hirsutum)</td>
<td>5.0-6.5</td>
</tr>
<tr>
<td>Potato (Solanum tuberosum)</td>
<td>5.0-5.5</td>
</tr>
<tr>
<td>Tea (Thea sinensis)</td>
<td>4.0-6.0</td>
</tr>
</tbody>
</table>

been synthesised on the wild edible food plants of India giving an account of over 600 species eaten by native communities in different regions (Singh and Arora, 1978). Ethnobotanical emphasis has been laid on the identity of new or less known food and other useful native plants and several of these have been reported, i.e. Moghania vestita, a less known edible root legume (Singh and Arora, 1973); Digitaria cruciata var. esculenta, a minor millet (Singh and Arora, 1972); Coix lacryma-jobi, a food-cum-fodder plant (Arora, 1980); rice bean Vigna umbellata, a tribal pulse of eastern India (Arora et al., 1980). Recently, the Bureau has also brought out synthesised information on less known food plants to generate more awareness on such plants for their utilisation and to initiate further studies on these plant resources.

Through build-up of genetic resources both by introductions from abroad and through collections made from within the country, rich genetic variability is maintained by the Bureau, particularly for rice bean, amaranth and minor millets. For some of these, NBPGR has been assigned global or regional responsibilities for conservation. The NBPGR
as the coordinating national agency undertakes collection, maintenance and conservation of genetic resources and has a gene bank which holds over 50,000 accessions of different agri-horticultural crops. This assembly of gene pools represents diverse crop germplasm with traits such as drought tolerance, adaptations to adverse soil conditions such as acidity, salinity, alkalinity and material adaptable to deficiency and toxicity of mineral elements in soils.

**FUTURE THRUSTS**

1. In view of the weather aberrations inherent in a rainfed agriculture in monsoon Asia, selection and breeding for drought tolerance must continue to receive great emphasis to evolve varieties suited to 'Drought Prone Areas'.

2. Rice in problem soils:
   
   i. Acid upland rice soils are often associated with Fe deficiency and Mn and Al toxicity.

   ii. Salinity, Al and Fe toxicity, P deficiency are constraints for rice production in acid sulphate soils which cover an area of 5 million hectares of flat land in the tropics. Rice breeding programmes should aim at evolving varieties adapted to these mineral stress conditions.

   iii. Cold tolerance: at high latitudes and high altitudes in the tropics rice suffers from cold injury. In addition, the prevailing low soil temperature aggravates P deficiency, Fe and CO₂ toxicity. Breeding programmes for cold tolerance may also deal with adaptation to such stress conditions. Rice germplasm of north eastern hill region as documented by Asthana and Majumdar (1981) is a valuable reference source for such programme.

3. Life support species of multipurpose value: the major constraints to high productivity of arable crops in arid and semi-arid regions of the tropics are low and erratic rainfall with risks of drought spells and adverse soil conditions such as shallow and light soils with poor water holding capacity, high degree of soil erosion and temporary waterlogging in heavy soils. The areas in this region also suffer from acute shortage of fodder and fuelwood. A vast majority of these areas are best suited to 'composite land use systems' rather than to arable cropping. Identification of suitable life-support species of multi-purpose value (food, fodder, fuelwood, fruits, oil and lac) to fit into agro-forestry, agri-horticulture and silvi-pastoral systems will not only enhance the production
LIFE SUPPORT SPECIES

potential of the lands but also check the land degradation and improve soil fertility. The improvements made in the successful selection and propagation of *Acacia* and *Prosopis* species for arid and semi-arid environments by the Central Arid Zone Research Institute, Jodhpur and other fodder grasses by the Indian Grassland and Fodder Research Institute, Jhansi need to be integrated into suitable alternate land-use systems for greening the degraded lands affected by various intensities of water and wind erosion. The National Wastelands Development Board, the Indian Council of Forestry Research and Education, the All-India Coordinated Project on Agro-Forestry and the Society for Promotion of Wastelands Development are engaged in providing the necessary policy directions and scientific support for promoting appropriate land use systems involving multi-purpose trees and shrubs.

4. Ravine lands represent the extreme degree of land degradation due to soil erosion. The best way of rehabilitation of these lands is to put them under permanent cover of trees and grasslands. Work done at the soil conservation research centres of the Central Soil and Water Conservation Research and Training Institute at Vasad, Gujarat has established the great scope of bamboo, (*Dendrocalamus strictus*) as a life supporting species. For ravine lands of Agra region in Uttar Pradesh, *Eucalyptus camaldulensis*, *Eucalyptus tereticornis*, and *Zizyphus nummularia* have shown good adaptation. The identified grass species most suited for ravine lands are *Amphilophis glabra*, *Andropogon ischaemum*, *Cenchrus ciliaris*, *Cenchrus setigerus*, and *Chrysopogon fulvus*. Developmental efforts for the reclamation of ravine lands utilising these multipurpose trees and grasses will usher in a better quality of life for the inhabitants of these harsh habitats.

5. Under certain harsh environmental conditions some, biological species, i.e. mangroves have come to play a major role in conservation and maintenance of ecological balance which directly acts as a saver of life support plants. The past decades have witnessed their over exploitation causing serious concern both to the ecology and the very existence of life support species. *In situ* conservation and concerted efforts for their rejuvenation and regeneration are urgently needed.

6. Research efforts to define quantitative relationship between stress parameters and biological responses need to be undertaken at identified selected centres. There is an urgent need to identify specific genes governing heritable differences in major crops regarding soil-stress tolerance for use in breeding programmes.
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THE NEED FOR LIFE SUPPORT SPECIES: AN INDIAN PERSPECTIVE

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Indian Council of Agricultural Research, New Delhi, India

The dependence of mankind on plant resources is inevitable. Since the dawn of agriculture, domestication and necessity based gathering of plant species has helped in the evolution of useful plant species. Living in close contact with the nature, man has learnt to use plants for food, fodder, medicine and other purposes. Over the years, we have exploited these resources to our advantage. So far, of the global wealth of 80,000 edible plants, only about 150 fall in the major useful category and of these about 20 species provide 90 per cent of the world’s food. The twelve centres of diversity of crop plants in the different continents and the 36 phyto-geographical regions of the world still constitute the botanical paradise, from where the newer resources to meet our growing needs are being tapped. While this is the major mandate, equally important is the hunt to exploit plants occurring in extreme environmental conditions such as drought, arid hot and cold deserts, in flood prone locations and soil stress habitats such as salinity, alkalinity, acidic soils etc. Such vast areas invariably do not support enough vegetation, particularly those which are useful adaptable types. In such adverse scarcity conditions/regions, the plants on which we depend constitute the life support species. Conditions of such stresses do prevail in large parts of India and, therefore, relevance of life support species for the possible human welfare is obvious. It is proposed to discuss briefly the options these life support species have to offer provided these are studied properly and utilised rationally.

THE STRESS PRONE HABITATS

India has extremely varied climate, soil, physiography and agro-ecology. The regions of stress prone environments fall in the tropical and temperate climates and may occur in large areas or as sporadic localised pockets. Broadly, such habitats prevail in:

(i) The arid hot deserts of north-western plains, mainly covering parts of Rajasthan and Gujarat.

(ii) Cold arid belt of the western Himalayas in Ladakh, Lahaul and Spiti in particular.
(iii) Areas prone to alkaline/saline soils largely in hot arid zones.
(iv) Areas prone to acidic soils as in the Himalayas or the laterite exposed (iron rich) soils in the humid tropical belt of the western and the eastern ghats.
(v) Brackish water habitats, mangrove habitats—like in Sundarbans and around the tidal/littoral back-water habitats.
(vi) The flood prone sites as in the plains of Assam and parts of West Bengal.

DIVERSITY IN LIFE SUPPORT SPECIES

Indian flora is extremely rich. The higher plants alone number around 17,000 species. The economic plants diversity is enormous and as the floras of different regions have been worked out, economic species for different habits are now known, though the information on these is scattered and not readily available. Earlier efforts to synthesis such records are still the monumental works in this direction (Watt, 1898), dealing elaborately with economic usages of plants—both cultivated and wild. Several plants in India have tremendous potential to be used as life support species. Systematic efforts to study them in detail are required so as to have their potential exploited for human welfare especially in conditions of adversities.

ICAR Efforts

Realising the importance of life support species, the Indian Council of Agricultural Research has initiated in the recent years research activities in a systematic manner. A synthesised account on the wild edible food plants of India, which also lists the famine foods (Singh and Arora, 1978) exists. Also, a coordinated programme on under-utilised and under-exploited species is being implemented since 1982, on an all India basis. This has promoted and strengthened work on less known potential economic plants for use as food, fodder, medicine and other uses. It has selected some 20 species which are being studied in different agro-climates. Researches so far reveal that species such as bamboos, *Leucaena leucocephala*, amaranth, rice bean, *Jatropha curcas*, and the Industrial introductions like guayule jojoba, agave, etc. offer considerable promise. The NBPGR also has done good work in exploring such genetic resources of value as food (Singh and Arora, 1973; Arora, 1980) and for other purposes. A catalogue on amaranth, winged bean and a synthesised account on the less-exploited legume crop—rice bean (*Vigna umbellata*) has also been published (Arora
et al., 1980; Chandel et al., 1988). Genetic resources of these and several other crops have thus been collected, introduced and augmented. Work on bamboos is in progress and it is intended to take up detailed studies on Khejri (Prosopis cineraria) and several useful plants suitable for abiotic stress in different parts of the country.

STRESS PRONE ENVIRONMENTS VIS-A-VIS PLANT WEALTH

The Arid Environment

The hot arid zone of Rajasthan and Gujarat is rich in flora adapted to drought situation. Considering the wider perspective, species important from socio-economic view point, locally, would include Prosopis cineraria, Acacia nilotica, A. senegal, Salvadora spp., Capparis decidua, Cordia myxa, Calligonum polygonoides, Zizyphus nummularia, Rhus mysoresensis, Commiphora mukul, Tecoma undulata, Saccharum munja and herbaceus vegetation/forage species such as Cenchrus setigerus, C. biflorus, Lasiurus sindicus, Citrullus colocynthis and Indigofera cordifolia.

In the cold desert habitats, Fagopyrum tataricum, prosomillet, amaranth, chenopods, wild nuts (Castanea, walnut, Pinus spp.), Salix, Populus and Quercus species, and wild medics and Agropyron are important. At timber-line belt, species of juniper and birch, with Artemisia locally hold promise.

Stress Prone Soils

Species for saline soils in hot, dry environment would include both cultivated and wild types. Diversity in durum wheat, hooded barley, moth bean and pearlmillet—with prominent wild vegetation of Tamarix gallica, Prosopis juliflora, Acacia nilotica and Salvadora oleoides. The sodic soils also support some of the above species, but populations of related taxa may be more prevalent such as of Tamarix articulata and Prosopis cineraria.

Also, in highly saline environments, halophytes occur. Salicornia, Suaeda, Salsola, Haloxylon and Atriplex species are important. Exotics like Atriplex pallida and other species for forage and Salicornia viglovii as oilseed crop hold promise. Protein rich plants like Kasteletzkya virginica need to be studied. NBPGR has introduced several of these, including Cakile edentula, the adaptability and success of which is yet to be known. Another potential species of such habitat is the bambara groundnut—a protein legume.

Brackish Water and Tidal Environment

Vast stretches of tidal and back water habitats along the coast line and deltaic areas are rich in mangrove species which are locally very
important—*Nipa fruticans*, *Rhzophora mucronata*, *Avicennia* spp., *Brujeria gymnorhiza* and *Exocarca agallocha*. The coastal saline soils support *Adenopus logopoides*, *Sporobolus helvolus* and *Oryza coarctata*. All these plants are important to local socio-economy.

**Acidic Soils**

The temperate habitats support several species on lateritic soils in humid tropical zone such as *Xyilia xylocarpa* and *Hopea parviflora* and several other hardwood species and *Pinus* and other conifers in the Himalayas. Forest plantations of *Populus*, *Salix* and others are also well adapted to such temperate, stony dry alpine habitats.

**AN OVERVIEW**

Scattered information is currently available on the life support species and other under-exploited flora. All available information on such species with their diversified local uses based on folk-lores and experience gained from native communities need to be brought out. These are also essential to check the over-exploitation of such useful flora under stress situation/famine, etc. Multiplication techniques to make available such useful species as per needs must be developed. Equally great in this context is the need for domestication of some species so as to have these as folk-domesticates, in the local environment or into the existing crop-growing patterns. Therefore, need to collect, evaluate, catalogue and conserve more and more of these species is obvious. With improvement efforts put in by plant breeders, better genotypes can be identified. A systematic approach in this direction would possibly help in the utilisation and conservation of the life support species and such selected useful flora of stress environments. Through collaborative efforts, useful species could also be exchanged and evaluated in different countries. Possible linkages at international level on life support species will be helpful in this direction and efforts are, therefore, required to generate necessary awareness both through research and training in this regard. Life support species have enough to offer for the betterment of mankind provided we give required attention to these valuable resources and donot let them continue in the category of unknown plants of economic importance.

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THE PLACE OF LIFE SUPPORT SPECIES IN HOSTILE OR RISK-PRONE ENVIRONMENTS: AN OVERVIEW

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INTRODUCTION

As life on earth is dependent on carbon metabolism through photosynthesis, mainly in green plant, and as all food chains develop from this base, it is true to say that all photosynthetic plants are life support species. At this workshop we are concerned with those species of plants which support human life in more or less direct ways, by providing food, fuel, shelter, fibres, medicines, and the raw materials for essential industrial processes. In particular, we are concerned with those species adapted to hostile environments and which are or could be utilised in times of need. Of the huge diversity of species, including some 80,000 edible plants, only some 150 species have ever been cultivated on a large scale. Most of these species have been domesticated for use in equable environments where man close to live. Life on earth is also dependent upon the thin biosphere which covers the surface of the planet. This fragile zone, which includes the soil, water and atmosphere, and which sustains the whole range of complex ecosystems is now rapidly changing as a result of human activities. Vegetation is being removed leading to massive losses of soil by erosion; hydrological balances and rainfall patterns are being altered; essential nutrients are being lost or exploited and their reserves are being depleted. Atmospheric pollution from industrial sources and the burning of fossil fuels are now excessive and the increased use of fertilizers and agro-chemicals adds to the environmental problems. As a result there is an increase in global temperatures leading to the ‘greenhouse effect’, and we have the problem of ‘acid rains’, and many ecosystems are being poisoned. Life itself is threatened, and in the worst situations may become no longer sustainable.

These environmental problems are well publicised today. But in view of vested commercial interests and the need to support the rapidly increasing human population, little more than lip service is being paid to arresting the degradation processes. More effort must be placed on developing environmentally acceptable production methods which are sustainable and indeed which lead to reversing the degradation processes.

All environments are becoming more hostile and risk-prone, but particularly at risk are the tropical and sub-tropical areas where soils are
generally inherently less fertile. When exposed to high levels of solar radiation, organic matter is rapidly oxidised. Intense rainfall leads to massive leaching and erosion. These are the processes which result in desertification. It is in these areas, too, that human populations are increasing most rapidly, leading to demands for space in which to live and for food, shelter and fuel. There are, therefore, enormous pressures to exploit these fragile environments using systems which are non-sustainable.

In her recent address to the 74th session of the Indian Science Congress, the General President, Archana Sharma (1987) concluded that immediate priority be given to the conservation of essential resources, including biological diversity, and that new resources must be modified and developed to fit specific situations.

This overview paper examines the problems which Governments, scientists and the custodians of the land—the farmers, must now face if life support species are to be catalogued, evaluated, conserved and utilised in risk-prone environments.

THE DIVERSITY OF LIFE SUPPORT SPECIES

Hunters and gatherers in the early generations of human evolution soon learnt which species were useful for their needs and survival. These were collected and used, and later a small number of them was brought into cultivation, the ancestors of today's crops. However, all civilisations continue to gather wild species to supplement their needs. In Britain today, many species are still used in this way including wild fruits, nuts, fungi and herbs. In other societies many more species are used to provide or supplement human needs. In times of crop failure as a result of drought, floods, disease or pest outbreaks, wild species assume vital importance in providing the means for survival.

It is now essential that these life support species be catalogued and conserved, so that their uses be recorded before environmental degradation results in their permanent loss. In some cases, these species could be domesticated and introduced into farming systems, in others the valuable genes which they contain could be transferred into the genetic backgrounds of our crops. Modern biotechnology is now available to manipulate the genes in this way. Other life support species should be utilised by distributing them throughout risk-prone environments, not for regular use, but to be available in times of need.

EXPLOITATION OF LIFE SUPPORT SPECIES

Exploitation of life support species has been slow, and is likely to continue to be so unless a major international effort is mounted, or major
commitments are made by National Governments. The reasons for slow adoption are many; the most important being:

- The cost and financial risks involved
- The opportunity cost of investing in alternative projects
- The low, or nil, rate of return; at least in the short/medium-term
- The time scale; especially for the domestication of new species
- Problems of integrating new crops into existing cropping patterns and farming systems.

It is felt that this workshop should examine three complementary objectives, each with its corresponding course of action.

1. The introduction of life support species into new areas—not for commercial exploitation but for use in emergency situation or as a “free” supplement to traditional, cultivated crops. The course of action required is to identify the species, to conserve them both in biosphere reserves and genebanks, to catalogue their environmental requirements, advantages and their potential uses and to distribute them widely within the risk-prone areas including road sides and areas of unutilised land.

2. To make specific advances in domesticating some of these species for incorporation in farming systems and to develop methods for their use and marketing.

3. To identify useful genes in life support species and incorporate them into crop genetic backgrounds to increase the latter’s adaptability to stress conditions.

From an aid-donor’s point of view, investment in these activities is difficult to justify. There is always an opportunity cost problem making alternative use of the funds a more attractive proposition and encouraging investment in projects having a greater rate of return, certainly in the short to medium-term.

Some of these issues may now be dealt with:

(i) The Cost

The cost of domesticating and bringing a “new” species into agriculture, horticulture or forestry is enormous and the time required is frequently many years. The investment can only be justified and profits realised if new enterprises are demand-led by a potentially lucrative market for the produce. The problem is that, although the market prices can frequently be estimated, the production costs and time required for development cannot, and there is high risk
attached to investments by Governments and Aid Agencies in research and development.

(ii) **Environmental Problems**

Environmental conditions on the farm, will undoubtedly differ from those in nature. Initial collections from the wild will be of variable material. In fact a specific attempt should be made to sample the range of natural variability so that it may be later exploited under cultivated conditions. An environment broadly similar to the natural one should be chosen for initial evaluation of the material, especially regarding rainfall, temperature, day length and soil conditions. Establishment, growth and yield can be initially assessed and some of the problems of domestication will undoubtedly appear at this early stage. Further work, often of a long-term nature, will be required to determine optimal environments for exploitation of the crop, but if early results are encouraging, it might be possible to initiate commercial production in advance of further environmental research.

(iii) **Incorporation in the Farming Systems**

However attractive the new crop appears after initial evaluation, it will have to find a place in existing or modified cropping systems or a place in an area not presently used. If the new crop is to replace an existing one, it must be shown to be sufficiently commercially attractive to justify a change. Will it produce a product better than the one it replaces in the economy of the producer; is it an alternative foodstuff, or does it replace a cash crop and, as such, has as good or better a market; and will it show a greater profit? Can the new crop be introduced into the present cropping pattern as an additional component and thus increase the efficiency of exploiting the available resources of land, water and labour? If so, then it may be readily adopted by the farmer. Further, can the new crop be introduced into an environment which is currently either not being exploited at all or not being utilised to the best of its potential? If so, is there labour available and does sufficient infrastructure exist to support a new enterprise, including roads for the movement of inputs and produce, and are required facilities for post-harvest processing available? If the new crop is to find its niche in the agriculture of any locality, risks for the investor are high, and problems will take time to emerge and even more time will be required for their solutions to be devised, but the rewards are likely to be high and the risk must be taken.
TAKING THE RISKS

The above account stressed the need about taking risks for the domestication of a new species or the expansion of life support species in the farming environment. There are few people or organisations prepared to take risks of this nature, and even fewer who also have the resources required to make the necessary investment. What, therefore, are the alternative and additional options?

Should Governments using taxpayer’s money, take the lead in research and development? I believe where the driving force is better land use or better exploitation of under-utilised environmental resources, bearing in mind the need for conservation; reduction or prevention of environmental degradation, or the reversal of degradation processes, and the potential value of life support species in times of need, Governments should take the lead. Indeed, they have a duty to do so not only for present economic gain but to ensure that life can be guaranteed for future generations. Governments should provide the resources needed for this type of innovative work, through existing institutions and universities and, in the case of industrialised nations, through aid programmes to the developing countries.

The farmer himself is unlikely to be able to take the lead in developing a new crop. He is already committed to survival or to making his living from existing crops, producing food or other produce to feed himself or to supply the existing markets. However, as he produces, his supplies begin to exceed the demand. As is happening in many cases in industrial countries today, he is open to new initiatives and, indeed, needs new enterprises in order to remain commercially viable.

CONCLUSIONS

There is an increasing need to broaden the range of plant species utilised by man. A massive, untapped potential of species exists in the forests, grasslands, savannas, swamps, rivers, seas and even in the deserts of the world. This potential is, however, a diminishing resource, diminishing in the face of environmental degradation of human and livestock population pressures and the requirements for food and raw materials on which to survive.

The resources must now be exploited and conserved. Governments, botanists, agriculturists, foresters and farmers have essential roles to play. Each should make his own investment, should take risks, and should improve dialogue with the other. Action is required, thus, in particular by:
(a) Governments: to increase investment in the research required to make full and sensible use of the environments. In particular, to be prepared to invest in "risky" research which neither industry nor individuals are in a position to do; to look more towards long-term gains than short-term returns on investment.

(b) Botanists and Ecologists: to identify potentially valuable species and opportunities of increasing their exploitation to put pressure on governments to take action.

(c) Conservationists: to work towards reducing the conflict between conservation and development and demonstrate both the immediate and long-term economic and environmental benefits of biosphere reserves, appropriate land use, and the value of life-support species.

(d) Farmers: to be prepared to venture into new enterprises when opportunities are presented particularly to meet the demands of new markets and to establish a reserve of plants within the farm system which can provide emergency supplies in time of stress.

REFERENCE

GROWTH PROPERTIES OF LIFE SUPPORT SPECIES:
CASE STUDY OF CHENOPODS

Promila Kapoor

Commonwealth Science Council, Commonwealth Secretariat.
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INTRODUCTION

Nature's storehouse has hardly been touched. There is need to begin exploring plant wealth which is being lost through the rapid loss of natural habitats especially in the tropics. The land-use patterns are predominantly influenced by agricultural and industrial production. However, now attention is being focused on marginal, wasted lands, etc. which have specific and/or extreme problems like drought, desertification, flooding, soil toxicity and soil salinity. These problems confront agriculturists, foresters, ecologists, and environmentalists, thus, challenging them to search such plant species which can not only reproduce and maintain in the fragile ecosystem or stress environments but are also economically and ethnobotanically important ensuring sustainable utilisation of bioresources. The ecological processes of life support systems in extreme environments can be either improved through indigenous and/or introduced plant species-populations which are endowed with tolerant genetic make-up enabling their survival and maintenance in these situations. These species are referred to as Life Support Species (LSS).

The local rural populations which inhabit the extreme environments have identified large number of plants since times immemorial. Some of these plants have already become agricultural crops or useful landraces in the breeding programmes of modern crops. Unfortunately biological diversity has many neglected plants, as well as plants which are also threatened and are suffering discrimination as they are by and large assumed to be "poor peoples plants". These plant populations/species provide source of food, fibre, medicines, materials, energy, etc. to man and his animals and also have ability to grow and reproduce in extreme environments.

Species which endure extreme environmental conditions are assumed to spend most of their lives under 'r' conditions. These environments are so frequently disturbed that plant populations are held perpetually in density independent conditions or where successful establishment of
individuals is limited to microsites so distant from each other that neighbouring plants do not interfere with each other's activities. Life Support Species can be described thus by identifying the growth properties which allow them to survive under following conditions: (a) very erratically or frequently disturbed fields, (b) under extreme conditions of temperature, water, soil, etc. These plant species differ from each other in abundance and in the breadth of their distribution for which several quite distinct types of explanations are given:

(a) Species of which individuals possess genotypes that confer very high plasticity and tolerance so that even a narrow range of genotypes permits a wide range of phenotypic expression and occupancy of a wide variety of different habitats. Such species are 'general purpose' genotypes which provide the plant with a wide environmental tolerance which gives it ability to grow in a multitude of climates and edaphic conditions.

(b) The species may include within it a range of locally specialised genotypes. The sites that are habitable for one sub-set of the species may be very small or infrequent but there may be very many sub-sets so that species, as a whole may be abundant and its distribution extensive.

(c) There may be certain habitat types and conditions that are themselves abundant so that critical, even very specialised requirements for growth and reproduction of the members of a species are frequently met, i.e. for the species, there are many habitable sites.

Some of the questions that need to be looked into in study of life support species are:

1. What are the distinctive characteristics of life support species in constant and variable ecosystem? Are they 'K' or 'r' or combination of two properties? Which of these predominantly characterise their evolutionary history?

2. Do we know inventory of life support species in the constant (e.g. Tropical Rain Forests) and variable environments (deserts, toxic soil, polluted water, flooded habitats)?

3. Are the life support species specific to a particular trophic level (e.g. producer, decomposer, herbivore)?

4. What criteria are required in the conservation of these life support species for specific ecosystem, constant and variable? How can these 'indicator life support species' be monitored and studied in situ or ex situ?
5. Is it possible to describe life support species in two categories—generalists and specialists depending on their utilisation in the food-chain relationships?

6. Can we identify, on ethno-geographical basis, priority environments where life support species are of direct and indirect value to human population (especially rural)?

CASE STUDY

There are several case studies available which can be used as models of reference, e.g. multipurpose acacias, palms, pseudocereals, amaranths and chenopods. Details for Chenopodium album are given here.

Grain chenopod is one such promising under-exploited food plant which serves to several traditional societies in hilly environments (Andes and Himalayas) as links between survival of their traditionally preserved ecological systems. The wild and weedy populations though are still treated as plants with potential survival value in these hilly ecosystems in spite of their nuisance value in other geographic regions. Several studies in the past have recommended these species for inclusion in modern agriculture (National Academy of Sciences, USA, 1975; Kapoor and Partap, 1979; Partap and Kapoor, 1984, 1985a & b, 1987).

A socio-economic survey of this plant species in the Himalayas has shown that under extremes of temperatures in winter, very poor families inhabiting remote areas of the hills use some of the cultivated (and even non-cultivated) populations, of Chenopodium album. These populations may or may not be cultivated in monocultures but necessarily are consumed as mixed food as gruel or as local fermented beverage to survive under low temperatures and very arid environments. The morphological, physiological, biochemical, life history characteristics including their competitive ability when observed under field and experimental conditions have shown that there are unique biological characteristics which distinguish these populations from others. A general guideline of characteristics which can be used as a ‘model’ for distinguishing such life support species which need to be used can come in the following two categories:

1. General biological details: life cycle characters (‘r’ or ‘K’ categories); wide ecological amplitude; genetic polymorphism; phenotypic plasticity, etc.

2. Economic characteristics: in relation to direct and indirect human value.
These two categories of details are reviewed in a series of papers by Partap and Kapoor (1984, 1985a & b, 1987). Based on these details following general guidelines are suggested for studying life support species:

(i) **Biological details**
(a) distribution range and abundance of intraspecific variability in centres of origin and environments.
(b) detailed plant characters ranging from photodynamic spectrum, population biology, reproductive biology, demographic and competition pattern in rare and abundant habitats.
(c) growth and developmental details associated with ecophysiological characters in native and introduced environments.
(d) agronomic potentials in multi-species mixtures and related agroforestry mixtures.
(e) pest, pathogen resistance or susceptibility.

(ii) **Economic evaluation**
(a) yield potentials for food and nutrition, fodder, fuel and energy value.
(b) biological compounds for use in chemical and pharmaceutical industries.
(c) fibre for industry and construction material.

(iii) **Conservation action details**
(a) to promote specialist databases on the decline of genetic diversity in selected life support species.
(b) gather and hold data on survival prospects of plant taxa and vegetation types which hold these LSS.
(c) provide and interpret information from international action by agencies like UNEP, IUCN, UNESCO, WWF, FAO, IBPGR and encourage its use specially on:
(i) recorded threatened plants of LSS
(ii) species prone to extinction
(iii) plants of value to man
(iv) sites and vegetation types
(v) *in situ* and *ex situ* conservation education.
REFERENCES


IBPGR AND LIFE SUPPORT SPECIES

D. H. van Sloten

IBPGR, Rome, Italy

Our Annual Reports provide full details on our programme and the role of International Board for Plant Genetic Resources (IBPGR) in the worldwide activities on plant genetic resources. It is sufficient to say that IBPGR is one of the thirteen centres of the Consultative Group on International Agricultural Research (CGIAR) and that it is hosted by the FAO.

IBPGR has similar functions worldwide as the National Bureau of Plant Genetic Resources (NBPGR) in India on a national scale. The mandate of IBPGR is to further the study, collection, preservation, documentation, evaluation and utilisation of the genetic diversity of useful plants for the benefit of people throughout the world. IBPGR shall act as a catalyst both within and outside the CGIAR system in stimulating the action needed to sustain a viable network of institutions for the conservation of genetic resources of these plants.

Following the second External Programme and Management Review of IBPGR, a considerable number of changes were made in IBPGR’s programme, including a considerable expansion in staff and a restructuring in two major programmes, i.e. the Field Programme and the Research Programme.

IBPGR acts as a catalyst in stimulating plant genetic resources activities worldwide and provides scientific advice and assistance throughout the world network. It should, however, be understood that IBPGR is no technical assistance or donor agency.

During this Workshop mention has been made of the limited number of crops for which international funding is available. Indeed, if one considers the crops being dealt with by International Agricultural Research Centres (IARC’s) other than the IBPGR, the number is restricted. However, IBPGR’s mandate covers a much wider range of crops (and forages) including for instance vegetables, fruits and some industrial crops. If one also considers the wild crop relatives and forages, IBPGR deals with a few hundred plant species.

Nevertheless, where resources are finite, priorities will need to be established, and IBPGR’s crop priorities serve in guiding our work and the funds we can make available. Whenever requests are received for
work on non-priority crops/species, IBPGR attempts to use its good offices to mobilise the necessary assistance from other sources.

In the past decade, our efforts were directed to safeguarding (collecting and conservation) of landraces and primitive cultivars which were being replaced by improved cultivars. IBPGR is now shifting its emphasis to wild species and forages, and so touching on those species referred to in this Workshop.

A Memorandum of Understanding has been signed with the Commonwealth Science Council (CSC) outlining the intent of both IBPGR and CSC to collaborate in those areas and for those species with overlapping interest.

It is suggested that this Workshop identifies a limited number of life support species for which a genetic resources programme could be developed and IBPGR is willing to consider to provide scientific assistance for those species which are within its established priorities.
LIFE SUPPORT SPECIES IN ARID AREAS: PRIORITIES FOR RESEARCH AND DEVELOPMENT

J. V. Possingham

CSIRO, Adelaide, Australia

INTRODUCTION

It is difficult to generalise about the life-support species as the preferences and requirements of different countries/groups would vary considerably. This paper briefly describes how arid lands for agriculture, utilised in Australia. It is necessary that we utilise such lands as almost half the Australian continent receives less than 250 mm of rain and a further one third between 250 and 500 mm. The latter part of this paper, gives a range of life support species which grow and produce crops in low rainfall areas for consideration for further research. The species selected fulfil some of the physiological criteria that enable them to survive and produce crops in arid environments.

FORAGE CROPS IN AUSTRALIA

The major use to which arid lands in Australia are put to is for the purpose of providing feed for grazing livestock such as sheep and cattle. In the case of sheep, the primary product is wool which is a valuable concentrated commodity, easily transported around the world. It enjoys considerable popularity as a natural fibre and is used on its own or in mixtures with synthetic fibres. Wool although valuable is not a life-support product for people who are short of food; but it is an efficient and valuable product for arid grazing lands.

A secondary product from sheep grazing is meat. In the sandy soils of Australia, sheep retain their teeth for only about 6 years before they are almost completely worn away. Accordingly, from the 150 million population of grazing sheep, there is an annual turn over of about 30 million per year. These provide strong flavoured meat and meat products for export to specialist markets that like such products. Generally sheep are preferred to goats in arid lands as goats tend to completely denude the landscape and readily cause soil erosion. However, recently there has been a major upsurge in the world’s demand for cashmere fibre which now receives high prices. Accordingly, some farmers are beginning to grow goats but there is very little demand for their meat particularly in Australian markets.
In the arid lands of Australia, it is not economic to plant exotic/introduced species, rather existing native species are utilised as forages. These species consist of a number of native grasses supplemented by a number of shrubs mainly in the family Chenopodiaceae.

**Australian Grain Crops**

In considering what can be done with arid lands, it is necessary to consider grain crops as there are many that can germinate, grow into plants, flower, set seed and fill grains in periods of less than 6 months. These crops are able to provide food on arid lands which have a continuous growing season of about this length.

Some of the cultivated wheats of Australia are able to produce good crops of grain in growing periods of less than 5 months from cumulative rainfalls of 250 mm. They are able to utilise stored soil water provided competition from weed species is removed either by cultivation or by herbicide treatment. Increasingly, Australian farmers are using minimum tillage techniques which involve a combination of herbicide treatments to kill weeds and a shallow discing in of seeds immediately after rains. Yields of the order of 1-2 tonnes of grain per hectare are obtained from areas with rainfalls of about 250 mm. Many of our arid areas are sown to wheat with the limited expectations of one good crop, one poor crop and one crop failure every third year. In this farming system, rainfall is the critical limiting factor. Barley is another grain crop which is used on marginal lands especially where there are higher levels of soil salinity. There are markets for barley for beer making and animal food. Rye is also grown on arid lands for its grain and for its capacity to overcome soil erosion.

**Life Support Species for Arid Lands**

*Selection Criteria*

Many of the arid lands of the world including Australia have an agriculture that is based on grazing animals such as sheep, goats and cattle utilising extensive areas of pastures, shrubs and even small trees. In areas where the rainfall is less than 250 mm per annum, animal-based agriculture is often the only option available. However, in lands receiving 250 to 500 mm of rainfall, growing plants which provide grains, fruits, nuts and foliage is a more efficient way to produce food for people.

It is important, when considering candidate species for arid lands, to accept the reality of the situation that there is a close relationship between the amounts of carbon fixed by photosynthesis and the amounts of water lost by transpiration. The water use efficiency of plants varies
considerably between species dependent on photosynthetic pathway. Table 1 provides comparative data on the relative water efficiency of the three plant types (Kriedemann and Downton, 1981). In extreme desert situations, plants with crassulacean acid metabolism (CAM) have advantages because they have the capacity to fix carbon dioxide at night when humidity is high and transpiration rates are low. On the other hand, C4 plants in general have much higher rates of carbon fixation and because of this a higher water use efficiency than C3 species.

<table>
<thead>
<tr>
<th>Photosynthetic Pathway</th>
<th>Species</th>
<th>Photosynthesis</th>
<th>Transpiration Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mg CO₂ h⁻¹ dm⁻²</td>
<td>H₂O/CO₂</td>
</tr>
<tr>
<td>C3</td>
<td>Alfalfa</td>
<td>20–40</td>
<td>450–600</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Sorghum</td>
<td>30–80</td>
<td>250–350</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM</td>
<td>Pineapple</td>
<td>3–20</td>
<td>150–600</td>
</tr>
<tr>
<td>Light</td>
<td>Sisal</td>
<td>10–15</td>
<td>25–150</td>
</tr>
<tr>
<td>Dark</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Considering photosynthetic characteristics, it would seem desirable to examine the features of species that are well adapted to survive, grow and produce crops in arid environments. Physiological features that offer advantages include the capacity to form deep roots and to make use of stored soil water, capacity for water storage in specialised structures such as stems and leaves, and the ability to modify growth rates to take advantage of periods of moisture sufficiency, and to survive at times of extreme water shortage.

Because the productivity and growth of arid species is in general adjusted to the available water supply, it is important in arid areas to utilise water that is concentrated by run off into rivers or into underground water storages. For this reason, desirable species are those that occupy ecological niches that allow them to obtain water supplies accumulated in the soil, such as from the beds of intermittently flowing rivers and in low lying areas. A well limited irrigation can permit the production of a wide range of fruits and nut crops, even in very arid environments and should be undertaken wherever possible.
Candidate Life Support Species for Arid Lands

At the CSC meeting at Kew in 1986, the view was expressed that in the development of under-exploited species, countries should be prepared to experiment with both native and introduced species. It is a common experience to find that plants actually grow and crop better when removed from their centres of origin as this event removes them from a range of well adapted pests and diseases. There are a range of fodder, fuel and timber species which are well suited to arid lands. These include a number of grain, fruit and vegetable crops that should be considered as candidate life support species for further research.

Grain Amaranths

There is a range of *Amaranthus* species largely from central and southern America that produce high protein and can contain up to 60% starch. The leaves of amaranths are also high in protein and also can be eaten as a leafy vegetable. Much has been written about this under-exploited crop which can be as productive as maize (Downton, 1973). It is not specifically adapted to arid lands but it may be possible to select short cycle cultivars for regions with limited growing seasons.

Grain Chenopods

There are a number of annual *Chenopodium* species that produce nutritious edible grains. *Chenopodium quinoa* is native to southern America and grows extensively in elevated areas of the Andes. The grains have a variable protein content and most have high levels of saponins which need to be removed to improve taste and digestibility. Some selections have seeds that can be directly consumed and others are used for animal foods.

Another species *Chenopodium album* is found in the Himalayas. The uses this species is put to were described by Partap (1986) at the CSC meeting in Kew. The use of this crop is declining in India and much valuable germplasm is being lost because of the growing of introduced crops such as maize and even wheat and rice.

As there are a number of different edible *Chenopodium* species, opportunities are available for inter-species crossing. However, there may be problems with consumers not liking the taste of these grains.

Gourds

Included under this heading are crops from the family Cucurbitaceae known in different countries as gourds, melons, squash and pumpkin. Quite some time ago, two species were suggested as warranting further
study by the U.S. National Academy of Sciences (1975). One is the wax gourd which has melon-like fruits that may be used as a cucumber substitute, a cooked vegetable or a food extender. It has many uses as it can be used in soup and also made into a sweet by cooking in syrup. The crop grows rapidly and can produce fruit in 2-5 months. The other, buffalo gourd, is a vigorous perennial which grows wild in the waste lands of southern USA and Mexico. It produces a watery fruit which contains edible seeds. The seeds are high in both protein and oil, 30-35% of each, and can be crushed to provide an edible polyunsaturated oil. The gourd has a large root which stores starch. This is also edible after soaking out bitter tasting glycosides. The buffalo gourd was used for food by the North American Indians and is a candidate crop for arid lands but requires further research and development.

Quandong

The fruit of the Quandong was an important source of Vitamin C to Australian indigenous people but the productivity of the crop is low and variable from year to year. However recent research has established that there is an extreme variation in the productivity of individual seedling trees. On an orchard basis, good yields can be obtained by grafting productive selections onto rootstock trees (Possingham, 1986).

Carob

Other species that might also be considered for arid regions include the carob (Ceratonia siliqua). This mediterranean species has selections which accumulate starch in their seeds and are primarily used for animal foods. Other selections accumulate sugar, and bear a similarity to the well known Tamarindus indica and may be directly consumed.

Grapevines

This crop grows well in arid lands especially if it gains access to some sub-soil moisture. In arid environments, they do not suffer from the range of fungal infections such as downy and powdery mildew and bunch rots which cause problems in cool areas. Rainfall of 500 mm is adequate for crops of the order of 5 tonnes per hectare especially if there is a good depth of soil for water storage. They can withstand summer temperatures in excess of 40°C and give yields of up to 20 tonnes per hectare with irrigation. They can be consumed as fresh fruit and can be preserved by drying to give a nutritious natural product.

Other fruits

For arid areas with rainfalls between 250 to 500 mm, the nut and fruit crops that can be grown are the pistachio nut, pomegranate, olive and
the date palms. All these crops respond to irrigation and are able to grow in soils with relatively high levels of salt.

**Palatability of Crops**

Experience from research in horticulture suggests that eating habits of people are very complex. For example, it is quite impossible to predict whether people will accept a new variety of fruit because it is novel and different, e.g. the New Zealand Kiwi fruit; or whether they will reject a new crop or a new variety out of hand because they differ from the common varieties. To a much larger degree, the promotion of under-exploited crops will experience difficulties because people from different countries do not like the taste of some of the new crops almost regardless of how hungry they are. Partap (1986) pointed out that despite the great advantage that the seeds of *Chenopodium album* can be fermented into a beer-like alcoholic beverage, the hill people of the Himalayas increasingly prefer maize as a grain crop. As well a rice variety from IRRI, IR8, met resistance when first released because some consumers did not like its flavour and taste.

**References**


LIFE SUPPORT SPECIES FOR WATER LOGGED CONDITIONS

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INTRODUCTION

The degree of soil salinity near sea shore varies in relation to the proximity of the sea to the shore and inundation of tidal water. The type of coastal vegetation occurring in such regions depends upon the prevailing climatic factors. Bhavnagar is situated on 72.15° E longitude and 21.75° N latitude on the creek of Gulf of Cambay and the coastal area is different from most of the sea coasts as the daily normal low tides are of 2-3 meters height and high tides are 8-10 meters. The highest tides are in the months of May and November attaining 11.6 meters height and rank it second highest tidal zone in the world. The seawater in the Gulf of Cambay, especially at Bhavnagar coast is usually turbid all throughout the year due to presence of silt and clay to the extent of 5 percent. During rainy season from July to September, the salinity of seawater at Bhavnagar coast fluctuates from 3.5 to 1.8 percent due to the discharge of major rivers like the Tapti, Narmada, Sabarmati, Mahi, etc. The average rainfall is 650 mm and is distributed from June to September with long hot and dry spell for 5-7 months. The temperature varies from 12°C to 40°C with solar radiation of 386-636 Cal/cm²/day.

The soil of the region is formed due to the deposition of silt and clay mainly brought by the major rivers and has the composition of 50% clay, 31% silt, 3-5% sand and 4% carbonates. The soil is highly saline containing 2.5 to 3.5% salts and pH ranges from 8.2 to 8.6 during various seasons.

The coastal region from old port area of Bhavnagar to Gogha, a distance of 15 km was surveyed in 1977 and resurveyed in 1982 to assess the distribution of halophytic flora. The survey was carried out by employing transect method. At each kilometer distance, a transect of ten meters in width was laid and the vegetation was studied. The plant species mainly found in the region are as follows:
Plant species

1. *Avicennia marina* (Avicenniaceae)
2. *Porteresia coarctata* (Gramineae)
3. *Sesuvium portulacastrum* (Portulacaceae)
4. *Aleuropogon lagopoides* (Gramineae)
5. *Salicornia brachiata* (Chenopodiaceae)
6. *Suaeda nudiflora* (Chenopodiaceae)
7. *Sporobolus helvolus* (Gramineae)
8. *Salvadora oleoides* and *S. persica* (Salvadoraceae)
9. *Cressa cretica* (Convolvulaceae)
10. *Prosopis juliflora* (Leguminosae)

Utility

- Forage
- Salad
- Forage for camel
- Forage/soil binder
- Forage/oil
- Pods as cattle feed
- Fuel wood

**AVICENNIA AS LIFE-SUPPORT SPECIES**

*Avicennia* is a member of the mangrove group and has a unique place among the mangrove vegetation due to its varied distribution in tropical and subtropical regions. At Bhavnagar sea coast, among the mangroves, only *Avicennia marina* var. *acutissima* grows extensively. The species is classified as salt excreting type of mangrove and is confined to far intertidal zone in inundated areas. *Avicennia* has variety of uses. In Saurashtra and Kutch, the camel browses on the stands of *Avicennia*. There is also a large scale exploitation of the natural stands in Saurashtra and Kutch. *Avicennia* compares well with common forage like sorghum, alfalfa, maize, *Pennisetum*, etc. (Table 1). In order to assess the availability of *Avicennia* biomass, first survey was carried out in the year 1977 and the second in 1982. From the extent of strand of *Avicennia* and availability of the biomass, it was noticed that the vegetation of *Avicennia* was more dense around the creeks and also near

<table>
<thead>
<tr>
<th>Name</th>
<th>Ether extract</th>
<th>Nitrogen extract</th>
<th>Crude fibre</th>
<th>Crude protein</th>
<th>Total Sodium</th>
<th>Potassium</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Chloride</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avicennia</td>
<td>3.49</td>
<td>61.63</td>
<td>15.66</td>
<td>7.98</td>
<td>11.27</td>
<td>2.54</td>
<td>1.00</td>
<td>0.65</td>
<td>6.26</td>
<td>0.18</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>1.81</td>
<td>34.68</td>
<td>29.51</td>
<td>19.50</td>
<td>11.73</td>
<td>0.09</td>
<td>1.69</td>
<td>2.00</td>
<td>0.26</td>
<td>0.53</td>
</tr>
<tr>
<td>Maize</td>
<td>0.90</td>
<td>47.07</td>
<td>35.95</td>
<td>6.74</td>
<td>4.99</td>
<td>—</td>
<td>0.60</td>
<td>0.52</td>
<td>0.44</td>
<td>0.17</td>
</tr>
<tr>
<td>Pennisetum</td>
<td>1.74</td>
<td>57.74</td>
<td>23.96</td>
<td>8.88</td>
<td>5.09</td>
<td>0.06</td>
<td>2.06</td>
<td>0.36</td>
<td>0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1.56</td>
<td>53.78</td>
<td>33.68</td>
<td>3.87</td>
<td>3.50</td>
<td>0.06</td>
<td>1.21</td>
<td>0.43</td>
<td>0.18</td>
<td>0.08</td>
</tr>
</tbody>
</table>
the protected areas of new port at Bhavnagar, wherein the plants are more than 2-4 meters in height and with the crown of 2-3 meters in diameter. The availability of the biomass of *Avicennia* during first survey in year 1977 is estimated to be 88.7 tons/15 km. of shore length (4.75 tons/ha.). The wood and twigs of *Avicennia* are used as firewood and the indiscriminate harvesting or felling of the *Avicennia* for forage and firewood has resulted in quick denudation of the species. In addition to above factors, recently a number of salt farms have sprung up on this coast seriously affecting the vegetation of coastal region. As a result of the above mentioned activities, the strand of *Avicennia* which was of 2-3 meters in height, was reduced to 0.5 m and availability of biomass reduced to 14.7 tons/15 km. (0.69 ton/ha.) denoting the extent of exploitation. It is feared that within a period of 5-8 years, the present sparse vegetation of *Avicennia* may get dwindled and become extinct on this coast.

**Nutritive value of *Avicennia***

*Avicennia* has been exploited as forage supplement since very long time in the coastal region of Saurashtra and Kutch. Kehar and Negi (1952) reported the palatability and the nutritive value of *Avicennia* foliage. But the complete nutritive assessment was not done. An attempt has been made to find out and compare the nutritive value of *Avicennia* with other common forages like *Pennisetum*, maize, alfalfa and sorghum by chemical test (Table 1). In order to confirm the results, the feeding trials were conducted with *Avicennia* fodder on sheep and heifers at Veterinary College, Madras and Rajasthan College of Agriculture, Udaipur respectively. The results clearly show that *Avicennia* fodder can replace the feed concentrates comprising of maize, gingelly cake, rice-bran and mineral mixture to the extent of 50 per cent without affecting growth rate of the animals (Table 2 & 3). This establishes the value of *Avicennia* as a fodder or a supplement to normal feed of animals.

**Propagation of *Avicennia***

The regular harvesting of *Avicennia* foliage for fodder not only affected its growth, the natural propagation through seeds also declined due to reduced flowering and fruit set. It was found necessary to propagate the plant by vegetative means. One year old pencil thickness cuttings planted in the natural habitat during rainy season did not root. Therefore, an attempt to get rooting by air-layering was successfully made with about 80-85% rooting in 4-5 months. Exogenous application of the hormones like IBA, IAA etc. were found ineffective in promoting
Table 2. Result of the feeding trial of *Avicennia* meal to sheep

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Control</th>
<th>A routine sheep feed supplied by Tamilnadu Dairy Development Corporation comprising of maize, gingelly oil cake, wheat bran, mineral mixture and salt.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Replacement of the above by 5 and 10% powdered leaves of <em>Avicennia</em>.</td>
</tr>
<tr>
<td></td>
<td>Duration</td>
<td>One month.</td>
</tr>
<tr>
<td></td>
<td>Result</td>
<td>There was no difference in the weight gain between Control and Treatment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trial 2</th>
<th>Control</th>
<th>Same as above.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
<td>Incorporation of 20, 30, 40 &amp; 50% of control with <em>Avicennia</em> meal.</td>
</tr>
<tr>
<td></td>
<td>Duration</td>
<td>One month</td>
</tr>
<tr>
<td></td>
<td>Result</td>
<td><em>Avicennia</em> meal incorporated even up to 50% of the concentrated mix sustained the same growth rate as the control. The palatability of the diet was good.</td>
</tr>
</tbody>
</table>

Jagan Nathan, 1980 (Personal communication)

Table 3. Result of the feeding trial of *Avicennia* meal to heifers

The following results were obtained in a 28 day trial with four heifers which were fed *Avicennia* fodder ad libitum with mineral licks.

<table>
<thead>
<tr>
<th>Feed intake (Kg/DM/day)</th>
<th>:</th>
<th>3.59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake of digestible CP (g/day)</td>
<td>:</td>
<td>206.2</td>
</tr>
<tr>
<td>Intake TDN (Kg/day)</td>
<td>:</td>
<td>2.16</td>
</tr>
<tr>
<td>Intake of water (Kg/day)</td>
<td>:</td>
<td>26.0</td>
</tr>
<tr>
<td>Daily weight gain (g)</td>
<td>:</td>
<td>305.0</td>
</tr>
</tbody>
</table>

Conclusion: *Avicennia* fodder appears to be a satisfactory fodder for livestock. It is equal in feeding value to sugarcane tops and rape straw and better than *Ficus* leaves, wheat and paddy straw and jowar karli. In TDN content the *Avicennia* fodder is as good as mulberry leaves, bamboo leaves, tapioca leaves and Bagomolasses.

Sharma, V. V., 1980 (Personal communication).

the rooting in the air-layers. Field trials conducted consequently for two years showed that 60–70 percent field establishment of air-layers could be obtained if 4–5 months old air-layers are planted during rainy season.

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LIFE SUPPORT SPECIES IN THE INDIAN THAR DESERT

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INTRODUCTION

Located in the westernmost part of India in the Rajasthan state, the Thar desert becomes specially inhospitable during prolonged droughts and famines. The people inhabiting this 32 million hectares hot desert have learnt to live with the frequent occurrence of agricultural droughts which are a regular feature (Rao, 1985). The stress conditions have forced the rural poor to look for life support species that could cater to their own and their livestock's subsistence level requirements of food and feed.

In the past, several ethnobotanists made personal efforts to talk to the rural population and to document the 'famine food plants' (King, 1869; Brandis, 1874). Recently, the Division of Basic Resources Studies, CAZRI, Jodhpur, has made a systematic and comprehensive inventory, of the life support species utilised by the rural poor during droughts and famines (Gupta and Kanodia, 1968; Saxena, 1979). These inventories provide local English and Latin names of plants and also describe the part of the plant eaten by human beings. Forage or feed plants have either been casually mentioned or omitted. Information on the plants used for fibre, for materials, e.g. thatching of huts, and for energy lies diffused in a score of technical reports on basic resources surveys in the Thar and can be located mainly under the title 'Economic and Medicinal Plants'.

Based on the above mentioned literature sources and also on the basis of my own experience of ecological surveys of vegetation of the Thar, a synoptic account of the life support species is presented in this paper.

LIFE SUPPORT SPECIES

Food plants

Of the total 594 (Bhandari, 1978) to 700 (Puri et al., 1964) plant species reported from the Thar, over 70% are annuals which complete the life cycle within 1 to 3 months in the normal year and much earlier in the
drought year. Foliage of about 6% plants of the flora is edible. Among the grasses that account for 13% of the flora, only 0.14% grasses produce seeds akin to the grains of minor millets. Edible fruit bearing trees account for 1.7% of the flora (Bhandari, 1974). The account for different categories is presented below for these food plants according to the plant part used.

**Foliage**

Nearly 4% of the herbaceous species are used as greens during scarcity periods. Most of the edible greens grow around villages and cultivated fields. Leafy greens along with tender shoots are usually boiled in water, squeezed out by hand, cooked with salts and condiments and eaten along with *chapati* (bread) made of *bajra* (pearl millet) and *chhachh* (butter milk).

**Seeds**

Seeds of grasses viz., *Cenchrus* spp., *Panicum* spp., *Brachiaria* spp., *Lasiurus* spp., *Eleusine* spp. and *Dactyloctenium* spp. and of some shrubs viz., *Haloxylon salicornicum* are mixed with *bajra* (pearl millet) grains to increase the bulk and made into flour for the *chapati* (bread). The seeds are dehusked before mixing with the *bajra* grains. Seeds of *matira* (*Citrullus lanatus*) are eaten raw after decorticating and also sometimes mixed with *bajra* grain. Seeds of *kumut* (*Acacia senegal*) are collected and stored as reserves, and are eaten after boiling it and making with it a spicy vegetable curry. Similarly, seeds of leguminous weeds viz., *Indigofera* spp. and *Vigna trilobata* are stored for use in the lean period.

**Fruits**

Bordi (*Zizyphus nummularia*) and *kair* (*Capparis decidua*) shrubs provide popular desert fruits. Fresh ripe fruits of these plants are eaten and also stored after drying in the sun. Raw *kair* fruits are also harvested and pickled. Ripe fruits of hilly plants viz., *dansri* (*Rhus mysorensis*), *gangeran* (*Grewia teñax*) and *gangeti* (*Grewia villosa*) are also eaten. Ripe fruits of *thor* (*Opuntia ficus-indica*) are also eaten after peeling off the outer skin (Shankar and Saxena, 1976). Fruits of *gunda* (*Cordia myxa*), *gundi* (*Cordia gharaf*) and *saijna* (*Moringa oleifera*) are cooked with salts and condiments and eaten as vegetables. Most popular is the fruits of *kair* (*Capparis decidua*), *kumut* (*Acacia senegal*) and sangri (*Prosopis cineraria*) which are dried in the sun, stored for their own use and the surplus marketed. The famous *pachkutta* (fruit of five trees) includes the fruits of above three trees plus fruits of *kachra* (*Cucumis* spp.) and *gunda* (*Cordia myxa*). All these five are mixed together and cooked as a nutritious vegetable eaten along with *chapati* (bread).
Flowers

Flowers and buds of *phog* (*Calligonum polygonoides*), *sajna* (*Moringa oleifera*) and *khejri* (*Prosopis cineraria*) are mixed in the curd, made saltish and spicy and eaten along with *chapati* (bread).

Roots and tubers

Tubers of *safed mushli* (*Chlorophytum*) and bulbs of *khadula* (*Ceropegia tuberosa*) are peeled off and eaten raw. Many people subscribe to the opinion that *khadula* is the famous energiser *somras* plant of the vedic era. During acute scarcity rhizomes of *Cyperus* spp. and roots of *satavar* (*Asparagus racemosus*), *dhak* (*Butea monosperma*) and *semul* (*Bombax malabaricum*) are eaten after boiling or roasting and spicing them.

Stem, bark and leaf pulp

Leaf pulp of *guar patha* (*Aloe vera*) that has succulent leaves, is normally eaten after boiling it and making a vegetable dish with salt and spices. In the extreme famine conditions, the bark of *khejri* is boiled and then eaten for sheer survival.

Forage and browse plants

During prolonged droughts and famines, the annual hebecous vegetation is grazed and when finished, the livestock starts grazing and browsing plants which are not touched in the normal years. For example, *Crotolaria burhia* and *Leptadenia pyrotechnica*, which are primarily used for rope making, are grazed, often severely, during successive droughts. The Thar is endowed with such hardy and protective grasses as *Lasiurus sindicus* which has very high water use efficiency (2.4 g/mm of water) and very high energy use efficiency (1% of the total solar radiation). During acute droughts also, this grass puts on some fresh growth but its potential air dry herbage production (3.5 t/ha) is reduced to one-fourth during droughts. Among the browse plants, *Prosopis cineraria* and *Zizyphus nummularia* provide the conventional leaf fodder which is also stored for the lean period. These three browse species, i.e. *P. cineraria*, *Z. nummularia* and *Haloxylon salicornicum* together with the predominant grass cover of *L. sindicus* make a productive silvi-pastoral system (Shankar, 1980; Shankar and Kumar, 1981).

Energy plants

The traditional fuelwood resources viz., *Calligonum polygonoides*, *Calotropis procera*, *Prosopis juliflora*, *Zizyphus nummularia*, *Acacia jacque-
*montii, Acacia nilotica* var. *indica, Acacia leucophloea* and *Acacia senegal* cater to the fuel needs in the droughts as well. When these are utilised, any dried material, sometimes dry grass tussocks, are used as fuel.

**Other useful plants**

The people need plant materials for a variety of other needs viz., for making huts (beams and thatchings), minor timber for camel carts and implements, and for making ropes etc. In the normal years, the new ones are generally made and the old ones repaired. But during droughts and famines, no new construction is possible and only repair or substitution of materials may be required. For this purpose people draw upon the traditionally used plant materials, e.g. *Crotalaria burhia* and *Leptadenia pyrotechnica* for rope making; twigs and branches of *Calotropis procera* and *Z. nummularia* for thatching, and branches of *P. cineraria, Tecomella undulata, Albizzia lebbek, Salvadoria persica, S. oleoides, Acacia senegal, Acacia leucophloea, A. nilotica* and *Ailanthus excelsa* etc., for beams to support the thatched roof of the hut which has also walls of plant materials woven into a thick circular fence.

**Conclusions**

Knowledge on the life support species, which is an outcome of the experience passed on to the successive generation, makes the desert dwellers specially the rural poor to survive not only in the normally harsh desertic environment but also in the prolonged droughts and famines. It is only after these resources are exhausted that they decide to leave their home and hearth and move to greener pastures along with their herds of livestock. In the recent times with improvements in the communication and transport systems, cereals and other materials are made available to desert population living even in remote villages. This is why dependence upon and consequently importance of local plant materials used during scarcity conditions is diminishing very fast. Nevertheless, as a legacy of the rich cultural heritage, the famine plants will continue to remind them through the folklores. The hardy life support species of the Thar also represent germplasm resources which agriculturists and foresters can depend upon for parent materials for breeding hardy varieties and/or for making selections for similar harsh environments.

**References**


UNESCO PROGRAMME ON BIOSPHERE RESERVES 
AS CENTRES FOR CONSERVATION OF GENE 
POOLS OF LIFE SUPPORT SPECIES 

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INTRODUCTION

The focus in this presentation at this workshop is on UNESCO Programme on Man and Biosphere (MAB) in the context of conservation, study and rational utilisation of gene pools of life support species. Human societies have developed by using natural resources extracted from an environment which they modify and upon which they depend. Interactions between the human race and its environment have become steadily more intensive. The human population has grown and human activities have become, with the rise, advance and expansion of industry and technology, so extensive and diverse that they exert increasingly heavy pressure on their environment. The problems of natural resources and the environment are clearly bound up with the available options in the area of development and ultimately with certain options relating to society. They call for a systematic and interdisciplinary approach which takes into account both the physical and biological characteristics of the ecosystems and the demographic, economic and cultural aspects of the lives of different societies.

In this context, every country needs to arrive at a better knowledge of the available natural resources, i.e. knowledge resting on a sound scientific basis. This is a necessary pre-condition not only for the development and use of these resources but also for a type of management which, while aiming to improve the welfare of the population in the short term, also strives to maintain those conditions of equilibrium in the biosphere which are essential for life and to hand on to future generations a heritage which is needful for their full and lasting development.

As rightly stated in the ‘Kendrew Report’, science and technology for development of wild species are of considerable potential benefit for man in agriculture, where they offer considerable potential for entirely new fields, in medicine and industry, as a source of natural products for drugs, fuels, fibre and industrial base compounds and additives. At the same time, much of the diversity in plant as well as animal genetic
resources is in danger of extinction. It gives a reason to realise about the contradictory nature of tendencies and attitudes towards the natural living resources constituting at the same time the important sources of life support products as well as the essential components of the national and global heritage. While on the one hand, there is a pressing need to conserve genetic resources in order to prevent their variability from the unscrupulous utilisation for satisfying immediate economic and commercial goals; on the other hand there is a need to extend their use and utilisation in order to meet the growing human needs.

**UNESCO's MAB Programme**

The integrated scientific approach to the use of land and terrestrial as well as marine resources which comprises conservation aspects and rational utilisation aspects, constitutes a distinctive feature of UNESCO's approach to the problems of natural resources in the global as well as the regional and national context. The Intergovernmental Programme on Man and Biosphere (MAB), launched by UNESCO in 1971 is a unique instrument for bringing about an integrated-interdisciplinary as well as international approach to the problem of environmental and its non-living and living (including the species of *Homo sapiens* itself) resources. MAB is a world-wide programme of international scientific cooperation dealing with people-environment interactions in the whole range of bioclimatic and geographic situations of the biosphere—from polar to tropical zones, from islands and coastal areas to high mountain regions, from sparsely populated regions to dense human settlements. Research under the MAB Programme is designed to provide the information needed to solve practical problems of resource management. It also aims to fill the still significant gaps in the understanding of the structure and function of ecosystems, and of the impact of different types of human intervention. Key ingredients in the MAB Programme are the involvement of decision-makers and local people in research projects, training and demonstration in the field and the pooling of disciplines from the social, biological and physical sciences in addressing complex environmental problems.

The International Co-ordinating Council which supervises the MAB Programme, at its first session in 1971, decided that one of the themes of this programme should to be the 'Conservation of natural areas and the genetic material they contain'. Under this theme the concept of the biosphere reserves was introduced. The concept was innovative due to its network character and because it combined nature conservation with scientific research, of its relationships with development, and also with environmental monitoring, training, demonstration, environmental education and local participation.
The first biosphere reserves were designed in 1976, and subsequently, the network has grown steadily until 1984; at present, it consists of 243 biospheres in 65 countries. In the same period, cooperation with other international organisations involved with conservation and sustainable development has been strengthened, particularly the Food and Agricultural Organisation (FAO), the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature and Natural Resources (IUCN). Representatives of these organisations meet together regularly through the Ecosystem Conservation Group to co-ordinate action.

**Action Plan for Biosphere Reserves**

It was in the joint interests of all these organisations that the First International Biosphere Reserve Congress was convened in 1983 in Minsk, USSR, to review the experience of the past ten years and to establish a general framework to guide the future development of the biosphere reserves network. It was followed by the Session of MAB Co-ordinating Council in Paris in 1984 where the Action Plan for the Biosphere Reserves was adapted. This document represents the programme network which identifies a range of actions for consideration by governments and concerned international organisations in developing the multiple functions of biosphere reserves within the overall context of the MAB Programme. A few items of this document which have a relation to the subject under discussion at this workshop relating to 'in situ conservation' respect needs, planning etc. and the recommendations concerned are as follows:

**Objective 3 of the Action Plan**:

—"In order to ensure the *in situ* conservation of key species and ecosystems, governments should be asked to take specific and urgent measures in relation to particular species and ecosystems of great importance or under particular threat.

—In order to illustrate the principles and methods of *in situ* conservation of wild relatives of economically important species, pilot projects should be initiated by FAO, in cooperation with UNEP, to demonstrate management techniques allowing their conservation in existing or potential biosphere reserves.

—FAO, in cooperation with UNESCO, should set up mechanisms for the exchange of information between those biosphere reserves providing for the *in situ* conservation of selected groups of organisms and those institutions dealing with the *ex situ* conservation of the same groups."
Objective 4 of the Action Plan:

— "UNESCO should try to marshal resources from other institutions to assist governments to conduct research on selected biosphere reserves on the priority research topics identified under the MAB Programme (such as on tropical mountains, soil biological processes, succession and regeneration, multipurpose plants, restoration of degraded ecosystems, etc.) in order to strengthen the cohesiveness of the Programme.

UNESCO, in cooperation with FAO, WHO and IUCN should develop and maintain a register of plant and animal taxa occurring in biosphere reserves. This register should include basic information on the ecology, distribution status of these taxa, paying due attention to those of potential agricultural or medical interest. In addition, UNESCO in cooperation with these same organisations, should organise the systematic collection and storage of information on the uses (traditional and modern) of these taxa and should build up a data bank and an information service to synthesise and disseminate this information."

Objective 6 of the Action Plan:

— "The emphasis should be given on one of the most valuable features of biosphere reserves that they offer an excellent way of integrated conservation with development by building on the knowledge of indigenous people about the sustainable management of their ecosystems and about the properties and values of the plants and animals therein. When this is appropriately supplemented by modern science and technology, such knowledge should enable even better use to be made of those ecosystems while preserving their essential character—and to do this in ways that benefits local people and are acceptable to them. Such measures will also serve to safeguard the primitive cultivars of economic crops. This path of development is especially suitable in many areas of the developing world but could also be followed with advantage in some of the less favoured rural sites of developed countries".

Promotion/Coordination of Activities

Giving high priority to the concept of biosphere reserves as the centres for the conservation of gene pools of species including life support species, UNESCO also brings about a widely spread number of activities in studying floristic, taxonomical, genetic and biochemical properties of plants of economic perspective, including medicinal and agricultural plants. Thus to mention as an example, the South and Central Asian
Medicinal and Aromatic Plants (SCAMAP) Network was established by UNESCO in 1979 as a result of the recommendations made at the Asian Symposium on Medicinal Plants and Spices, held in Sri Lanka in 1977. At present there are 12 countries participating in the SCAMAP Network (Afghanistan, Bangladesh, Bhutan, Burma, India, Iran, Maldives, Mongolia, Nepal, Pakistan, Sri Lanka and Turkey). Emphasis has been placed on the exchange of information between the participating countries on medicinal and aromatic plants research etc., on training activities in such areas as pharmacological techniques for the evaluation of natural products, spectroscopic techniques, structure elucidation, high altitude natural products chemistry, etc.

Methods and means of biotechnology such as plant tissue culture, genetic engineering and DNA-cloning are among the new trends which UNESCO is promoting in the Member States through its key areas programme in science. Numerous workshops and training courses have been held in cooperation with International Council of Scientific Unions (ICSU) and its bodies like Committee on Science and Technology for Development (COSTED), International Cell Research Organisation (ICRO), Asian Network of Biological Sciences (ANBS) and many others. The main objective of these activities is to spread and share knowledge and experiences in new experimental methods and biotechnologies in order to make available extended cultivation of plants representing economical, medicinal and life support species. UNESCO will be glad to join hands with the Commonwealth Science Council in these programmes and activities.

UNESCO also sees one of its ultimate objectives in preparation of scientifically sound integrated approach to exploration and utilisation of natural resources in a harmonious context of safeguarding natural and cultural heritage of the mankind. An example of such an effort in the Asian Region is initiated by UNESCO International Project on Integrated Mountain Development which has led to the establishment of the International Centre for Integrated Mountain Development in Hindu-Kush Himalayan Region, hosted by Nepal in its capital, Kathmandu.
LIFE SUPPORT SPECIES OF THE HIMALAYAN REGION

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INTRODUCTION

The Himalayas are a store-house of genetic diversity in temperate crops. The rugged topography and enormous variation in climate and soil in this region, have added towards the diversification of plant genetic resources. Equally diverse in this mountain environments are the farming systems suited to annual and perennial crops; horticulture occupying a place of prominence. While the temperate habitat extends above 1600 m upto the timber line limit where Betula utilis occurs amidst alpine shrubby vegetation (4500 m), the extensive valleys, terraces and slopes support rich crop diversity within this altitudinal range. Invariably, for the major part, rainfed crops are taken and with increasing altitude, combined with low rainfall and high temperature, cold-arid climate of Ladakh, Lahaul and Spiti and Kinnaur, supports crops grown in stress environment. The life support species in this region would include the less grown crops, cultivated types, emergency foods and other useful/wild types (Arora, 1980; Arora et al., 1980, 1988) These genetic resources include prosomillet, buckwheat, amaranths, chenopods, field peas, beans, cucurbits and several pome, stone, nut and soft fruits. The major crops raised, i.e. wheat, barley, potato and others, do not come within the present perview.

LIFE SUPPORT SPECIES IN THE HIMALAYAS

Pseudo-cereals and millets

Several species of amaranths are grown, both as leafy types and for grain. The diversity exhibited is greater in western Himalayas than in eastern Himalayas, particularly in grain-types, with much variation in inflorescence, finger length, colour (yellow, brown, green, pale, whitish, intermediate); grain (creamish, yellow, brown, red/pink). Dwarf and tall types occur, and the mountain variability exhibits protein rich genotypes (protein upto 24%). As compared to amaranth, chenopods are only meagrely grown; particularly in Himachal Pradesh in Chamba hills. Tall types in Chenopodium album are raised both for leaves and grain. More popular and secure crop relatively all through the Himalayas, is
buckwheat in mid-elevation to high elevation zone up to 4200 m. Both *Fagopyrum esculentum* and *F. tataricum* are grown, the latter on a lesser scale, more adaptable to cold in the high altitude zone (its sour leaves are used like spinach and its grain for flour). *F. esculentum* is more widely grown and several local types—early/medium/late adapted to rainfed farming at high altitude slopes and even for mixed cropping in valleys occur. The grain is roasted, pounded and eaten or made into a flour and/or a dough is prepared out of it. Several other local usages are also known. The buckwheat provides a balanced, protein rich food.

Among the millets, proso millet (*Panicum miliaceum*) is sporadically grown; tall types for fodder as well as grain, local variability prevailing all through in eastern and western Himalayas between 2000–4000 m. Bold grain (blackish, creamish, yellow) types with compact panicles occur. The hay is stored for winter use. Further among other millets, *Setaria italica* for which more variability is known from eastern region is sporadically grown. It is also used likewise. In Kashmir valley, *Digitaria* is grown and in Khasi hills (Meghalaya) *Digitaria cruciata* var. *esculenta*; both are endemic and localised cultigens, adapted to cold and utilised for grain and for fodder. Equally important here, in Nagaland and other hilly area, is the diversity in soft shelled forms of *Coix lacryma-jobi* (var. *mayun*) which too provides a protein rich food. The grains are pounded and mixed with rice, cooked and consumed. They are also eaten raw out of hand for their sweet kernel.

**Vegetables**

While the socio-economy of the local farming communities in high altitudes, is governed by potato and several European vegetables, much importance is attached locally to Brassicae, largely as kitchen garden crop, and among others in cucurbits, i.e. *Cucurbita maxima* and *C. moschata*. The sliced chips are sun-dried and stored as emergency vegetable for winter.

**Fruits**

*Prunus, Pyrus, Armeniaca, Sorbus, Docynia, Rubus, Ribes* and several others are consumed locally. Native types in *Malus* are sour or sub-sweetish and are sliced, sun-dried and stored as emergency food. In *Armeniaca* and *Prunus*, pulp is made into a drink and the sweet kernel eaten as nut, while bitter kernel yields oil, considered nutritious and medicinal. Also *Castanea* nuts yield edible kernel.

**Wild edible and other useful types**

While the above are some prominent crop-plants which can be classified under the life support species, an enormous diversity occurs in
LIFE SUPPORT SPECIES

the wild types (Singh and Arora, 1978). Several fruits, leafy vegetables, grain types etc. are collected locally for emergency use: (a) Pome/stone fruits include *Prunus rufa*, *P. undulata*, *P. acuminata*, *P. punctata*, *Malus baccata*, *M. sikkimensis*, *Pyrus griffithii*, *P. thomsonii*, *P. nepalensis*, *P. cornuta*, *P. cerasoides*, *P. salicina*, *P. wallchittii*, *P. jenkinsii*, *P. undulata*, *P. tomentosa*, *P. pashia*, *P. kunanoi*, *P. serotina*, *P. jacquimontiana*, *P. polycarpa*, *Sorbus lanata*, *Dacynia indica*, *D. hookeriana*, *Crataegus oxyacantha*, *C. crenulata*, *C. clarkei*, *Myrica esculenta*. *Fragaria indica*, *F. nilgerreensis*, *Ribus spp.*, *Rubus ellipticus*, *Vitis diversicata*, *V. himalaica*, *V. rubifolia* and *Zizyphus oxyphylla*; (b) tuber types such as *Houttynia cordata* and *Flemingia vestita*; (c) leafy types *Phytolacca acinosa*, *Perilla frutescens*, *Polygonum spp.*, *Allium spp.* (d) forage types such as legumes like *Medicago falcata*, species of *Trigonella, Melilotus* and *Trifolium*; and grasses such as *Bromus, Dactylis, Lolium, Agrostis* and *Pennisetum* species.

AN OVERVIEW

The enormous diversity in cultivated and wild types as given above needs to be collected, evaluated for its utilisation and conserved for posterity. Activities in this direction are already being pursued by the NBPGR. However, specific emphasis needs to be laid exclusively in life support species, their screening for bio-chemical-agronomic evaluation and preserving such genetic wealth in botanical garden or genetic resources centres. The Regional Stations of the Bureau at Shimla, Bhowali, Srinagar and Shillong have much responsibility to share in meeting these goals. It is also gratifying to note that the coordinated projects on under-utilised and under-exploited plants (ICAR), and on ethno-botanical studies (DOEn, ICAR, CSIR) have considerably contributed in this endeavour. Several of the above cultivated plants like chenopods and minor millets are part of the cultural/ethnic systems prevailing among tribal communities which are true custodians of such preferred kinds. All the same, still much stress and drive is required in the national context on such life support species/potential economic flora.

The International Centre for Integrated Mountain Development (ICIMOD) in collaboration with the International Development Research Council (IDRC), had recently organised an International Workshop on Mountain Agriculture and Crop Genetic Resources. This Workshop also discussed the utilisation aspects of native germplasm of the mountain eco-system and the feasibility/desirability of establishing a network for mountain crops. By and large, it was felt that considering the complexity and diversity of the mountain eco-system in terms of vegetation/flora/genetic resources; emphasis need to be placed on:
(a) Preparing the checklist/floristic list of such plant species with their local names, range of distribution, habitat etc., notes on their utility.

(b) Compilation of reports on diversity in crop plants/genetic resources with emphasis on native plants/endemic cultigens, land races, local selections, etc. Also, to list out the protected plants of semi-domesticated nature (Arora, 1985).

(c) To pin-point species diversity and its status mainly of the current collections held and to define areas from where further collections are required.

(d) To effectively develop international linkages for exchange of material.

(e) To promote international programmes for build up of genetic diversity in life support species by involving funding agencies like IBPGR, IDRC, ICIMOD and others and intensify such activities in areas of diversity since many of such species may be endangered.

The above efforts directed properly would go a long way to improve the socio-economy of the farming communities and people in general in the mountain regions. The preservation of this wealth, much of which still needs to be evaluated for its full utilisation assumes priority. Research on life support species thus, in different facets of plant genetic resources in the temperate regions is of great relevance.

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COLD TOLERANCE VARIABILITY IN RICE AND VARIETAL DEVELOPMENTS FOR TEMPERATURE-LIMITING TROPICAL AREAS

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INTRODUCTION

Critical temperatures for rice vary depending upon the stage of growth and the variety. Generally, critical temperature at seedling stage is 12-13°C, at tillering 9-16°C, at panicle initiation, the most sensitive stage, 15-20°C, and anthesis 19-22°C (Yoshida, 1981). Japonica rices have relatively high tolerance for low temperature as opposed to indica or tropical rices. Japonica rices from temperate countries do not perform well under tropical conditions. Their grain and straw yields are low, they are susceptible to diseases, their eating quality is unacceptable and they exhibit poor dormancy.

In South and Southeast Asia alone, modern high yielding varieties cannot be planted on about 7 million hectares because of low temperature. The area includes regions in Burma, China, India, Indonesia, Malaysia, Philippines, Thailand and Vietnam. Low temperature also limits rice production in Central and South America as in Brazil, Peru, Cuba and Ecuador and in Africa such as in Tanzania and Madagascar.

ACHIEVEMENTS

The breeding objective for rice in the highland tropics of Asia is high yielding, indica varieties with cold tolerance at one or more growth stages. The development of such varieties requires variability for cold tolerance in the rice germplasm which is currently available. Screening techniques had to be developed before germplasm screening could begin. No single test is possible because low temperature can affect rice at all growth stages. Tolerance at one stage does not necessarily mean tolerance at other stages. Screening methods have been developed for cold tolerance at germination, seedling, tillering, panicle initiation and anthesis (Salahuddin and Vergara, 1974; Vergara et al., 1976). Initial work at the International Rice Research Institute (IRRI) identified javanica and indica entries in the germplasm but excluded the japonicas. The rationale for using the indicas and javanicas is the ease
of crossing them with modern high yielding indica varieties in which the ideotype for high grain yield in the tropics has been established. The cold tolerance improvement programme in Japan and Korea concentrated on identifying new donors, especially those from the indica group (Satake and Toriyama, 1979; Matsumoto et al., 1981).

Initial screening of the 45,000 entries in the International Rice Germplasm Center (IRGC) in 1975 resulted in the identification of 11 varieties with cold tolerance at seedling, panicle initiation and anthesis. These varieties have a relatively short growth duration, and intermediate plant height. The identified donors were crossed with improved varieties at IRRI and in national programmes such as Bangladesh, India, Indonesia, Japan and Korea (Vergara and Visperas, 1985). Many of the resulting crosses were accelerated through the rapid generation advance facilities at IRRI so that four generations per year instead of one could be grown. The materials were screened in the Philippines at IRRI in Los Baños and at Banaue, at high altitude area where IRRI collaborates with the Philippine government for development of cold tolerant rices. In collaboration with Rural Development Administration of Korea, selected entries were further screened at much lower temperatures in Chuncheon.

Breeding materials from national programmes are also screened in Korea. The national programme makes its own crosses or requests IRRI to make the crosses. Initial selections are made on site and part of the seeds are returned to IRRI for further evaluation and for the use of other national programmes. National programme participation is valuable in the screening and development of the materials.

New materials are also introduced to national programmes through the International Rice Testing Programme (IRTP), which is coordinated by IRRI and funded by the United Nations Development Programme. Elite and outstanding donors are included in the International Rice Cold Tolerance Screening Nursery (IRCTN). IRTP distributes the IRCTN annually to its cooperators; 21 sites in 11 countries in 1985.

An example of networking is shown in the cross made by Satake and Toriyama (1979) and processed through shuttle breeding and networking (Vergara and Visperas, 1985). Donor parents were identified at IRRI, further tested in Japan, and two varieties (Silewah and Leng Kwang) were found more tolerant than the check varieties. Crosses with Silewah were found highly fertile and seeds were sent to IRRI for rapid generation advance. After three generations, the selected materials were sent back to Japan, further selections were made and returned to IRRI for seed increase and further evaluation for cold tolerance in
Korea. Materials were then sent to other countries and some lines eventually were included in the IRCTN for wider distribution and possible use by national programmes.

The result of the varietal improvement programme is shown by the production of new higher yielding varieties in areas where low temperature has been limiting such as in India, Nepal, the Philippines and Indonesia (Table 1).

Table 1. List of IRCTN entries named as varieties in different countries

<table>
<thead>
<tr>
<th>Designation</th>
<th>Name given</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chianung sen yu 23</td>
<td></td>
<td>Taiwan (China)</td>
</tr>
<tr>
<td>Chianung si-pi 661020</td>
<td></td>
<td>Taiwan (China)</td>
</tr>
<tr>
<td>Suweon 290</td>
<td></td>
<td>China</td>
</tr>
<tr>
<td>Kulu</td>
<td>Sin Kalaya</td>
<td>Burma</td>
</tr>
<tr>
<td>IR2307-247-2-2-3</td>
<td>Semeru</td>
<td>Indonesia</td>
</tr>
<tr>
<td>KN-1B-361-1-8-6-10</td>
<td>RPKn-2</td>
<td>Philippines</td>
</tr>
<tr>
<td>IR3941-4-Plp2B</td>
<td>Kanchan</td>
<td>Nepal</td>
</tr>
<tr>
<td>IR2298-PlpB-3-2-1-1B</td>
<td>Himali</td>
<td>Nepal</td>
</tr>
<tr>
<td>Krosnodorski 424</td>
<td></td>
<td>Turkey</td>
</tr>
<tr>
<td>Lieto</td>
<td></td>
<td>Turkey</td>
</tr>
<tr>
<td>B2161-C-MR57-1-3-1</td>
<td>B2161</td>
<td>Cameroon</td>
</tr>
<tr>
<td>IR7167-33-2-3</td>
<td>IR7167</td>
<td>Cameroon</td>
</tr>
<tr>
<td>HPU 71 (Pusa 33-C-30)</td>
<td>Himalaya 2</td>
<td>India</td>
</tr>
</tbody>
</table>

The importance of the rice germplasm collection at IRRI cannot be underestimated, even in a well-established crop. Many of the recent crosses for cold tolerance used traditional varieties from the hill areas of Bhutan, Thailand, Indonesia and other countries, such as the crosses made by a national breeder in Thailand. He crossed traditional hill rices from northern Thailand with modern varieties to increase rice yields in areas traditionally planted mostly to poppies. The cross was sent to IRRI for rapid generation advance. The $F_4$ and $F_5$ bulk materials were then screened in Korea for earliness and cold tolerance. The selected plants were brought to IRRI for seed multiplication, disease resistance evaluation and selection for other important agronomic traits. The selected lines will be sent to northern Thailand for field evaluation this May, 1987.

The results of screening for cold tolerance at seedling stage are kept in IRRI's data bank and are available to all. Of the 64,744 entries in the IRGC, 4,649 have been screened for cold tolerance at the seedling stage. The rice germplasm is also being screened for tolerance to other adverse environments: 22,207 entries have been screened for drought
tolerance; 1,192 for deep water tolerance; 8,717 for flood tolerance; and 8,095 for salinity tolerance. The names and characteristics of these potential life support varieties are available in the data banks at IRRI. The IRTP data bank has IRCTN data for cold tolerance based on growth duration, sterility, panicle exertion, plant height and general phenotypic acceptability under low temperature. Similar data are available for many breeding lines.

Many accesions in the germplasm bank have cold tolerance and will yield grain even at relatively cold temperature. Yields, however, are low and improvements in cold tolerance and plant type are necessary. The prospects of increasing grain yields have already been shown in several areas (Vergara and Visperas, 1985).

Rice will continue as a life support species in the tropics providing the staple food under extreme environments such as low temperature, deep flooding, salinity and drought. Yields may not be high under saline soils and drought stress, but progress is being made to incorporate tolerance for these stresses. The need for collecting rice germplasm, especially in adverse environments should be given priority to ensure the availability of a diverse gene pool.

REFERENCES


LIFE SUPPORTING ARID ZONE PLANTS IN FAMINE PERIOD

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INTRODUCTION

The entire arid tract of the country often faces mild to acute droughts whereas the desert belt of the Thar desert experiences more frequent droughts and famines. The climatological features have been well ingrained in the minds of the desert dwellers. According to the nomenclature of the desert people the famines can be categorised into three types: (i) Ann-kal (food famine); (ii) Jal-kal (water famine); and (iii) Chara-kal (fodder famine). But when all the three scarcity conditions occur, it is termed as Tri-kal (triple famine), when whole of the desert tract experiences a catastrophic condition. Large herds of animals migrate to adjoining states. Rural adult population migrates to adjoining areas for seeking employment. Many of the natural resources of rural tract are diverted to urban areas to earn cash. This accelerates the process of desertification. Western districts like Barmer, Bikaner, Jaisalmer, Jodhpur and Nagaur are prone to high frequency of droughts and famines. For their survival, the people of desert tract have conceived a tendency of conservation of all the life supporting material. Many wise men gave slogans in the name of religion to save the flora and fauna of the region and improve the environmental conditions, e.g. cutting of khejri and killing of deer (wild life) is strictly prohibited in Vishnoi region. Even under normal conditions people conserve many desert fruits, seeds, tubers and rhizome, leafy types etc. for scarcity conditions. Particularly, the nomads, tribesmen and poor people depend upon the natural flora and fauna.

Earlier workers like King (1869), Brandis (1874) and Lisboe (1886) have given a concise account of plants used during famine conditions. In the last two decades some more information has trickled down [Kanodia and Gupta (1968), Gupta and Kanodia (1968), Bhandari (1974, 1978), Saxena (1979) and Mann and Saxena (1980)]. Puri el 01. (1964) and Bhandari (1978) have listed 700 and 594 plants respectively from the arid region of Western Rajasthan. In drought or famine years some rainfall does occur which enables the well adapted native flora to germinate but this is regulated by the amount of rainfall. Under low rainfall conditions only
30% seeds of weeds and grasses shall grow, while in good to above normal rainfall condition 80-90% flora will germinate. This condition allows the flora to evade adverse climatic conditions and continue the progeny indefinitely. An account of life supporting food material used in scarcity/famines is presented in this paper.

**Life Support Species**

**Leafy plant material**

About thirty species are known to contribute leafy edible types in the time of scarcity/famine. Most of them develop around village wastelands or fallow cultivated fields. Most prevalent are the herbaceous species during monsoon period (July to September) viz., Chandlai (Amaranthus gracilis), Jangli chandlai (A. spinosus), Lal cholai (A. hybridus), Unda kanta (Achyranthes aspera), Khokte (Acalypha indica), Jangli kulfa (Portulaca oleracea), Morang (Gisekia pharmaceoides), Murga kalgi (Celosia argentea), Morang (Digera muricata), Luni or Lunki (Portulaca quadrifida) and Bagre (Cleome viscosa). Here, either the whole plant or only leaves are used by desert dwellers after boiling. Two herbs, generally met in rocky situations, are Bakna (Commelina benghalensis) and Kansura (C. forskailii). Herbaceous parts of some undershrubs like Kesudo (Cassia occidentalis and C. obtusa), Goma (Leucas aspera), Halkhura (L. cephalotes) and Bapchi (Ocimum americanum and O. basilicum) are consumed during July to November. During monsoon season the leaves of few shrubs like Thor (Euphorbia caducifolia) and Arg (Securinga leucopyrus) are available in plenty from hilly tracts.

A few winter weeds like Bathua (Chenopodium album), Goila (C. murale), Pathri (Launaea pinnatifida) come up on irrigated wheat fields. These are consumed in large quantity as regular greens. A few creepers, climbers and ramblers also provide either whole plant or leaves as greens, i.e. Narz (Ipomoea aquatica), Peelwan (Coeculus pendulus), Kauphuti (Cardiospermum halicacabum), Sata (Boerhaavia diffusa) and Mota Sata (B. verticillata).

In reserved forests newly sprouted buds of bamboos (Bambusa arundinacea) and few planted trees at various community centres and irrigation wells, etc. like Sainjna (Moringa oleifera), Imli (Tamarindus indica) provides leaves, fruits and flowers for vegetable consumption.

**Seeds**

Ten species are known to provide seeds which are akin to Bajra (millet) grain, and are mixed with it to increase its bulk. Desert tribes invariably collect the grass seeds to use in lean period of the year.
During famine, large scale collection of Dhaman (*Cenchrus ciliaris*), Motha dhaman (*C. setigerus*), Bhurat (*C. biflorus*), Sewan (*Lasiurus sindicus*) are made. Their grains are taken out after beating them in jute sacks. Grains of a few other grasses like Gramna (*Panicum antidotale*), Murut (*P. turgidum*), Kuri (*Brachiaria ramosa*), Ganthi (*Dactyloctenium sindicum*), Makta (*D. aegyptium*) and Tantia (*Eleusine compressa*) are simply taken out by hand threshing. All these are mixed with bajra grain to increase the bulk. To improve the quality and quantity of bajra flour, the seeds of two creepers, i.e. Mateera (*Citrullus lanatus*) and Tumba (*C. colocynthis*) are also mixed. They provide better taste and lustre to the baked chapatis (pancake). In normal conditions the cotyledons of these two species are taken out and mixed with sugar to make sweets. Their seeds are directly roasted and eaten raw. Seeds of soma or homa (*Echinochloa colonum*) and samaw (*E. crusgalli*) are collected from the low lying fields, are boiled with water and used as a substitute for rice. Seeds of few leguminous species like Arak moth (*Vigna trilobata*) and Bekario (*Indigofera* species) are cooked independently or mixed with bajra grains.

There are few desert shrubs and undershrubs whose seeds are directly used, e.g. Bapchi (*Ocimum cant/m*), Maruva (*O. basilicum*), Ekad (*Sesbania aegyptiaca*) and Tarakanchi (*Abutilon indicum*). Also a, large quantity of seeds are provided from few desert tree species like Babool (*Acacia nilotica*), Urojio (*A. leucophloea*), Kumut (*A. senegal*) and Ihli (*Tamarindus indica*). They are fried and used as raw or mixed with jowar or bajra grain.

**Fruits**

*Kair* (*Capparis decidua*) and Bordi (*Zizyphus nummularia*) are the most common shrubs of Indian desert. Ripe fruits of Kair locally called “Dhalu” available during May and October are eaten raw. During summer the unripe fruits are plucked for making vegetables or pickles. Fruits of Bordi, available abundantly during November-December, are also eaten raw. Sometimes they are dried and used during summer for making cold drinks. During famine, the cotyledons are removed from the stone which are fried and eaten raw or mixed with bajra seeds. Fruits of Gangeran (*Grewia tenax*), Gangeti (*G. tillosa*), Falsa (*G. asiatica*) and Dansri (*Rhus mysorensis*) found mostly on the hilly tract, are available during September-November and mostly eaten raw. In the month of February-March the buds and flowers of Phog (*Calligonum polygonoides*) which is common on sand dunes and sandy undulating plains, are consumed.

A few tree species also provide edible fruits, e.g. Bargad (*Ficus bengalensis*), Pipal (*F. religiosa*), and Gular (*F. glomerata*). These trees
are limited in number and are found on irrigation wells or village Panchayat centres. Fruits of Gunda (*Cordia myxa*), a cultivated plant along the field boundaries, and available during February-May are largely consumed as vegetable or made into pickle. Gundi (*Cordia gheraf*) is distributed on rocky situations, and its ripe fruits during September-October are eaten raw. Sainjna (*Moringa oleifera*) a common tree of irrigated area, is mostly grown on wells or near houses. Its flowers, leaves and long fruits available during November-March (drum sticks) are consumed as vegetable. Jal (*Salvadora oleoides* and *S. persica*) trees found on medium heavy to heavy saline soils of alluvial plains provide ripe fruits “Pillu” during May-June. In Jaisalmer, they are known as “Grape of the desert” and much liked by local population. Ripe fruits of Jangal Jalebi (*Pithecellobium dulce*) and Neem (*Azadirachta indica*) are consumed under scarcity conditions. Khejri (*Prosopis cineraria*), a prized tree of the desert (Mann and Saxena, 1980) is well distributed on alluvial flats. Almost all parts of this tree are utilised by the local population. It is the mainstay during famine period. Green foliage is given to livestock during summer months when other forage are scarce. Unripe pods in the month of April-May are harvested and used as vegetable. They are boiled and stored dry for lean period. Ripe pods locally known as “Khaka” are eaten raw. Under extreme conditions of scarcity even the bark of this tree is consumed (King, 1869). Among others, Kachra or Machri (*Cucumis callosus*) and Mateera (*Citrullus lanatus*) grow wild on the sandy tract of Western Rajasthan especially in the district of Barmer, Bikaner and Jaisalmer. Ripe fruits are eaten raw while green ones are utilised as vegetable. Kankera and Bankarela (*Momordica* sp.) fruits are available during September-October and used as vegetable.

**Underground parts and pulpy material**

The roots, tubers, rhizomes and pulp of a few desert plants are popular during famine. Local tribesmen excavate them from the ground and use in various ways. Succulent young roots of Dhak (*Butea monosperma*) and Semul (*Bombax ceiba*) are roasted or boiled and eaten raw with salt. Similarly, tubers of a herbaceous twiner Khadula (*Ceropegia tuberosa*) are also eaten raw or after roasting. During famine, the people take out the rhizome of Motha (*Cyperus* sp.), whose black nuts are boiled and starch material is consumed after peeling off the outer skin. On rocky situations, another thorny climber Satavar (*Asparagus racemosus*) occurs, whose swollen roots are very much popular among tribesmen.

The pulp of the succulent leaves of Guarpatha (*Aloe barbadensis*), a common species on cemeteries, is either cooked with bajra flour or made into a paste after mixing with sugar.
REFERENCES


LIFE SUPPORT SPECIES FOR HEAT TOLERANCE

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INTRODUCTION

Desert plants possess innumerable contrivances that help them in the adjustment of their more exacting life in harsh and inexorable desertic conditions. Heat tolerance, which is intimately associated with the environmental temperature, is one of the most important factors for the growth and development of any species. It may act on any stage in the life cycle of a plant so as to affect its survival, reproduction or development. Depending upon its phenotypic plasticity, each species of plant can happily survive in different environments to which it has been put or finds itself. But the more important question related to this type of approach is to probe into the question as to why and how that species of plant has adapted by evolution to the environment of its preference. In response to heat factor, plants show morphological and physiological adaptations that enable them to withstand high temperature and extreme heat.

Heat, which is the direct result of high temperature of the environment, along with moisture forms two master limiting factors for the distribution of plants. Temperature may act at any stage and limit the distribution of species through its effect on (a) Survival, (b) Reproduction, (c) Development of young organisms, and (d) Competition with other forms near the limits of temperature tolerance.

MORPHOLOGICAL AND PHYSIOLOGICAL ADAPTATIONS

Plants living in hot deserts have three options open to them to deal with the extreme heat, namely: 1. Tolerate it, 2. Avoid it, and 3. To use water evaporation to remain cool. It is mostly the xerophytes, or desert plants, which have developed the modifications necessary for withstanding both extremely high temperature and great aridity. Both morphological and anatomical characters are instrumental in diminishing transportation, and some of these adaptations may at the same time be protective against strong insolation or overheating. The following anatomical features serve to diminish transpiration: thick, cutinised epidermal cell walls and cuticle; reflection of light from the cuticle;
formation of waxy or resinous coatings; reduced number of stomata; narrowing of the stomata below the general level of the epidermis, either singly or in numbers, in special flask-shaped depressions on the underside of the leaf, or the over-arching of the stomata by adjoining cells so that they come to be situated in cavities protected from the wind. Hairs, whether woolly, stellate, or scaly, which are filled with air and give the plants a whitish or grey appearance, may serve as protection against the sun’s rays. On the other hand, evergreen leaves may be small, leathery and relatively poor in sap. The effectiveness at which plants will function at high temperatures depends on the degree to which the following modifications are developed.

1. Leaf position

Leaf position enables many desert plants to escape high, lethal temperatures. Leaves oriented vertically to the sun, absorb a minimum amount of solar energy and remain several degrees cooler than those exposed more at right angles. If a leaf is turned at a 10° angle away from perpendicular to the incoming light, heat absorption is reduced about 15 per cent; when oriented more than about 70°, heat absorption becomes negligible. Leaves of such type of plants completely avoid rays of the sun when it is at its peak. Thus plants like *Salvadora oleoides*, *Calotropis procera* and *Clerodendrum phlomoides* orient their leaves in such a manner, that they absorb minimum amount of solar energy, which enables them to remain cool and hence green in the face of the most scorching sun.

2. Leaf colour

Leaf colour greatly influences heat absorption. Dark surfaces absorb heat, while light surfaces reflect heat. Whitish or grey-green leaf and stem coloration, characteristic of many desert plants, reflects the sun’s rays, limiting heat absorption. *Calotropis procera*, *Aerva persica* and *Aerva pseudo-tomentosa* have almost whitish leaves which enable them to escape excessive heat absorption. Similarly, prostrate plants like *Neurada procumbens*, *Tribulus terrestris* and *Tribulus rajasthanensis* as well as *Acacia senegal* which grow on hot sand or rocky surfaces, reduce this effect by their hirsute hairy nature.

3. Development of cuticle

Cuticle, a thick waxy layer of cutin covering the leaves of many desert plants, reflects large amounts of the heat and partially insulates underlying cells. Although reflection is often high, transmission is reduced and absorption is higher than for more mesic leaves. Plants like *Fagonia cretica*, *Tecomella undulata*, *Balanites aegyptiaca* and many
others develop a large amount of cutin on their leaves as well as on their seeds which protect them from high temperature.

4. Leaf hairs

Leaf hairs have been reported to be of value in shading the living cells. Hairs, whether woolly, stellate or scaly, which become filled with air at an early stage, give the plants a whitish or grey appearance which serves as a protection against sun’s rays. By absorbing or reflecting much of the incident heat energy, leaf hairs may reduce the temperature of the underlying cells by 1° to 2°C. By improving conductive cooling, leaf hairs act as fins, greatly increasing the leaf surface area and facilitating conduction of heat to the atmosphere. This type of modification could be seen in plants like *Aerva persica*, *A. pseudo-tomentosa*, and *Tephrosia filiformis*, *Calotropis procera* and a large number of other desert plants such as *Farsetia macrantha* and *Convolvulus microphyllus*.

5. Transpiration

The loss of water from plant tissues in a vapour form, is an important mechanism for transferring much of the absorbed heat energy out of the leaf, thereby reducing its temperature. A high rate of transpiration protects plants exposed to the high incidence of light and heat energy. Only through transpiration are they able to transfer the overabundance of heat energy absorbed out of the leaf and in this way to avert lethal temperatures. Thus, contrary to the belief, the rate of transpiration of desert plants is much higher, particularly the broad leaved species such as *Calotropis procera*, *Clerodendrum phlomoides* and *Tecomella undulata*. But the most important and most frequent means of protection against excessive transpiration is the reduction of the transpiring surface. This is effected either by the reduction in number and size of the leaves, or by the total absence of leaves themselves, as is witnessed in plants like *Sarcostemma acidum*, *Capparis decidua*, *Dipterygium glaucum*, etc.

6. Hydration of the protoplast

The moisture content, or degree of protein hydration in the protoplasm, influences heat tolerance. High temperature tolerance decreases with the degree of hydration. When there are fewer water molecules present, hydrogen is more strongly attached or, more accurately attached at more points to the protein molecules. Plant species can sometimes acquire heat tolerance by hardening, that is building up of resistance by exposure to gradual increases in temperature. Hardening is determined by the thickening viscosity of the cytoplasm. A gradual increase in
cytoplasmic viscosity results in a higher degree of water binding in the cells, which increases the capacity of molecules to adjust to the molecular deformation caused by high temperature.

7. Root development

One of the most important aspects of desert plants to nullify the effect of high temperature of the desert atmosphere is to absorb maximum amount of water. This they do by having a very limited vegetative apparatus above ground while their root apparatus is not only well developed and ramified, they are digging deep into the soil to absorb a sufficient amount of water which keeps them cool even against their high transpiration rate. One such example is Prosopis cineraria, known as the queen of the desert. Its roots not only penetrate very deep, as much as 80 metre long, although above ground the plant is only 8–10 metres high. Another characteristic of these plants is the branching of the tap root right from the start so that when the roots are exposed due to severe wind blowing, the plants will survive even when their roots are exposed considerably as is seen in Salvadora oleoides, Maytenus senegalensis, Calotropis procera, Calligonum polygonoides, etc. Acacia tortilis is an exotic plant in the Indian desert, and is not suitable for plantation on the sand dunes, due to its single long tap root.

8. Dew and its effect on plant growth and development

The formation of dew occurs mainly at night because it depends on radiational cooling of leaf and soil surfaces until they reach dewpoint temperatures. The total amount of dewfall is unlikely to exceed 1 mm in a night. Dew absorption has been found to vary widely with plant species; it is largely dependent on the intensity and duration of dewfall as well as on the soil moisture regime, being higher under dryland conditions than under irrigation. Dew can only provide a very small proportion of the water requirements of a normally transpiring plant, but may be of some importance to plant under water stress. Occurring as it does at night, it may accelerate the restoration of leaf turgor, and in the morning can delay the onset of renewed stress. In dry regions, dew may, therefore, be beneficial to plant growth and make a positive contribution to the water balance of the plant. Moreover, the severest stress for plants that are inadequately supplied with water, occurs during the hottest hours of the day, long after the dew has completely evaporated. Desert plants such as Calligonum polygonoides, Leptadenia pyrotechnica and Maytenus senegalensis absorb a very large amount of dew. Immediately after they absorb dew, these plants begin to flower.
LIFE FORM PATTERN DUE TO HEAT STRESS

High heat stress has developed a pronounced type of life form pattern. Thus, like all warm deserts of the world the Indian desert also has a deciduous summer active perennials, drought enduring evergreen shrubs, and the succulents, distributed along the heat gradient. As one goes from east to west, the life form spectrum changes progressively in response to the protection of the renewal bud due to increasing hot climate.

A comparison of the life forms in the flora of seven important hot deserts of the world shows that these mostly comprise of annuals which escape extreme drought. The pre-eminence of Therophytes, the low proportion of Cryptophytes and a good representation of Nanophaenerophytes are common features of these seven deserts.

Flora in the Indian desert is thus characterised by distinct species containing plants of unusual structure and behaviour. One could easily note that the desert plants are widely spaced, often leaving much bare ground. They are stunted trees such as Prosopis cineraria on sand and Acacia senegal on rocks.

CONCLUSIONS

As has been seen above, the plants found in areas like the Indian desert, which are influenced by excessive heat, have developed enough contrivances to mitigate the heat stress either by escaping the excessive heat effects or by developing enough morphological, anatomical and physiological adaptations. Their life form pattern is peculiar. Moreover, they have successfully migrated from east to west and vice versa and those which have been able to adjust to the scorching sun have survived in the long run. We need particularly to weave together the thread of knowledge of their natural setting, their design and adaptations to fully understand their heat tolerance.
Life support species for saline environment would include plants that are able to survive and produce economic yields under the adverse conditions caused by soil salinity. Salinity tolerance of agricultural crops has been expressed as yield decrease due to a given level of soluble salts in the rooting medium as compared with yields under non-saline conditions. Use of saline environments for growing domesticated plants on a commercial scale has become imperative because of increasing population and scarce availability of good land in many developing countries. Researches are, therefore, being made to evolve technologies for diverse situations. Research institutions specifically for salt affected soils have been established in countries like United States, Australia, Netherlands, Hungary and India. Investigations for management and improvement of saline environments for growing commercial plants in many other countries have been overwhelmingly encouraging. Experimental results of such researches have been reviewed. Life support species for maximisation of productivity of selected saline environments are listed.

Species for saline soils

The available salt tolerance data relating some known salinity index to the yield were reviewed by Maas and Hoffman (1977). They presented the information in tabular form indicating salinity at which yield begins to decline (threshold value) and the rate of yield decline with increased salinity (Table 1). Divisions for qualitative salt tolerance ratings of agricultural crops were also given and crop tolerances grouped as follows:

<table>
<thead>
<tr>
<th>Relative crop salinity tolerance rating</th>
<th>ECe at which yield loss begins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive</td>
<td>Less than 1.3 dSm⁻¹</td>
</tr>
<tr>
<td>Moderately sensitive</td>
<td>1.3 — 3.0 dSm⁻¹</td>
</tr>
<tr>
<td>Moderately tolerant</td>
<td>3.0 — 6.0 dSm⁻¹</td>
</tr>
</tbody>
</table>

*Central Soil Salinity Research Institute, Karnal, India.*
Tolerant
Unsuitable for most crops unless reduced yield is acceptable.

Table 1. Salt tolerance of important agricultural crops as a function of ECe where relative yield = 100-B (ECe-A).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Threshold salinity (dSAm&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Percent yield decrease per unit increase in salinity beyond threshold (B) (%)</th>
<th>Qualitative salt tolerance rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Agricultural crops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hordeum vulgare (Barley)</td>
<td>8.0</td>
<td>5</td>
<td>T</td>
</tr>
<tr>
<td>2. Phaseolus vulgaris (Bean)</td>
<td>1.0</td>
<td>19</td>
<td>S</td>
</tr>
<tr>
<td>3. Vicia faba (Broad bean)</td>
<td>1.6</td>
<td>10</td>
<td>MS</td>
</tr>
<tr>
<td>4. Zea mays (Corn)</td>
<td>1.7</td>
<td>12</td>
<td>MS</td>
</tr>
<tr>
<td>5. Gossypium hirsutum (Cotton)</td>
<td>7.7</td>
<td>5</td>
<td>T</td>
</tr>
<tr>
<td>6. Vigna unguiculata (Cowpea)</td>
<td>1.3</td>
<td>14</td>
<td>MS</td>
</tr>
<tr>
<td>7. Oryza sativa (Rice)</td>
<td>3.0</td>
<td>12</td>
<td>MS</td>
</tr>
<tr>
<td>8. Sorghum bicolor (Sorghum)</td>
<td>5.0</td>
<td>20</td>
<td>MT</td>
</tr>
<tr>
<td>10. Saccharum officinarum (Sugarcane)</td>
<td>1.7</td>
<td>6</td>
<td>MS</td>
</tr>
<tr>
<td>11. Triticum aestivum (Wheat)</td>
<td>6.0</td>
<td>7</td>
<td>MT</td>
</tr>
<tr>
<td>12. Arachis hypogea (Peanut)</td>
<td>3.2</td>
<td>29</td>
<td>MS</td>
</tr>
<tr>
<td>B. Horticultural plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Prunus amygdalus (Almond)</td>
<td>1.5</td>
<td>19</td>
<td>S</td>
</tr>
<tr>
<td>2. Malus sylvestris (Apple)</td>
<td>—</td>
<td>—</td>
<td>S</td>
</tr>
<tr>
<td>3. Rubus spp. (Black berry)</td>
<td>1.5</td>
<td>22</td>
<td>S</td>
</tr>
<tr>
<td>4. Phoenix dactylifera (Date palm)</td>
<td>4.0</td>
<td>4</td>
<td>T</td>
</tr>
<tr>
<td>5. Vitis spp. (Grape)</td>
<td>1.5</td>
<td>10</td>
<td>MS</td>
</tr>
<tr>
<td>6. Citrus paradisi (Grape fruit)</td>
<td>1.8</td>
<td>16</td>
<td>S</td>
</tr>
<tr>
<td>7. Citrus sinensis (Orange)</td>
<td>1.7</td>
<td>16</td>
<td>S</td>
</tr>
<tr>
<td>8. Fragaria spp. (Strawberry)</td>
<td>1.0</td>
<td>33</td>
<td>S</td>
</tr>
<tr>
<td>9. Prunus persica (Peach)</td>
<td>1.7</td>
<td>21</td>
<td>S</td>
</tr>
<tr>
<td>C. Olericultural plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Brassica oleracea-capitata (Cabbage)</td>
<td>1.8</td>
<td>10</td>
<td>MS</td>
</tr>
<tr>
<td>2. Daucus carota (Carrot)</td>
<td>1.0</td>
<td>14</td>
<td>S</td>
</tr>
<tr>
<td>3. Cucumis sativus (Cucumber)</td>
<td>2.5</td>
<td>13</td>
<td>MS</td>
</tr>
</tbody>
</table>

Continued
### LIFE SUPPORT SPECIES

<table>
<thead>
<tr>
<th></th>
<th>Life Support Species</th>
<th>Salt Tolerance</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><em>Allium cepa</em> (Onion)</td>
<td>1.2</td>
<td>S</td>
</tr>
<tr>
<td>5</td>
<td><em>Capsicum annum</em> (Chillies)</td>
<td>1.5</td>
<td>MS</td>
</tr>
<tr>
<td>6</td>
<td><em>Solanum tuberosum</em> (Potato)</td>
<td>1.7</td>
<td>MS</td>
</tr>
<tr>
<td>7</td>
<td><em>Raphanus sativus</em> (Radish)</td>
<td>1.3</td>
<td>MS</td>
</tr>
<tr>
<td>8</td>
<td><em>Beta vulgaris</em> (Sugarbeet)</td>
<td>7.0</td>
<td>T</td>
</tr>
<tr>
<td>9</td>
<td><em>Lycopersicon esculentum</em> (Tomato)</td>
<td>2.5</td>
<td>MS</td>
</tr>
</tbody>
</table>

#### (Table 1 Continued)

<table>
<thead>
<tr>
<th></th>
<th>Life Support Species</th>
<th>Salt Tolerance</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><em>Cynodon dactylon</em> (Bermuda grass)</td>
<td>6.9</td>
<td>T</td>
</tr>
<tr>
<td>11</td>
<td><em>Medicago sativa</em> (Alfalfa)</td>
<td>2.0</td>
<td>MS</td>
</tr>
<tr>
<td>12</td>
<td><em>Trifolium alexandrinum</em> (Berseem)</td>
<td>1.5</td>
<td>MS</td>
</tr>
<tr>
<td>13</td>
<td><em>Vicia sativa</em> (Vetch)</td>
<td>3.0</td>
<td>MS</td>
</tr>
<tr>
<td>14</td>
<td><em>Aeritum elongatum</em> (Wheat grass)</td>
<td>7.5</td>
<td>T</td>
</tr>
<tr>
<td>15</td>
<td><em>Sorghum sudanense</em> (Sudan grass)</td>
<td>2.8</td>
<td>MT</td>
</tr>
<tr>
<td>16</td>
<td><em>Lolium perenne</em> (Rye grass)</td>
<td>5.6</td>
<td>MT</td>
</tr>
<tr>
<td>17</td>
<td><em>Eragrostis spp.</em> (Love grass)</td>
<td>2.0</td>
<td>MS</td>
</tr>
</tbody>
</table>

Beyond threshold salinity, yield is shown to decrease linearly with increasing salinity. Most of this information is suitable for general use under different soil and climatic conditions. However, the situations under which most of these data were obtained should be considered cautiously and their limitations clearly noted. Uniform salinity distribution with depth and time, establishment of crops under low salinity conditions, a high level of management maintained with respect to soil fertility, irrigation and crop protection are these conditions (Shelhevet and Kamburov, 1976). Serious limitations, which question application of salt tolerance data given by Maas and Hoffman (1977) for diverse types of soils, agro-climates and widely varying irrigation practices, are seldom observed for uniform salinity distribution with depth and time in natural saline soils and linear decrease of yield with increase in salinity level.

Table 1 shows that horticultural and olericultural (vegetable) crops are generally more sensitive to saline conditions than agricultural crops and forage grasses. Bresler *et al.* (1982) have also documented in tabular form the relative productivity of moderately sensitive plants with increasing salt concentration in the root zone. Salt tolerance of plants is invariably dynamic in a given environment. This is so because of complex interactions among infinite climatic, soil, management and plant factors that affect tolerance or growth (Paliwal, 1972). The management for amelioration of saline soils involves leaching of excess soluble salts down the active rooting zone by ponding good quality water. But when ground water table is high, provision of appropriate drainage system is imperative.
Correct choice of crop species for sodic soils is also important as plants tolerant to high ESP can yield reasonable returns. Important crops for their different relative tolerance to soil sodicity as reported by Pearson (1960) and Abrol (1982) are listed in Table 2. In general, crops able to withstand excess moisture condition in soils are more tolerant to sodic soils. High tolerance of rice to sodicity is due to its requirement for a layer of water on the soil surface throughout the growing season. Rice yield was found decreased by only 10 per cent at an ESP of 55 whereas wheat was unable to grow due to the same sodicity.

Table 2. Relative tolerance of important crops to exchangeable sodium

<table>
<thead>
<tr>
<th>Tolerant</th>
<th>Semi-tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. <em>Beta vulgaris</em> (Sugarbeet)</td>
<td>2. <em>Hordeum vulgare</em> (Barley)</td>
<td>2. <em>Cicer arietinum</em> (Gram)</td>
</tr>
</tbody>
</table>

*Yields are seriously affected if ESP is more than 55, 35 and 10 in respect of tolerant, semi-tolerant and sensitive crop respectively.

Only a few wild plant species are able to grow on highly sodic soils. Therefore, amelioration of sodic soils with application of appropriate
amount of gypsum or other amendments has been widely recommended (Richards, 1954; Abrol and Fireman, 1977; Abrol, 1982; Bresler et al., 1982). During reclamation phase, rice is considered an ideal crop species for cultivation as it enhances the reclamation process (Chhabra and Abrol, 1977). Abrol and associates evaluated a large number of crop species during 1970–1986 by applying graded levels of gypsum in a sodic soil and reported critical limits of soil ESP at three yield reduction levels (Table 3). Data indicate that rice, *dhaincha* and forage grasses are relatively more tolerant to soil sodicity whereas leguminous crops are sensitive. That is why sparse vegetation on natural landscapes of sodic soils comprises of grasses, namely, *Desmostachya bipinnata*, *Sporobolus marginatus*, *S. diander*, *Cynodon dactylon* and *Diplachne fusca* (Bhumbla et al., 1972).

Table 3. Critical limits of soil ESP at three yield reduction levels for important crops.

<table>
<thead>
<tr>
<th>Crop species</th>
<th>Critical ESP for yield reduction (%) of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>1. <em>Oryza sativa</em> (Rice)</td>
<td>38</td>
</tr>
<tr>
<td>2. <em>Triticum aestivum</em> (Wheat)</td>
<td>23</td>
</tr>
<tr>
<td>3. <em>Helianthus annuus</em> (Sunflower)</td>
<td>23</td>
</tr>
<tr>
<td>4. <em>Pennisetum typhoides</em> (Pearl millet)</td>
<td>15</td>
</tr>
<tr>
<td>5. <em>Hordeum vulgare</em> (Barley)</td>
<td>30</td>
</tr>
<tr>
<td>6. <em>Ricinus communis</em> (Castor)</td>
<td>15</td>
</tr>
<tr>
<td>7. <em>Carthamus tinctorius</em> (Safflower)</td>
<td>10</td>
</tr>
<tr>
<td>8. <em>Glycine max</em> (Soybean)</td>
<td>10</td>
</tr>
<tr>
<td>9. <em>Allium cepa</em> (Onion)</td>
<td>14</td>
</tr>
<tr>
<td>10. <em>Pisum sativum</em> (Peas)</td>
<td>10</td>
</tr>
<tr>
<td>11. <em>Brassica juncea</em> (Raya)</td>
<td>20</td>
</tr>
<tr>
<td>12. <em>Sesbania bispinosa</em> (<em>Dhaincha</em>)</td>
<td>16</td>
</tr>
<tr>
<td>13. <em>Cynodon dactylon</em> (Bermuda grass)</td>
<td>60</td>
</tr>
<tr>
<td>14. <em>Diplachne fusca</em> (Kallar grass)</td>
<td>13</td>
</tr>
<tr>
<td>15. <em>Chloris gayana</em> (Rhodes grass)</td>
<td>15</td>
</tr>
<tr>
<td>16. <em>Vigna unguiculata</em> (Cowpea)</td>
<td>11</td>
</tr>
<tr>
<td>17. <em>Linum usitatissimum</em> (Linseed)</td>
<td>14</td>
</tr>
<tr>
<td>18. <em>Allium sativum</em> (Garlic)</td>
<td>15</td>
</tr>
<tr>
<td>19. <em>Secale cereale</em> (Rye)</td>
<td>14</td>
</tr>
<tr>
<td>20. <em>Brachiaria mutica</em> (Para grass)</td>
<td>30</td>
</tr>
<tr>
<td>21. <em>Setaria sphacelata</em> (Setaria grass)</td>
<td>25</td>
</tr>
<tr>
<td>22. <em>Dichanthium annulatum</em> (Marvel grass)</td>
<td>23</td>
</tr>
</tbody>
</table>

Experimental efforts in CSSRI, Karnal are also being concentrated on identification of suitable forest tree species for afforestation of salt soils.
Our studies show that success of afforestation programmes depends upon correct choice of tree species and the site preparation technique for planting their saplings. Studies have shown if a post-hole of 15 cm diameter is pierced through calcic horizon and refilled with a mixture of original sodic soil, 2–3 kg gypsum and 5–10 kg farm yard manure, saplings of several species grow well in sodic soils. Application of amendment was found essential for survival and early rapid growth (Gill and Abrol, 1986). For saline soils, planting of saplings in trenches or furrows than on ridges and flat surface was observed better (Gupta, 1987). Field scale experimentation has yielded us information for identification of a few forest tree species for their different tolerance to the soil sodicity and salinity (Table 4). Suitability of given tree species for saline environments in arid areas and regions with high water table vary greatly. Documented information on this aspect is limited and it needs to be evolved for practical purposes. It is particularly important to evaluate the effect of large scale plantations on water balance of the area and how this influences drainage requirements in areas with high water table.

Table 4. Tree species for their tolerance to soil sodicity and salinity

<table>
<thead>
<tr>
<th>Tolerant</th>
<th>Semi-tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOR SODIC SOILS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>Albizia lebbeck</strong></td>
<td>5. <em>Syzygium</em> strictum</td>
<td>5. <em>Dendrocalamus strictus</em></td>
</tr>
<tr>
<td>7. <strong>Butea monosperma</strong></td>
<td>7. <em>Dalbergia</em> sissoo</td>
<td></td>
</tr>
<tr>
<td>8. *<em>Zizyphus</em> spp.</td>
<td>8. <em>Prosopis</em> cineraria</td>
<td></td>
</tr>
<tr>
<td>9. <strong>Sesbania sesban</strong></td>
<td>9. <em>Grevillea</em> robusta</td>
<td></td>
</tr>
<tr>
<td><strong>FOR SALINE SOILS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. <strong>Tamarix gallica</strong></td>
<td>1. Eucalyptus camaldulensis</td>
<td>1. <em>Syzygium cuminii</em></td>
</tr>
<tr>
<td>2. <strong>Prosopis juliflora</strong></td>
<td>2. <em>Pongamia</em> pinnata</td>
<td>2. <em>Salix</em> babylonica</td>
</tr>
<tr>
<td>3. <strong>Casuarina equisetifolia</strong></td>
<td>3. Eucalyptus hybrid</td>
<td>3. <em>Tamarindus indica</em></td>
</tr>
<tr>
<td>6. <strong>Acacia auriculiformis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. *<em>Melaleuca</em> spp.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PROMISING HALOPHYTES**

A large number of plants which grow naturally in highly saline environments (halophytes) can open up new vistas for introducing entirely new genotypes for salinity tolerance into agricultural production.
First step involves screening of the halophytes for their potential as crops. Utilisation as forage and grains for animals may be easier to start with than food for human beings. Potentially useful halophytes for different purposes are described below:

(i) **Species for grains and other seed**: *Chenopodium quinoa* is a promising plant for high quality of its seed protein (Lopez, 1973) and moderate salt tolerance (Somers *et al.*, 1978). *C. album* can grow successfully in water of 25–30 dSm⁻¹ salinity if established with fresh water. Species of *Salicornia, Suaeda, Kochia, Allenrollea, Salsola* and *Atriplex* genera are other members of Chenopodiaceae which inhabit highly saline environments. *Atriplex patula* is of specific importance as it grows well using water of 25–32 dSm⁻¹ salinity. It yields about 1.2 t ha⁻¹ seeds whose protein content is about 16 per cent (Somers *et al.*, 1978). *Kosteletzkya virginica* is a perennial which produces relatively large seeds (about 20 mg each) containing 33 per cent protein with a good spectrum of essential amino acids. *Althaea officinalis* is another good halophyte which grows well in water of at least 20 dSm⁻¹ salinity. *Zizania aquatica, Spartina alterniflora* and *Distichlis palmeri* are other outstanding halophytes for use as cereals. However, yield data in case of most of these species are not available.

(ii) **Forages**: Among various grasses native to saline habitats, species of *Spartina* possess considerable potential. *S. alterniflora* and *S. patens* can be grown successfully using highly saline water (30–32 dSm⁻¹ salinity). Former grows well in poorly drained soils whereas latter grows better on well-drained soils. *Distichlis spicata* and closely related *D. stricta* also grow in highly saline environments. *Chenopodium album* is also a highly palatable forage.

(iii) **Leafy vegetables**: *Chenopodium album, C. quinoa* and *Atriplex patula* are also suitable for use as pot herbs. Latter can be used as a green salad when the plants are young and tender.

(iv) **Speciality crops**: Some Brassicaceae halophytes appear useful for pharmaceutical use. Two species belonging to this family *Cakile edentula* and *Lepidium virginicum* are reported (Somers *et al.*, 1978) to grow well in highly saline water. Fruits of these species are highly favoured like other species of this family. Leaves of the former possess attractive spicy flavour.

Scientific evaluation of selected promising species for diverse situations should be done as available information is exceedingly limited. In case of halophytes, yield is generally, comparatively very low. Yield potential of promising species should be increased by involving genetic tools.
Mangroves are the combination of trees and/or shrubs that grow on edge of the sea and, thus, are cultivated with sea water. Their principal product is wood, a renewable resource that substitutes for fossil fuels. Mangroves are helpful for (i) prevention of erosion (ii) protection against wind storms and waves (iii) usefulness as fuel, fodder and timber (iv) creation of environment conducive for growth of several species of fish etc. Mangroves are mostly confined to tidal regions with heavy soils. In India about 60 per cent of this area is in West Bengal. Mangrove forests are widespread in the Indo-Pacific area and are associated with deltas of the rivers entering the Bay of Bengal, the straits of Malacca; Southern Borneo, New Guinea, Thailand and Vietnam (Macnae, 1974). Mangroves are potentially diverse, including at least 12 familiar plants and more than 50 species (Chapman, 1970).

On the eastern coast in India, tree species of the genus *Avicennia* form the predominant vegetative cover on the soils of the Ganga, Godavari and Cauveri deltas. In Sunderban areas of West Bengal, there is a reserved area of 422000 ha. About 55 per cent of this grows a natural stands of mangroves whereas 41.3 per cent is covered by water and the rest is barren and sandy. The saline areas adjoining Karnataka are without any tree growth except some mangrove vegetation. Areas adjoining saline land are steep and undulating and interspersed with a number of rivers and streams. In coastal regions of Gujarat, *Avicennia marina* is the only mangrove species and is heavily exploited for forage and fuel. The plants are rarely allowed to grow more than a metre in height. But in areas not easily accessible to man and animals, stands develop and plants attain over 4m of height. Over-exploitation of mangroves in India has endangered some plant species, such as *Heritiera fomes* which is one of the biggest tree in mangroves of Gangetic deltas. *Sonneratia apetala* has completely disappeared from Cauvery delta and western coast whereas *Nipa fruticans* faces disappearance from Indian subcontinent. *Bruguiera gymnorrhiza* and *Rhizophora* species are under threat in Kerala.

Annual increments in biomass accumulation of mangrove forests are considerably high which indicates that there is great potential for enhancing productivity of wood and forage while utilising saline environment near the sea by establishing mangroves. Principal uses of some Indian mangrove species are listed below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aegialitis rotundifolia</em></td>
<td>Honey production</td>
</tr>
<tr>
<td><em>Aegiceros corniculatus</em></td>
<td>Fuel, bark as poison for fish</td>
</tr>
</tbody>
</table>

LIFE SUPPORT SPECIES

Avicennia spp. Firewood, fodder, green manure
Bruguiera gymnorrhiza High density wood, bark contains 40 per cent tannin
Xylocarpus spp. Wood for small implements, boats
Ceriops spp. Fuel and construction wood
Cynometra ramiflora Carpentry, local medicine
Excoecaria agallocha Fishing boats, crates, etc.
Hibiscus tiliaceus Fibre from bark used for cards
Nipa fruticans Valued as roofing material
Rhizophora spp. Firewood, production of charcoal, tannin

COASTAL SALINE SOILS

The natural landscape of regions a few km from the coast includes forage plants tolerant to high salinity. These include Aeluropus lagopoides, Brachiaria setigera, Chloris barbata, Cymbopogon species, Cynodon dactylon, Cyperus bulbosus, Dicanthium annulatum, Echinochloa colonum, Sida species, Sporobolus helvolus and Tamarix species. Amongst these, Aeluropus lagopoides was observed to be most salt tolerant followed by Cyperus bulbosus, Cynodon dactylon, Sporobolus helvolus and Tamarix species. However, research efforts to evaluate relative productivity of these species and their agronomic requirements for improved performance are completely lacking. Performance of several Atriplex species was evaluated by T. Kurian (Personal communication) under different salinities and A. nummularia was found to be the most tolerant. Under conditions of slight to moderate salinity (ECc 6–8 dSm⁻¹), a forage yield of 8–10 t ha⁻¹ per annum could be obtained after second year. Trials in Gujarat state are also in progress for evaluation of performance of tree species for firewood and fodder production under adverse soil conditions. Prosopis juliflora, Salvadora persica, Tamarix articulata, Acacia tortilis, A. nilotica, Parkinsonia aculeata and Zizyphus species were found promising (Mahiti Project, personal communication).

FUTURE GUIDELINES

The research information available on life support species for salt affected environments is mostly only qualitative and of academic nature. But there is some information practicable for use in sodic soils. Therefore, it is imperative to generate quantitative data regarding productivity of promising species of food, forages, trees and mangrove plants under saline environments. Levels of tolerance of most species to soil sodicity
and salinity are yet unknown. The rate of decline in production of biomass of plant species with increasing salt stress at different growth stages must be quantified. There is limitless scope for evolving package of agronomic practices to enhance the productivity level of promising plant species under highly saline habitats. Production of forage and firewood in coastal saline soils and the mangroves particularly need more attention. Some halophytes are wonderful plants because they grow on very salty environments. But their inherent yield potential is comparatively very low. Thus, genetic improvement by evolving genotypes of promising halophytes with high yield potential is also of utmost importance.

REFERENCES


LIFE SUPPORT SPECIES FOR ACID SOILS

R. S. RANA

Central Soil Salinity Research Institute, Karnal, India

INTRODUCTION

Acid soils (pH around 5, often below 3) are of widespread occurrence in many countries of tropical Africa, Asia and Oceania. Tropical rain forest and savanna regions are in particular dominated by acid soils which are classified mainly as Oxisols and Ultisols. They may be situated in low or high rainfall climates with or without dry seasons. Some countries in cool temperate regions also face soil acidity problems. There are also some other categories of acid soils, with similar properties and potentials, occurring in volcanic ash soils, well-drained red sands, and poorly drained (water-logged) acid sulphate soils.

Development of the soil problem

Acidity normally develops in leached soil horizons where the supply of bases to the soil water, either from weathering of primary minerals or from other sources, is less than the losses suffered by leaching. Its intensity, however, depends upon the amounts and the strength of acids produced during the formation of secondary minerals and by the decomposition of organic matter added to the system. Factors favouring depletion of bases, and also of nutrients, in freely drained soils include high seasonal excess of precipitation, over evaportranspiration, parent materials being low in weatherable minerals, and accumulation of organic matter. On the other hand, changes in oxidation-reduction potential, oxidation of sulphur compounds under aerobic conditions and subsequent hydrolysis, resulting in production of mineral acids contribute to a decrease in pH on drying in case of acid sulphate soils.

Major constraints

Toxicity of Al and Mn along with deficiency of Ca and P (also fixation of added P) are the major detrimental factors affecting plant growth in acid soils. The oxisols and ultisols have a pH around 5.0, or less, associated with a high Al saturation (70% or more), a low Ca saturation (6.20%) and deficiency of most of the essential nutrients. Iron toxicity also occurs in strongly acid ultisols and in acid sulfate soils often in association with other stresses such as salinity, phosphorus deficiency and low base status.
APPROACHES TO SOLUTION

In general, well-drained acid soils can be made favourable for crop production through the use of lime and added nutrients wherever economic considerations permit such application. Where farmers are unwilling to take the risk of such investments, low-input soil management technology offers a more viable and practical solution. This approach involves “living with” certain soil constraints and maximising yield per unit of added chemical inputs through proper selection of tolerant plant species or varieties. It may be noted that the elimination of soil amendment or fertilizer application is not contemplated though dose levels are intended to be carefully curtailed.

Plants differ a great deal regarding their nutritional requirements as well as their ability to extract nutrients from the soil. They are also capable of undergoing evolutionary development to adapt themselves to the prevailing stress environment by responding to the selection pressure exerted by specific stress factor(s).

In recent years, we have come to learn more about soils as well as climates and we are better aware of their influence on plant growth and yield. We also now know more about plant adaptation to specific soil-climatic situations. Much remains to be done, however, to utilise this information in optimising natural combinations of plants, soils and climates with a view to evolving low-input technology to match the farmers’ resources in the target area.

Relevant plant species

Food Crops

- Rice (*Oryza sativa*), Bread wheat (*Triticum aestivum*), Cowpea (*Vigna unguiculata*), Rye (*Secale cereale*), Sugarcane (*Saccharum officinarum*), Cassava (*Manihot esculenta*), Plantain (*Musa paradisiaca*), and Yam (*Dioscorea alata*).

Fruit Trees


Other Perennials

- Coffee (*Coffea arabica*), Cola (*Cola nitida* and *C. acuminata*), Black pepper (*Piper nigrum*), Nipa palm (*Nipa fruticans*), Oil palm (*Elaeis...*)
guinensis), Pine (Pinus caribaea), Rubber (Hevea brasiliensis), Eucalyptus (Eucalyptus grandiflora) and Jacaranda.

Pasture Plants

Grasses

Andropogon gayanus, Brachiaria decumbens, Brachiaria humidicola, Digitaria decumbens, Panicum maximum, Pennisetum purpureum and Paspalum notatum.

Legumes

Desmodium heterophyllum, Stylosanthes capitata, Stylosanthes scabra, Stylosanthes viscosa and Zornia latifolia.

Mangroves and Halophytes

Heritiera fomes, Heritiera minor, Avicennia marina, Sonneratia apetala, Rhizophora mucronata, Rhizophora mangle, Ceriops decendra, Kandelia candel and Salicornia brachiata.

MAINTENANCE AND EVALUATION

Acid soils, saline acid soils, acid sulphate soils and peaty soils together form a very heterogenous group having some common constraints but each of these categories is distinct by itself because of soil, climatic and ecological characteristics. Plant species adapt to totality of their prevailing environments though the principle of growth limiting factors operates. In other words, associated stresses accompanying the major soil stress factor(s), in a particular situation of acid soils, are also important and should receive due consideration in maintenance and evaluation of relevant life support species. This makes the job of evaluation under stimulated set-up complex and more demanding. Another difficult decision pertains to the sample size for such studies in view of the remarkable genetic variability of these materials that appears to sustain stability of their population performance under a variable stress environment. Long-term consequences of attempts to develop uniform-looking (promising) selections from these heterogenous populations are far from clear. Yet another aspect of this subject, that has received wide attention, is the need to maintain computerised files on these valuable materials containing summarised data on their adaptive features, ecological preference and geographic relevance.
SALINITY AS A CONSTRAINT TO INCREASING RICE PRODUCTION IN ASIA

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*International Rice Research Institute, Los Baños Philippines*

**INTRODUCTION**

The benefits of modern rice technology have been substantial. But closer examination of the success shows that production increases have been confined primarily to favourable environments such as irrigable rice lands. Current trends indicate that in future, production increases from favourable environments may not be able to keep pace with projected population growth. Therefore, substantial research must be devoted to further increase the yield potential of irrigated rice. At the same time, there is an urgent need to attack the problem of rice production for unfavourable environments more vigorously than in the past.

Soil related factors are among the most significant constraints to rice production in unfavourable environments. The most common and most extensive problem is salinity. Furthermore, there are many million hectares of land suited to rice cultivation, but these are lying idle largely due to salinity. These areas could be brought into rice production through varietal development. Varieties now grown in saline soils have salt tolerance but low yield potential because of poor plant type and susceptibility to diseases and insects.

Tolerance to salinity can be combined with good agronomic and other desired traits. However, the high degree of location specificity caused by variation in soil and climate requires that distinct varieties be identified for each area, a process that will require careful coordination of research efforts. IRRI, in collaboration with some national programmes of Asia, has established a research cooperative with the objective of developing improved germplasm for salt-affected rice lands.

**RICE GROWING ENVIRONMENTS AND ECOLOGICALLY DISADVANTAGED AREAS**

Rice growing environments have been classified into five major categories: Irrigated, rainfed lowland, deepwater, upland and tidal wetlands (IRRI, 1984). These major categories have been divided into several subcategories as shown in Table 1. Of these, the irrigated category and the rainfed shallow, favourable sub-category, which constitutes
Table 1. Rice-growing environments. (Worldwide extent under each major category is indicated in parentheses)

1. **Irrigated** (77 million ha)
   a. Irrigated with favourable temperature
   b. Irrigated, low temperature, tropical zone
   c. Irrigated, low temperature, temperate zone

2. **Rainfed lowland** (33 million ha)
   a. Rainfed shallow, favourable
   b. Rainfed shallow, drought-prone
   c. Rainfed shallow, drought and submergence-prone
   d. Rainfed shallow, submergence-prone
   e. Rainfed medium-deep waterlogged

3. **Deepwater** (12 million ha)
   a. Deepwater—50–100 cm water depth
   b. Very deepwater—100 cm or more water depth

4. **Upland** (19 million ha)
   a. Upland with long growing season and favourable soil factors
   b. Upland with long growing season and unfavourable soil factors
   c. Upland with short growing season and favourable soil factors
   d. Upland with short growing season and unfavourable soil factors

5. **Tidal wetlands** (5 million ha)
   a. Tidal wetlands with perennially fresh water
   b. Tidal wetlands with seasonally or perennially saline water
   c. Tidal wetlands with acid sulphate soils
   d. Tidal wetlands with peat soil

About 20 percent of the rainfed lowland category, are considered the most favourable rice-growing environments. The rest are the ecologically disadvantaged rice areas.

In the Asian region, China, Japan, Korea and Pakistan grow rice under irrigated conditions. When these countries are excluded, of about 78 million hectares of rice lands in the region (including Bangladesh, Bhutan, Burma, India, Indonesia, Kampuchea, Laos, Malaysia, Nepal, Philippines, Sri Lanka, Thailand and Vietnam), roughly 53 million hectares or 68 percent are ecologically disadvantaged areas.

Various soil and climatic stresses are responsible for the low productivity of ecologically disadvantaged rice lands. Climatic stresses, though hazardous, rarely exclude the use of land for rice. Therefore, the development of technologies for minimising soil constraints becomes an important part of efforts to increase the productivity of ecologically disadvantaged rice lands. Moreover, it has been found that there are
about 58 million hectares of lowlands in South and Southeast Asia that are climatically and hydrologically suited to rice cultivation but lie idle due to soil problems.

Soil-related stresses can be relieved to some extent by soil amendments or reclamation, but such methodologies are not always feasible and economically viable. The availability of genetic variability to soil-related stresses in the rice germplasm suggests that the use of tolerant varieties can increase the productivity of current problem soils without costly amendments. Such varieties could also bring idle lands into cultivation without enormously expensive reclamation measures. Of the 58 million hectares of idle lands in Asia, roughly 23 million hectares can be used if rice varieties tolerant to soil problems become available.

The development of improved varieties tolerant to soil-related stresses is thus considered an area of high priority and urgency.

SOIL-RELATED STRESSES

Soil stresses are of three kinds: deficiencies (N, P, K, Fe Zn), toxicities (salts, Na, Fe, Al, Mn, B, H₂S and organic acids), and mineral imbalances. There is a wide range of soils that have only one major stress such as N−, Zn−, P−, K−, Fe− or S− deficient soils and Fe− or B− toxic soils. In disadvantaged rice lands, however, soil stresses are complex and are commonly called problem soils. These problem soils are broadly classified into five categories: saline, sodic, acid sulphate, peat and acid upland. Chemical stresses associated with these problem soils are given in Table 2. There are no accurate estimates of the extent of problem soils cultivated or cultivable to rice, but there is no disagreement that the commonest and most extensive of the soil problems is salinity. In fact, when rice varietal improvement research began in South Asia in the 1930s, breeding programmes specific to salt tolerance were initiated (Parthasarathy, 1972).

Table 2. Promising salt-tolerant lines developed at IRRI and their sources

<table>
<thead>
<tr>
<th>Source of salt tolerance</th>
<th>Improved salt tolerance lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pokkali</td>
<td>IR4630-22-2-5-1-3</td>
</tr>
<tr>
<td></td>
<td>IR4595-4-1-13</td>
</tr>
<tr>
<td>Nona Bokra</td>
<td>IR9884-54-3</td>
</tr>
<tr>
<td></td>
<td>IR10198-66-2</td>
</tr>
<tr>
<td>Kalarata</td>
<td>IR10167-129-3-4</td>
</tr>
<tr>
<td>SR26 B</td>
<td>IR10206-29-2-1</td>
</tr>
</tbody>
</table>
SALT TOLERANCE IN RICE

The differential response of rice varieties to salinity was established decades ago. In 1939, the salt-tolerant variety Pokkali from India was found to be suitable for saline land along the west coast of Sri Lanka and was recommended for cultivation there in 1945 (Fernando, 1949). In the mid 1940s, India established several rice stations, particularly for identifying salt-tolerant varieties (Parthasarathy, 1972). A review of the status of salt tolerant rices in India revealed several varieties in 10 states (Bhattacharjya, 1971).

During the past 25 years, many methods of screening rice varieties for salt tolerance have been developed to enhance breeding efforts (Ikehashi and Ponnamperuma, 1978). At the International Rice Research Institute (IRRI), laboratory and field methods are used to screen varieties for salt tolerance. From 1969 to 1986, a total of 1,03,493 varieties and elite breeding lines were screened; of these, 19,937 (19.3%) were found to be tolerant. Similarly, many national agricultural research institutes in the region conduct varietal screening research.

IR36 and IR42 are two modern varieties that have moderate levels of tolerance to several soil problems including salinity, although no deliberate attempt was made to incorporate such traits into them (Khush; 1984). The traits were inherited from the parents or were due to recombination and remained undisturbed during selection for other characters. Varieties such as IR36 and IR42 thus demonstrate the possibility of combining high yielding ability with salt tolerance.

At IRRI, breeding specifically for salt tolerance commenced in 1974. Well-known tolerance donors such as Pokkali, Nona Bokra, Kalarata, and SR26B were hybridised with varieties having good agronomic characters, and several high yielding lines with salt tolerance have been developed. The lines in Table 2 have repeatedly shown promising results.

Other improved salt-tolerant lines have been developed, by national research programmes, among them BR51-282-8 (Bangladesh); RP975-109-2, C5, and PNL32-10-1-1 (India); and At 69-2 (Sri Lanka). Although these and other varieties have been in circulation for several years, the salt-affected lands in disadvantaged areas are still being cultivated to traditional varieties or their pure line selections. The main reason is that tolerance to salinity is essential to the varieties, but there are many other plant characters that determine acceptability and adaptability. These characters are not found in improved salt-tolerant lines.
Varietal requirements

Salinity rarely occurs alone. In arid and semi-arid lands, salinity is usually associated with alkalinity. In coastal saline lands, acidity, acid-sulphate conditions and peatiness are common. These soil conditions cause additional stresses such as Fe, Al, Mn, B, H₂S, and organic toxicities; and deficiencies of N, P, K, Zn, and Fe, depending on the soil type (Table 3). As a result, most salt-affected ricelands require varieties with tolerance to multiple soil-stresses.

In addition to soil problems, these lands also suffer from climatic stresses such as flash-floods (submergence), deepwater conditions, and drought. For example, some saline ricelands in West Bengal, India, have deepwater problems; in Bangladesh, the crop is prone to submergence during its early stages; and in the Philippines, drought is common during ripening. Therefore, the heterogeneity of climate and water regimes must be considered in any breeding programme. Traditional salt-tolerant varieties are photoperiod-sensitive. The degree of sensitivity varies among varieties, but this trait is essential to cope with climatic stresses. Pests and diseases do not take a heavy toll from saline ricelands. However, nutrient deficiencies and toxicities often cause increased susceptibility, thus reducing yield stability. Therefore, some degree of resistance to pests and diseases is also essential.

The traditional varieties have the cooking and eating qualities preferred by the growers. In fact, some of the varieties grown in salt-affected lands are considered of premium grain quality. For example, Kho Dawk Mali of Thailand, Wagwag of the Philippines, Aromatic Sambas of Sri Lanka, the Siam and Bayer types of Indonesia and the well known Basmati of India and Pakistan have excellent cooking and eating qualities. The very high prices fetched by these rices offset their low yields. Any new variety must thus have the same grain quality or a yield potential very much higher than that of traditional varieties.

Crop management practices on disadvantaged lands are very different from elsewhere. Seedlings are transplanted when they are about 4–6 weeks old. In Indonesia, double or triple transplanting is common. Weed control measures are minimal. Applications of fertilizers and agro-chemicals are rare. For such management conditions, the modern plant type is not suitable. The requirement is a type adaptable to these conditions as well as responsive to improvements in management.

Apart from salinity other important traits such as multiple stress tolerance, photoperiod sensitivity, pest and disease resistance, grain quality, and plant type must be considered in breeding better varieties for salt-affected ricelands. The breeding strategy should, therefore, be to improve the yield and the stability of adapted traditional cultivars.
Table 3. Problem soils and their associated chemical stresses.$^a$

<table>
<thead>
<tr>
<th>Stress</th>
<th>Saline</th>
<th>Sodic</th>
<th>Acid Sulfate</th>
<th>Peat</th>
<th>Upland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arid</td>
<td>Acid</td>
<td>Coastal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonsodic</td>
<td>Sodic</td>
<td>pH&lt;5</td>
<td>pH&gt;7</td>
<td>Coastal</td>
</tr>
<tr>
<td>Salinity</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>P deficiency</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>H₂S toxicity</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Fe toxicity</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Al toxicity</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn toxicity</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe deficiency</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn deficiency</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodicity</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B toxicity</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic toxicity</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ + = present.
Breeding Strategy

Adaptability and productivity traits of traditional varieties possess negative correlations; hence, the problems of these undesirable genetic linkages must be overcome. The availability of genetic male sterility in rice (Singh and Ikehashi, 1981) allows the use of breeding methods such as recurrent selection and population improvement to break undesirable linkages. Yet, there are several other problems. Photoperiod sensitivity delays the breeding progress. To overcome this delay, methods such as shuttle breeding, anther culture, and generation advance under controlled conditions have to be employed. To select for local adaptability, breeding materials must be evaluated in target environments, but adaptability traits in different environments may vary widely compelling simultaneous multilocation testing. Selection for pest and disease resistance must be done under controlled conditions, since such biotic stresses are not frequent and uniform in target environments. Advanced breeding lines must be tested against individual biotic and abiotic stresses to confirm adaptability.

A range of research activities is required. Conventional breeding methods must be supplemented with innovative techniques. A large portion of breeding activities must be carried out in target environments to identify strains with adaptability to location-specific stresses. Rapid generation advance techniques must be employed to expedite breeding. These activities would require enormous resources, manpower, and facilities, investments, which are not economical because of the low returns from the efforts required to effect significant changes in these lands. Therefore, improvement can be possible only with the active cooperation of concerned scientists and institutes in sharing available resources. In this context, certain national rice research programmes of South and Southeast Asia and IRRI have recently established a research cooperative for improving the productivity of rice lands with problem soils. In this cooperative, the Central Soil Salinity Research Institute, India, will collaborate with IRRI to develop improved rice varieties for saline soils. The two institutes will jointly design research programmes, accepting responsibility where each has a comparative advantage. Elite strains developed by the programme will be made available to all other interested national programmes.

REFERENCES


SOME PROMISING LIFE SUPPORT SPECIES FOR MARGINAL (ALKALI) SOILS

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INTRODUCTION

A large number of under-exploited plants have shown good promise for utilisation of the marginal soils, vast areas of which otherwise lie barren as wastelands. The utilisation of these marginal lands will help augmenting supplies of these commodities without conflicting with the food priorities. Among these, noteworthy success has been achieved with respect to the winged bean (*Psophocarpus tetragonolobus*) and grain amaranths (*Amaranthus hypochondriacus*). Both these species yield good quality seed protein in common. The former one yields good quality edible oil too. Likewise, species of Sesbania (*S. aculeata*, *S. sesban* and *S. grandiflora*) are the other promising species suited for raising plantations on such lands to alleviate the firewood crisis. Yet another multi-purpose plant *Moringa oleifera* deserves due consideration for its food and fodder values, besides finding use in paper industry. The present paper deals with agronomic and chemical evaluation of some of the aforesaid promising life support species suited to marginal (alkali) soils.

PROMISING LIFE SUPPORT SPECIES

**Winged bean (*Psophocarpus tetragonolobus*)**

Winged bean with its seemingly exceptional merits has recently aroused great enthusiasm in the countries of the third world, as almost all parts of the plant are edible, the young green beans constitute an important item which may be consumed fresh as green vegetables or ripened, the mature seeds provide a source of good quality edible oil and high protein food. While hot humid tropical conditions are best suited for its growth, winged bean responds favourably to irrigation and, consequently, can be grown in drier regions also. Considering these attributes of the plant (Anon., 1981; Racie and Luse, 1978) and to expand the knowledge base for its efficient exploitation in new areas, series of field and laboratory trials have been conducted, the results of which are reported as under:

The data presented in Table 1 indicate that winged bean possesses wider adaptability to the soil and the climatic conditions. The level of
Table 1: Yield of winged bean seeds (tons/hectare) under different culture treatments

<table>
<thead>
<tr>
<th>Experiment 1 Growth fashion</th>
<th>Experiment 2 Planting dates</th>
<th>Experiment 3 Spacing experiments cm²</th>
<th>Yield of seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staked</td>
<td>April 19</td>
<td>1.39</td>
<td>32.4</td>
</tr>
<tr>
<td>Unstaked</td>
<td>May 1</td>
<td>1.49</td>
<td>36.0</td>
</tr>
<tr>
<td>SEM±</td>
<td>May 16</td>
<td>1.56</td>
<td>40.0</td>
</tr>
<tr>
<td>LSD</td>
<td>June 1</td>
<td>1.18</td>
<td>44.4</td>
</tr>
<tr>
<td></td>
<td>June 15</td>
<td>1.34</td>
<td>49.2</td>
</tr>
<tr>
<td></td>
<td>June 30</td>
<td>1.34</td>
<td>54.8</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>60.7</td>
<td>1.193</td>
</tr>
<tr>
<td></td>
<td></td>
<td>67.5</td>
<td>1.179</td>
</tr>
<tr>
<td></td>
<td></td>
<td>74.9</td>
<td>0.962</td>
</tr>
<tr>
<td></td>
<td></td>
<td>83.1</td>
<td>1.076</td>
</tr>
<tr>
<td></td>
<td></td>
<td>92.4</td>
<td>0.934</td>
</tr>
<tr>
<td></td>
<td></td>
<td>102.4</td>
<td>0.857</td>
</tr>
<tr>
<td></td>
<td></td>
<td>113.9</td>
<td>0.686</td>
</tr>
<tr>
<td></td>
<td></td>
<td>126.4</td>
<td>0.628</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140.3</td>
<td>0.554</td>
</tr>
<tr>
<td></td>
<td></td>
<td>155.2</td>
<td>0.485</td>
</tr>
<tr>
<td></td>
<td>SEM±</td>
<td>0.184</td>
<td>0.361</td>
</tr>
<tr>
<td></td>
<td>LSD (0.05)</td>
<td>0.184</td>
<td>0.361</td>
</tr>
</tbody>
</table>

SEM = ± Standard error of the mean
LSD = Least significant difference
NS = Non significant

Seed production, 0.7–1.56 tons/hectare, obtained under the present set of conditions compares fairly well with their yield of 1.2–1.4 tons in other tropical countries. The yield, however, tends to vary under varied agronomic conditions. As for the time of planting, although mid-May sown crop gave the highest yield (1.56 tons/hectare) there was no difference in the yield response due to planting dates which therefore do not appear to be of much significance. However, the seeds must be sown latest by June. Thereafter, once the monsoon has started, it becomes difficult to work on the clay soils.

Provision of stakes in the cultivation of winged bean increase the seed yield (to the extent of about 73% was obtained from the staked crop over the unstaked one). The results are in conformity to the findings of Rachie (1974). Pospisil et al. (1982) have also reported that winged bean grown on supports produced about three times as many pods and 2.72 times as much dry seeds as plants grown without supports.
Among the agronomic components the density of the plants, governed by inter and intra row spacings, plays a major role in the crop production. The plant population per unit area which is directly associated with its spacing, has shown a marked effect on the seed yield of winged bean. The highest seed yield (2.199 tons/hectare) was obtained with the closest spacing (32.4cm$^2$). The yield per unit area, however, continued to decline with increase in spacing. Higher population involved increased cost towards seed and stakes. To determine an optimum limit, curves corresponding to the seed and cost factor were found to intersect each quality of levels between 44.4 and 49.2 cm, thereby, suggesting that the optimum spacing lies between these two limits, and the plant population at this level works out to 38726 to 31211 with corresponding seed yield of 1.1–1.2 tons/hectare. Other factors being constant the cost towards the seed and staking works out to Rs. 3100 (US $ 258) at this level.

**Sesbania spp.**

*Sesbania aculeata*

It is a quick growing annual which finds several uses. It is well adapted to problematic soils, i.e. the saline-alkali and water logged soils. It is an ideal green manure crop for improvement of such soils which often remain barren for want of suitable crops. The seeds are rich source of gum to the extent of 30–42 per cent by seed weight, suitable for sizing textiles and paper products and for thickening and stabilising solutions. When grown for seed, a yield of 10–15 q per hectare can be obtained besides the dry sticks which makes useful firewood. The stem also provides bast fibre (9 per cent) which is said to be stronger than jute. The *S. aculeata* also finds use in pulp for paper products.

*Sesbania grandiflora*

Despite its several uses, *S. grandiflora* has not been fully exploited and investigated. It forms a small tree when fully grown and provides forage, firewood, pulp and paper, food, green manure and landscape decorations, also it appears to have much potential for deforestation of eroded lands and wastelands. It is a promising species for short rotation forestry on the tropical wastelands including the salt affected soils. It can ideally fit in the short rotation high density planting programmes to meet the immediate firewood requirements.

The young leaves, tender pods and giant flowers of *Sesbania grandiflora* are favourite vegetable used, in various ways, i.e. in curries and soups or fried, lightly steamed or boiled. The leaves contain 36 per cent crude
protein and with a high mineral and vitamin content make a remarkably nutritious spinach-like vegetable. The plant has been traditionally used as a support for pepper and betel.

*Sesbania aegyptiaca*

*S. aegyptiaca* is a short lived tree that regenerates after pruning and has a tendency to form root nodules by symbiotic association with soil bacteria capable of fixing atmospheric nitrogen. In fuel scarcity areas, *S. aegyptiaca* is often planted to provide firewood. Being fast growing, it provides enough firewood per unit area in a short period of time to meet the urgent and immediate requirements. *S. aegyptiaca* can tolerate a wide range of soil conditions. It can withstand the acid reactions of the soil as well as alkaline soils which suffer from periodic flooding and water logging. It can endure 0.4–1.0 per cent salt concentration in the seeding stage and 0.9–1.4 per cent near maturity.

The yield of fresh biomass of *S. aegyptiaca* raised on alkali soils (pH ranging between 9.3 to 9.8) varies between 61.8 to 132.5 q per hectare per year depending upon the plant population per unit area. Corresponding to this, yield of air dried fuel to the tune of 20.0 to 48.0 q is obtained. The moisture percentage in fresh biomass of one year growth ranges between 70–75 per cent. The plant growth on the salt affect ed soils tends to improve the soil conditions more so with leguminous species like *S. aegyptiaca*. It tends to raise the Ca/Na ratio in the soil by mobilising the immobile Ca as a result of acidic conditions generated by the roots.

**Grain amaranth (Amaranthus hypochondriacus)**

The grain amaranth has fast maturation, is adaptable to marginal soil conditions and is tolerant to cold when grown at high attitudes. This group holds great promise as a subsidiary food crop in the developing countries. Although there is a considerable area under grain amaranth cultivation in the Indian sub-continent, the package of agricultural practices for this potential life support species is yet to be worked out. The trial conducted on its performance under varying planting densities by Mishra *et al.* (1985) on the alkali soils reveals that the growth and development of grain amaranth is greatly influenced by the plant population per unit area (Tables 2 and 3).

The data on yield per hectare of grain amaranth (Table 4) reveals that the yield increased with increasing plant population as a result of closer inter and intra row spacings. Whereas at higher plant density the yield per plant decreased, the total yield per unit area, however, showed an increasing trend due to a greater number of plants. In terms
Table 2: Plant growth and yield of grain amaranth under different planting densities

<table>
<thead>
<tr>
<th>Spacings</th>
<th>Plant population (000)/ha</th>
<th>Height of plants (cm)</th>
<th>Length of inflorescence (cm)</th>
<th>Grain yield per plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 cm</td>
<td>7.5</td>
<td>4.44</td>
<td>110.463</td>
<td>49.738</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>2.22</td>
<td>110.563</td>
<td>53.008</td>
</tr>
<tr>
<td></td>
<td>22.5</td>
<td>1.48</td>
<td>111.783</td>
<td>55.225</td>
</tr>
<tr>
<td>45 cm</td>
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<td>2.96</td>
<td>109.420</td>
<td>53.038</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>1.48</td>
<td>108.588</td>
<td>54.500</td>
</tr>
<tr>
<td></td>
<td>22.5</td>
<td>99</td>
<td>105.250</td>
<td>54.588</td>
</tr>
<tr>
<td>60 cm</td>
<td>7.5</td>
<td>2.22</td>
<td>106.080</td>
<td>54.550</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>1.11</td>
<td>108.575</td>
<td>56.650</td>
</tr>
<tr>
<td></td>
<td>22.5</td>
<td>74</td>
<td>108.075</td>
<td>57.263</td>
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<tr>
<td>75 cm</td>
<td>7.5</td>
<td>1.78</td>
<td>109.075</td>
<td>56.450</td>
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<td></td>
<td>15.0</td>
<td>89</td>
<td>106.325</td>
<td>57.088</td>
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<td></td>
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<td>58.150</td>
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<tr>
<td>SEm±</td>
<td>3.457</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td>7.313</td>
</tr>
</tbody>
</table>

LSD = Least significant difference  
NS = Not significant

Table 3: Yield of grain amaranth (q/ha) under different spacings

<table>
<thead>
<tr>
<th>Spacings</th>
<th>7.5 cm</th>
<th>15.0 cm</th>
<th>22.5 cm</th>
<th>SEm±</th>
<th>LSD (0.05)</th>
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</thead>
<tbody>
<tr>
<td>30 cm</td>
<td>13.694</td>
<td>12.207</td>
<td>11.768</td>
<td>0.733</td>
<td>1.437</td>
</tr>
<tr>
<td>45 cm</td>
<td>12.055</td>
<td>10.083</td>
<td>8.970</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>60 cm</td>
<td>12.491</td>
<td>8.324</td>
<td>7.471</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>75 cm</td>
<td>10.961</td>
<td>7.794</td>
<td>6.752</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SEm±</td>
<td>0.846</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.659</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

LSD = Least significant difference

of plant population, the highest yield was obtained with 444,444 plants per ha followed by 296,206 (45 × 7.5 cm) and 222,222 (60 cm × 7.5 cm). It appears, therefore, that a plant population between 2-5 lacs (one hundred thousand) per hectare would be adequate to obtain the desired results from the crop under the marginal soil conditions.
Moringa spp.

Two species viz., M. oleifera and M. concanensis are reported from India of which M. oleifera is commonly grown and finds a place in kitchen garden/courtyards. All parts of the plant are used. The leaves are a good source of Vitamin C and the leaf protein is equivalent to a rich source of phosphorus, and serves as a good cattle feed. Moringa is a potential crop for dryland agriculture and also grows well in marginal wastelands. The alkaloids, Moringine and Moringinine, are used in medicine.

REFERENCES


LIFE SUPPORT TREE SPECIES ON SODIC SOILS

G. S. SRIVASTAVA

National Botanical Research Institute, Lucknow, India

INTRODUCTION

Sodic soils occupy a major area of wastelands in the country. These can be harnessed to fruitful purpose by planting useful tree species. Trees improve the biosphere, provide shelter and useful articles of our use and by root penetration and soil amelioration improve the land tremendously. They bring about a marvellous transformation of the wasteland into excellent arable land. For growing trees, a choice of the right type of species has to be made and certain techniques to be adopted. By providing chemical amendments, we can grow probably any species in sodic soils depending on the agro-climate to which the particular species is suited. There are hundreds of species which can be grown even without providing any inorganic amendments (Srivastava, 1970; Srivastava et al., 1973; Srivastava, 1987; Srivastava and Srivastava, 1987 a & b). What is needed is a wide knowledge of the availability of plants, their soil and climatic adaptations, and experience of plants based on close touch with the nature and the will and efforts to grow them. Such an effort was made by the author during 1958–1963 and 1965–1972 and observed that numerous useful trees along with medicinal plants, fibre yielding plants, fodder grasses, etc. could be successfully grown. The results are presented.

PLANT SPECIES FOR SODIC SOILS

The work was carried out at the Banthra Research Station of NBRI, Lucknow (formerly known as the National Botanic Gardens). There were two blocks of land on which the plantations were established. In the first block where the tree shelter belt was established, the average pH of the soil varied from 9.0 to 10.5 in 0–30 cm layer. The soil was underlaid at depth of 1 metre by a hard pan and was poorly drained. The second block where Acacia species, Eucalyptus species and other generic collections such as of Bauhinia, Callistemon, Ficus, Lagerstroemia, Prosopis, Sterculia etc. were raised, had a varying pH in patches, pH of 8.5 to 9.0 at the surface, and higher pH at lower levels, up to 10.5 at 60 cm depth. It had a hard pan at a depth of 80 to 100 cm, while in some patches the pH varied from 8.1 to 8.7 at the surface and 9.7 to 10.5 at 60 cm depth.
No inorganic amendments were used in reclamation of the land. The techniques adopted in cultivating the species is reported by Srivastava (1987). These constituted:

1. **Contour bunding**

   The contour bunding was done in the plots which were subjected to erosion due to surface run off during the monsoon. Small bunds having a height of about 25 cm were made to permit impounding of irrigation water and drainage into a lake. The bunds were very useful for growing trees such as *Dalbergia sissoo*, *Albizzia lebbek*, *Acacia nilotica*, *Derris indica* and *Caesalpinia coriarea*. These plants could be successfully raised by direct sowing of seeds on the bunds during the rainy season. The trees have grown exceedingly well without much care except watering the seedlings in the young stage.

2. **Interplanting**

   In the intervening spaces between the bunds, as also between rows in some places, close planting of tolerant shrubs as *Clerodendrum indicum*, *C. phlomoides*, *Ipomoea fistulosa*, *Jatropha gossypifolia*, *Sesbania grandiflora*, *Leucaena glauca*, *Sesbania aegyptiaca* and *Vitex negundo* was done by seeds or cuttings. This helped in lowering soil pH, increasing permeability and providing organic matter to the soil.

3. **Breaking of hard pan and filling of pits**

   Breaking of hard pan was considered necessary to establish a number of species. Pits about a metre cube were dug and refilled with soil, taken at more than 1.5 metre depth in ditches. Some pits were also filled with soil mixtures consisting of:

   (i) Soil mixed with thin cinders (burnt coal from mills or railways) in the ratio of 1:1.

   (ii) Soil mixed with river sand in, the ratio of 3:1.

   (iii) Soil mixed with available organic matter such as paddy straw, plant twigs, leaves, etc. in the ratio of 2 parts soils and 1 part organic matter.

**Selection of species**

There existed considerable variability among different patches within short distances and so the plant selection for different patches was important. It was found that in places, where ‘kankar’ layer was exposed,
it was possible to raise *Prosopis juliflora*, *Acacia nilotica*, *A. farnesiana*, *Mimosa rubicaulis* and *Parkinsonia aculeata* by direct sowing of seeds.

In places where waterlogging was a problem, plantations of *Salix tetrasperma*, *Typha elephantina*, *Pandanus tectorius* and *Acorus calamus* could be raised. Along the slopes of the roads, *Borassus flabellifer* and *Acacia nilotica* could be raised by direct sowing of the seeds.

In the shrubberies, *Hibiscus* species, *Thevetia peruviana*, *Nerium indicum*, *Clerodendrum inerme*, *C. aculeatum*, *Lawsonia inermis* and *Tecoma stans* could be grown with great success and these could also be used to make good hedges. Performance of many of these was better than on sandy soils of Lucknow. Analysis of leaf samples, collected from current season’s growth of various species of ornamental shrubs grown on normal and alkali soils for macronutrient elements showed that concentrations of N, K, P and Ca were within the recommended ranges of sufficiency.

In places where raising of plants was difficult, some grasses such as *Brachiaria mutica* and *Panicum antidotale* could be established. On some bad patches where it was found difficult to grow other plants, a cover was made by planting *Crinum asiaticum*, *C. defixum*, etc., by providing damp conditions. In addition, *Carissa carandas/C. congesta* and *C. spinarum* could be planted successfully along the borders. Trees such as *Callistemon lanceolatus* and *Sesbania grandiflora* could be grown on raised pits.

### Treating plants differently

All plants did not grow well under the same treatments. So it was necessary to treat some plants differently. Mulberry and *Lantana* planted on flat ground instead of pits grew better. Similarly watering of different plants had to be adjusted differently.

The following species were successfully grown:

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*Barringtonia acutangula*, *Bauhinia acuminata*, *B. diphylia*, *B. erubescens*, *B. hookerii*, *B. purpurea*, *B. retusa*, *B. rufescens*, *B. variegata*, *B. variegata* var. *candida*, *Bombax ceiba* and *Borassus flabellifer*. 
LIFE SUPPORT SPECIES


—Dalbergia sissoo, Delonix regia, Diospyros montana and D. peregrina.
—Ficus benghalensis, F. benjamina var. camosa, F. hispida, F. lacor, F. religiosa and F. rumphii.
—Hibiscus elatus, H. elatus var. variegatus and H. tiliaceus,
—Lagerstroemia floribunda, L. flos-reginae, L. rosea and L. thorelii.
—Madhuca indica, M. longifolia, Markhamia stipulata, Melaleuca leucadendron, Melia indica, Millingtonia hortensis and Morus laevigata.
—Peltophorum pterocarpum, Pithecellobium dulce, Prosopis nandubey and P. spicigera.
—Salix tetrasperma, Soymida febrifuga, Streblus asper and Syzygium cumini.

Behaviour of Plants

Some species such as Azadirachta indica and Delonix regia do very well in the beginning but they either die after some time or become stunted and sickly. On the other hand, there are some species of Cassia, which grow slow in the beginning but after some years they establish into healthy plants.

Some other species cultivated on the land have shown the tendency of running wild. They colonise in pockets that are favourable for their growth. The species are Brachiaria mutica, Ipomoea turpethum and Malachra capitata.

CONCLUSIONS

A number of tree species, particularly those belonging to the genera Acacia, Bauhinia, Callistemon, Eucalyptus, Ficus and Terminalia have
found adaptable to sodic soils. A good hand at planting and care is important. Preferential treatments have to be given in some cases. Based on the experience, trees can be selected to form different life support systems, some of which are mentioned below:

1. **Sources of oils and fats**

   *Alangium lamarkii, Azadirachta indica, Caesalpinia bonduc, Jatropha curcas, Madhuca indica, Pithecellobium dulce and Pongamia pinnata.*

2. **Sources of tannins**

   *Acacia catechu, A. leucoxloea, A. mollissima, A. nilotica, A. polyacantha, A. suma, Albizzia procera, Anogeissus latifolia, Caesalpinia coriaria, Cassia auriculata, C. fistula, Eucalyptus leucoxylon, E. tessellaria, Feronia limonia, Pithecellobium dulce, Punica granatum, Terminalia arjuna, T. chebula and T. tomentosa.*

3. **Sources of honey**


4. **Sources of gum**


5. **Sources of forage**

   *Acacia albida, Ficus benghalensis, F. benjamina var. camosa, F. hispida, F. lacor, F. religiosa, F. rumphii, Pithecellobium dulce and Prosopis spicigera.*

**REFERENCES**


IMPROVING FUELWOOD SPECIES—NEED FOR AN INTEGRATED APPROACH

O. P. VIMAL

Department of Non-Conventional Energy Sources, Ministry of Energy, New Delhi, India

INTRODUCTION

Fuelwood is the dominant source of energy in the rural sector. Around 100 million people in developing countries live in firewood deficit areas, whereas another 1000 million meet their needs by cutting in excess of sustained supply. According to the National Commission on Agriculture, fuelwood shortage in India is expected to be of the order of 100 million m³ by 1990. This spectrum calls for a serious look at various approaches which may help in increasing bioproductivity of fuelwood species.

One of the limitations of the fuelwood programme has been the fact that, so far most of the species utilised as a source of fuel are otherwise cultivated for various commercial purposes. The use as fuelwood has been of secondary nature despite its value in our national endeavour, restricting the choice to species having a variety of uses. Lately, along with the use of such taxa, the need for choice of species with primary objective of their utilisation as fuelwood has been deeply felt and this forms the core of the energy plantation programme.

Till now, the fuelwood programme has been principally oriented towards utilising the existing germplasm resources rather than the generation of the improved types. But, the parameters for the choice of fuelwood are quite different from those of other forestry species. The prime criteria of fast growth rate, rapid coppicing ability, non-lodging, drought tolerance, and high biomass yield need to be given serious consideration in fuelwood programme. The species utilised so far being mostly of timber value, the germplasm base has also been very narrow. Thus, broadening of the genetic base is imperative.

IMPROVEMENT OF ENERGY PLANTS

The genetic improvement in energy plants is to be associated with necessary physiological parameters and agronomic stability of desired genotypes should be undertaken in terms of the fast growth and rapid rate of branch regeneration. In such types, the generation time, cell
cycle and DNA content, which have different values in the perennials require genetic manipulation to ensure rapid growth. Standard genetic techniques exemplified by selection, mutagenesis, breeding and polyploidization, aided by \textit{in vitro} procedure may pay very high dividends in bio-energy research. However, tissue culture techniques in crops have the dual advantage of rapid propagation and enrichment of genetic diversity through \textit{in vitro} instability. Such \textit{in vitro} instability in energy plants has very little scope for utilisation. This is simply because of the fact that in natural forests the perennials have undergone a long period of evolution to attain stability. Any attempt to secure highly variable genotypes arising \textit{in vitro} and to stabilise such forest species in cultivation may require generations, and that too with the uncertainty of its adaptation to the forest ecosystem. In view of this limitation, it is preferable to utilise the \textit{in vitro} technique in energy plants principally for mass scale propagation of elite clones and analysis of genetic and bio-chemical pathways, characteristic of energy plants.

In order to have a breakthrough in the improvement of energy plants, a coordinated programme on a priority basis is imperative. Such a programme is desired to involve an integrated approach of genetics, physiology and agronomy, so that the selected species can satisfy the needs of the people throughout this sub-continent. Success of genetic programme is dependent on the location and control of genetic variability. This can be done by mapping natural distribution and comparing growth measurements and allied data from widely separated regions of the species distribution. Studies of genetics and reproductive biology are of immense help in understanding the genetic make-up of natural variation and of open pollinating seeds, both of which are linked with genecology of the species. A knowledge of flowering, pollination, seed-setting, seed fertility, sterility, seed quality, seed viability, germination, seeding and sapling mortality and growth of widely distributed forest species are of practical importance. The work on indigenous species is essential as in the long run, they are better adapted than exotics in respect of survival and productivity.

The study of stress environments

The methods of tree genetic improvement for adaptability and productivity on salt-rich alkaline \textit{usar} areas are different from those applicable to normal productive forestry. Trees on such sites are absent or scarce because tree establishment and survival are difficult. Selection for inherent characters of site-adaptability and salt tolerance of species, races and provenances, therefore, become important and trial testing of provenances for site/genotype reaction is essential for successful afforesta-
Selection of such sites. Selection is basic for genetic improvement of trees followed by selective breeding. The primary parameters for selection are survival at nursery level, survival after transplantation, establishment rate, growth and productivity of adapted germplasm in terms of biomass production and superior fuel (calorific values, wood density, dry weight, etc.) and soil ameliorative characteristics.

Water is often the chief limiting factor for crop establishment and growth of energy plantations, and every effort is needed to conserve moisture by adopting site preparation and cultural practices.

In arid and semi-arid areas, 'sand drift' is prevented by fixing barriers in parallel strips or in chess-board design, using locally available bushes and shrubs. Plantation is raised by planting sturdy seedlings in containers filled with a mixture of sand, clay and farm yard manure in equal proportion. Before plantations are raised, saline/alkaline lands are improved by drainage through deep ripping, lowering water table through tubewells, soil amendment by gypsum, sulphur and pyrite and use of green manure or other organic matter.

The available land for energy plantation (fuel wood) in hills is either stress-prone, disturbed or full of weeds. Therefore, the selected species should be stress tolerant, defensive as well as offensive in their behaviour. In addition to these general characteristics, these should have the potential of rapid, early growth and ease of regeneration.

In trees, specially while dealing with forestry and that too in hills, the chances of application/use of irrigation and fertilisers are remote. However, genetic manipulations in the selected species are possible, provided the species characters related to productivity and survival are well established. Some of the studies, having bearing on genetic manipulations, need to be explored. These are:

(a) Investigations on water-use pattern by the trees. This will include studies on the basis of water-use efficiency and stomatal behaviour.

(b) Studies on the effect of extreme temperatures on trees. Attention should be directed towards energy exchange studies and cellular and molecular lesions associated with temperature stress.

(c) Considering the importance of roots in acquisition of water and nutrients, studies on root growth need immediate attention.

Agronomical practices

Priority for research on agronomical practices of fuelwood systems needs emphasis on:

- Establishment of methods related to direct seed sowing, determination of age and size of planting stock and time of planting and restocking.
- Standardisation of spacing trials covering the range from dense to free growth and thinning trials on existing plantations amenable to such trials. Depending on the crown and branch structure, the spacing of $1 \times 1 \text{ m}$, $2 \times 1 \text{ m}$, or $2 \times 2 \text{ m}$ may be adopted.

- Increase in biomass yield through improved silvicultural and management practices, mainly including foliage manipulation through pruning, coppicing, suckering or hedge rows. Some species are managed on a very short coppice rotation, often as short as a year. These short rotations may be used for the production of small sized wood for domestic fuel.

- The coppicing ability of many species is known but for others it still needs investigation. In coppicing, an investigation into the best time of the year for cutting the trees is needed. Such factors as coppice rotation and the number of stems to be retained per stool, to maximise production of desired size of timber, are also to be considered for many species.

- Tolerance of energy plants towards salt (salinity, alkalinity) and water stress needs to be worked out as most of the ‘wastelands’ fall under these categories. Water requirement per unit of biomass is an important criterion of a species that needs to be worked out.

- Development of improved techniques for the culture and inoculation of N-fixing species with known strains of *Rhizobium* sp., *Franka* sp. and actinomycetes before their use in nursery and field trials.

- Evaluation trials, incorporating new or modified techniques of growing N-fixing species. in pure or mixed culture with non-N fixing species.

- Inventory using biomass partitioning, and comparative study of the status of soil nutrients in relation to pure or mixed plantations and ameliorating effect on the soil.

- Fertilizer experiments on nutrient deficient areas to determine suitable low input or medium output technology. Short-term simple experiments are required to indicate the need for fertilization at nursery and plantation stage. This is particularly important in case of high density plantations.

AN OVERVIEW

The Fourth Convention and Symposium organised by the Bioenergy Society of India, Rajasthan Chapter, at Udaipur, during September, 1987, in the panel discussion on ‘Bio-Energy for Arid Region’ stressed the need
to broaden the narrow genetic base of fast growing drought resistant plants. This calls for a survey of the existing genotypes and creation of chain of germplasm resource banks which would be available for all regions. The necessity of preservation of desired diversity need not be over emphasised.

From this synoptic survey, it is evident that improvement of fuel-wood species is an essential parameter to meet the growing crisis. The success of ‘Green Revolution’ is attributed mainly to the adoption of high yielding varieties and development of management practices, and some strategy needs to be practised in forestry programmes on waste/degraded lands. Institutional infrastructure already exists in the country in the form of agricultural universities, research institutions, extension agencies; what is needed is only development of an integrated approach based on genetic, physiological and silvicultural techniques.
USE OF LIFE SUPPORT SPECIES FOR SURVIVAL PURPOSES IN NEW ZEALAND

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DSIR, Lincoln, New Zealand

INTRODUCTION

New Zealand lies in an isolated position in the South-West Pacific, with its nearest land mass being Australia. It has a temperate to subtropical oceanic climate with changeable and windy weather. January (summer) temperatures in the inhabited part of the country average 10°C to 24°C, while July (winter) temperatures average 5°C to 20°C. Rainfall varies with the wettest areas being those on the west side of the north to south mountain axis of the country. These mountains intercept humid westerly winds with rainfall exceeding 3000 mm per annum in some locations. Some inland areas are dry, but no part of the country is extremely arid. These climatic features suit the growth of temperate plant species, and apart from at high altitudes, growth continues throughout the year, although most plants show marked seasonality of vegetative growth, flowering and fruiting. The native species are mostly evergreen.

Of an area of 269,000 km², approximately 46% of New Zealand’s land is unsuited to agricultural use. Much of this area is mountainous, but some is used for forestry, while 39% remain as wilderness with value for water catchment, recreation and conservation. The application of this paper is mostly directed at the support of human life in these non-agricultural areas. The capacity of the agriculturally used area of New Zealand to produce the plant materials required for basic food and shelter far exceeds the requirements of the human population of New Zealand’s 3.35 million.

The daily life and economic well-being of the people of New Zealand is based largely on the use of plants, both directly for human consumption, and as food for livestock, mostly sheep and cattle, whose products provide 48% of the value of New Zealand’s overseas trade. This plant productivity is almost entirely based on introduced species, the most important of which are listed in Table 1. These plants have all been the subjects of considerable research and development in New Zealand. At the top of the list is white clover (Trifolium repens) which coupled with appropriate amelioration of soil conditions to suit its growth is the essential legume supporting much of New Zealand’s pastoral indus-
Table 1: Ten most important plants species contributing to food production in New Zealand

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Origin</th>
<th>Product</th>
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<tr>
<td><em>Trifolium</em></td>
<td>White clover</td>
<td>Fabaceae</td>
<td>Eurasia</td>
<td>Forage, nitrogen fixation, honey</td>
</tr>
<tr>
<td><em>repens</em></td>
<td></td>
<td></td>
<td>N. Africa</td>
<td>Forage</td>
</tr>
<tr>
<td><em>Agrostis</em></td>
<td>Browntop</td>
<td>Poaceae</td>
<td>Eurasia</td>
<td>Forage</td>
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<tr>
<td><em>chapallaris</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lolium</em></td>
<td>Ryegrass</td>
<td>Poaceae</td>
<td>Eurasia</td>
<td>Forage</td>
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<tr>
<td><em>perenne</em></td>
<td></td>
<td></td>
<td>N. Africa</td>
<td></td>
</tr>
<tr>
<td><em>Hordeum</em></td>
<td>Barley</td>
<td>Poaceae</td>
<td>Asia Minor</td>
<td>Grain</td>
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<tr>
<td><em>vulgare</em></td>
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<td></td>
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<tr>
<td><em>Triticum</em></td>
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<td>Asia Minor</td>
<td>Grain</td>
</tr>
<tr>
<td><em>aestivum</em></td>
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<td></td>
<td></td>
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<tr>
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<td>Potato</td>
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<td>America</td>
<td>Tubers</td>
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<tr>
<td><em>tuberosum</em></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Malus</em></td>
<td>Apple</td>
<td>Rosaceae</td>
<td>Eurasia</td>
<td>Fruit, juice</td>
</tr>
<tr>
<td><em>domestica</em></td>
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<td></td>
<td>Forage</td>
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<tr>
<td><em>Dactylis</em></td>
<td>Cocksfoot</td>
<td>Poaceae</td>
<td>Eurasia</td>
<td>Forage</td>
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<tr>
<td><em>glomerata</em></td>
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<td></td>
<td>N. Africa</td>
<td></td>
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<td><em>Actinidia</em></td>
<td>Kiwi fruit</td>
<td>Dilleniaceae</td>
<td>China</td>
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<td><em>chinensis</em></td>
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<tr>
<td><em>Zea mays</em></td>
<td>Maize, corn</td>
<td>Poaceae</td>
<td>America</td>
<td>Grain</td>
</tr>
</tbody>
</table>

This paper is primarily directed to those plants, mostly native but some introduced, which grow in the wild state and can be recognised as having use as food for life support in emergency or disaster situations.

**Disaster and Emergency Situations in New Zealand**

New Zealand is subject to a variety of natural hazards, namely flood, drought, earthquake, fire, hurricane, tsunami and volcanism. However, food shortages are not a feature associated with these disasters. The population is small, food production by agriculture widespread, and there is a well developed transport infrastructure that functions well under stress. Also, the variable geography results in disasters that tend to be localised. It would require a disaster of vast proportions such as a massive volcanic eruption or nuclear war to create real food shortages.

There are, however, many remote areas of New Zealand in which people may find themselves without food. These areas have recreation use for tramping and hunting the introduced wild animals, and are regularly traversed by air traffic. Stranding through, for instance, air accidents or by trampers, becoming lost or cut off by flooded rivers, is a situation in
which individuals or small groups may have to rely on naturally occurring foods. In a country where food is otherwise plentiful, to live off the land in wilderness areas, apart from those on the coast where shellfish and other seafoods can be easily gathered, is not a straightforward matter. The one important advantage is that water is usually available nearby, and that it is generally safe to drink.

**Native Food Plants**

There are two peculiar features of New Zealand's biogeographic past that have contrived to make those kinds of foods so often available in other lands as rare, absent or difficult to obtain. The first is that New Zealand has no native marsupials (like Australia does) or mammals, except for a few rare bats. These absences are a consequence of a long geographical isolation. Although part of Gondwanaland, New Zealand's separation was prior to both marsupial and mammal evolution, leaving the land mass with only small reptiles and amphibians, and birds. The effects are two fold: firstly, larger animals are unavailable as a food source themselves and secondly, their absence has resulted in little selection for large edible fruits. Most fleshy fruits are very small, being taken by the many small passerine birds found in New Zealand. The larger birds, many of which such as the moas are extinct, seem to have been predominantly grazers of leaves and shoots. Birds can be used as a food source, but with the introduction of feral predators, those that are easiest to catch are now very rare or extinct.

The second feature restricting food availability in New Zealand's remote areas is the rarity of plants with edible vegetative parts, especially underground storage organs. This is probably a consequence of a mild oceanic climate in which few native plants die back over winter, and in which storage organs confer no advantage. A few plants do have edible vegetative tissues, such as the rhizomes of bracken (Pteridium esculentum) and the shoots of the cabbage tree (Cordyline spp.) but these are difficult to harvest or require complex preparation. Nor have New Zealand's mountains, in contrast with South America, provided an environment producing underground storage organs, as these mountains are of very recent origin. Seeds with large and nutritious endosperm are also rare, the only plant of note being karaka (Corynocarpus laevigatus), the kernels of which must however be cleared of a poisonous constituent by a long process of continuous boiling in water. A small number of nutritious delicacies are to be found, but are highly seasonal, such as the nectar of flax (Phormium tenax) flowers, or are of unreliable appearance, such as the flowering bracts of the kiekie (Freycinetia banksii).

There are also important geographic aspects to the availability of native edible foods in New Zealand. Apart from a few small alpine
fruits, most food is found in lowland vegetation and close to the coast. Indeed the pre-European Maori inhabitants seldom ventured beyond these areas, and then only to pass from one location to another. These coastal and lowland areas have likewise been extensively occupied by Europeans. The remaining more remote areas are those that are poor in food supply.

**INTRODUCED FOOD PLANTS**

Human settlement of New Zealand has introduced many food plants and animals. While the first Polynesian settlers who arrived before 1000 A.D. found land and waters well stocked with fish, birds, reptiles and large insects, exploitation of these was rapid and in many cases this led to extinction. The best example is that of the moas, a group of giant ratite birds. The early missionary explorer Colenso recorded the significant food plants of the Maori, and these are listed in Table 2. Several of these were brought from the South Pacific by the Polynesian settlers who became the Maori, and as those plants were of tropical origin, their growth was severely restricted by New Zealand’s temperate climate. These foods required elaborate cultivation and storage techniques and as the areas of New Zealand in which they could be grown were restricted, they had

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Origin</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipomoea batatas</td>
<td>Kumara,</td>
<td>Convolvulaceae</td>
<td>S. America</td>
<td>Tubers</td>
</tr>
<tr>
<td>Colocasia esculent</td>
<td>Taro</td>
<td>Araceae</td>
<td>S. E. Asia</td>
<td>Fleshy rootstock</td>
</tr>
<tr>
<td>Lagenaria siceraria</td>
<td>Hue, gourd</td>
<td>Cucurbitaceae</td>
<td>Old World Tropics</td>
<td>Fruits</td>
</tr>
<tr>
<td>Pteridium esculentum</td>
<td>Aruhe, Bracken</td>
<td>Dennstaedtiaceae</td>
<td>S. Pacific Australasia</td>
<td>Rhizomes</td>
</tr>
<tr>
<td>Cordyline terminalis</td>
<td>Tiipara, Cabbage tree</td>
<td>Agavaceae</td>
<td>S. Pacific</td>
<td>Fleshy shoot apex</td>
</tr>
<tr>
<td>Corynocarpus laevigatus</td>
<td>Karaka</td>
<td>Corynocarpaceae</td>
<td>New Zealand</td>
<td>Fruit kernel</td>
</tr>
<tr>
<td>Cyathea medularis</td>
<td>Mamaku,</td>
<td>Cyatheaceae</td>
<td>S. Pacific, Australia</td>
<td>Fleshy shoot apex</td>
</tr>
<tr>
<td>Sonchus kirkit</td>
<td>Puwha,</td>
<td>Asteraceae</td>
<td>New Zealand</td>
<td>Vegetable</td>
</tr>
<tr>
<td>Solanum aviculare</td>
<td>Poroporo, Nightshade</td>
<td>Solanaceae</td>
<td>New Zealand</td>
<td>Fruits</td>
</tr>
<tr>
<td>Freycinetia bankstii</td>
<td>Kiekie</td>
<td>Pandanaceae</td>
<td>New Zealand</td>
<td>Fleshy flowering bracts</td>
</tr>
</tbody>
</table>
a marked influence on the distribution of the Maori people before European settlement. Of the native plants used as food, many required elaborate preparation to make them palatable, and of these bracken and karaka needed the most. It is very probable that the kiori rat (*Rattus exulans*) and the dog kuri (*Canis familiaris*) acted to diminish food stocks by their predation of indigenous animals by more than they provided a food source for their Polynesian human introducers. From their contact with the English explorer James Cook on his first visit in 1769, the Maori were quick enough to accept and use European food plants, and of those listed in Table 2, only Kumara is used much by the Maori people today.

Many of the edible plants introduced by the Europeans have become established in the wild and the most important of these are listed in Table 3. Most, however, have not succeeded in spreading far beyond the areas directly modified by the inhabitants. In contrast, the introduced mammals have spread into remote areas and many such as rabbit, Australian possum, rat, cat and deer are widespread and have inflicted damage on vegetation and birds unused to the grazing and predation of these mammals. To people isolated in remote areas, these animals are a nutritious food source if they can be shot or trapped. Another advantage is the widespread availability in most New Zealand rivers of trout, introduced in Victorian times, and eels.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Family</th>
<th>Origin</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubus fruticosus</td>
<td>Blackberry</td>
<td>Rosaceae</td>
<td>Eurasia</td>
<td>Fruits</td>
</tr>
<tr>
<td>Chenopodium album</td>
<td>Fathen</td>
<td>Chenopodiaceae</td>
<td>Eurasia, N. Africa</td>
<td>Vegetable</td>
</tr>
<tr>
<td>Rorippa palustris</td>
<td>Cress</td>
<td>Brassicaceae</td>
<td>Europe</td>
<td>Vegetable</td>
</tr>
<tr>
<td>Brassica rapa</td>
<td>Korau, Wild turnip</td>
<td>Brassicaceae</td>
<td>Europe</td>
<td>Vegetable</td>
</tr>
<tr>
<td>spp. sylvestris</td>
<td>Puwha, Sow thistle</td>
<td>Asteraceae</td>
<td>Europe</td>
<td>Vegetable</td>
</tr>
<tr>
<td>Sonchus oleraceus</td>
<td>Elder</td>
<td>Caprifoliaceae</td>
<td>Europe</td>
<td>Fruits</td>
</tr>
<tr>
<td>Sambucus nigra</td>
<td>Gooseberry</td>
<td>Grossulariaceae</td>
<td>Europe</td>
<td>Fruits</td>
</tr>
<tr>
<td>Ribes uva-crispa</td>
<td>Banana, Passion fruit</td>
<td>Passifloraceae</td>
<td>S. America</td>
<td>Fruits</td>
</tr>
<tr>
<td>Passiflora mollissima</td>
<td>Cherry plum</td>
<td>Rosaceae</td>
<td>S. E. Europe</td>
<td>Fruits</td>
</tr>
<tr>
<td>Prunus cerasi fera</td>
<td>Wild parsnip</td>
<td>Apiaceae</td>
<td>Europe</td>
<td>Rootstock</td>
</tr>
</tbody>
</table>
All these features demonstrate that it is not easy to find food when isolated in remote parts of New Zealand unless equipped with firearms or traps. The plants offer little help. Edible species are mostly near human habitation and the others offer little reward for the time spent for aging. Documentation of native edible plants is provided in a field guide prepared in response to the question as to what plants can be safely eaten if supplies run out when tramping or lost in the wild. Crowe put this knowledge to a practical test by once trying to survive on plants alone in a diverse lowland forest vegetation during fruiting time. Even though he found food available, he suffered from an energy drain which made searching difficult. Some, such as the widespread bracken, although edible, required complex preparation. The problem is, therefore, of energy balance.
IDENTIFICATION AND CHARACTERISATION OF LIFE SUPPORT SPECIES IN MALAYSIA

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University Kebangsaan Malaysia, Bangi, Malaysia

INTRODUCTION

Malaysia is located in the tropical rain forest belt and has a high degree of diversity in plant life. The region constitutes a major gene pool for many fruit tree species (Soepadmo, 1979a) and for a number of important crop species (Frankel, 1975). The need for conservation and eventual utilisation of the above plant genetic resources have been identified (Zakri, 1986). However, many wild and semi-wild species which are under-utilised still exist as potential sources of food, fibre and energy for human and livestock. For the most part, these species are neglected since, in the tropics, there is a lack of mechanism for systematic and routine introduction and investigating little known but potentially useful plants (Anon., 1975).

Such species can be found under two local ecosystems, namely, the coastal and inland ecosystems. The former is generally under mangrove and peat, while inland ecosystem is found under flooded and non-flooded conditions. Many of these species are known to the local inhabitants and some information on these have already been made (Burkill, 1935). This account is outdated and, thus, inventory of such plants including their present and potential uses is required. A proposal for such a handbook on South-East Asian plant resources has been put forward recently (Westphal and Jansen, 1986). Information on some of the potential plant species available in Malaysia is presented.

COASTAL ECOSYSTEM

Mangrove swamp

This ecosystem supports a unique group of plants in Malaysia but they are rapidly dwindling in number. The mangroves survive waterlogging, poor soil aeration, high salinity, high humidity and strong winds. It also supports the aquatic food chain of micro-organisms, fish, crabs, clams, oysters, squids and birds. Several important plants found here,
LIFE SUPPORT SPECIES

including the ones belonging to Rhizophoraceae and Avicenniaceae, are given in Table 1.

Peat swamp

There are about 80 species of *Ficus* found in Peninsular Malaysia, (Burkill, 1935). In the swamp forests occur *Ficus callophylla*, *F. consocia*ta, *F. delosyce*, *F. retusa* and *F. microcarpa*. The important species are given in Table 1.

INLAND ECOSYSTEM

Flooded

The freshwater swamps and wet areas in the forests provide numerous habitats for the growth of some promising but neglected species of palms (Whitmore, 1977). On top of this list is the Sago palm (*Metroxylon sagu*), which has a high economic value but is grossly under-exploited (Flach, 1983). In areas of high water table and high rainfall, trees from the genus *Garcinia* have the potential to be exploited, especially the tropical fruit, the mangosteen (*G. mangostana*). The important plants are given in Table 2.

Non-flooded

Under this ecosystem, there can be found several nitrogen fixing tree species, fruit tree species and the plant species whose leaves or young shoots are consumed by local people. The latter group is traditionally, known as *ulam* but their wide use need not necessarily mean that they are widely cultivated. Instead many exist in the wild state and are harvested by food gatherers from time to time. The important species are listed in Table 2.

Traditional Malay Vegetables (ULAM)

These vegetables are consumed raw or half-boiled. In a survey conducted recently (Kamilah Noor, 1986), 60 species from 31 families were identified. Twenty five species from this group were analysed for ash, fat, fibre, starch and protein content, and the results compared with selected temperate vegetables such as *Lactuca sativa* (lettuce), *Brassica oleracea* (cabbage) and *Daucus carota* (carrot). Most of the *ulam* were found to have a higher nutritional value, while the rest were equivalent in their nutritional composition to that of temperate greens. Table 3 shows the wide usage of wild and semi-wild plant species in the traditional eating habits of the Malays and the parts of the plant used for *ulam* and the various ways of preparing them.
<table>
<thead>
<tr>
<th>Species</th>
<th>Local name</th>
<th>Family</th>
<th>Origin</th>
<th>Characteristics</th>
<th>Uses</th>
<th>Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Mangrove Swamp</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Rhizophora</td>
<td>Bakau minyak</td>
<td>Rhizophoraceae</td>
<td>S. E. Asia</td>
<td>Height upto 30 m</td>
<td>Firewood, charcoal tannins</td>
<td>Coastal mangroves</td>
</tr>
<tr>
<td>candelaria</td>
<td>Bakau belukap</td>
<td>Rhizophoraceae</td>
<td>S. E. Asia</td>
<td>Height upto 30 m</td>
<td>Firewood, charcoal tannins</td>
<td>Coastal mangroves</td>
</tr>
<tr>
<td>Rhizophora</td>
<td>Nipah</td>
<td>Palmae</td>
<td>Sri Lanka</td>
<td>Height upto 7 m</td>
<td>Thatching (leaves), basket, cigarettes</td>
<td>Tidal mud, around estuaries</td>
</tr>
<tr>
<td>mucronata</td>
<td>Derris indica Mempari</td>
<td>Leguminosae</td>
<td>S. E. Asia</td>
<td>Height upto 20 m, bushy crown</td>
<td>Firewood, fodder (leaves), oil (seeds) pest control (leaves)</td>
<td>Coastal forests, tidal streams and rivers</td>
</tr>
<tr>
<td>fruticans</td>
<td></td>
<td></td>
<td>Pacific Islands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Peat Swamp</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ficus</td>
<td>Beringin</td>
<td>Moraceae</td>
<td>South Asia</td>
<td></td>
<td>Firewood, edible fruits</td>
<td>Swampy ground</td>
</tr>
<tr>
<td>benjamina</td>
<td>Putat</td>
<td>Myrtaceae</td>
<td>S. E. Asia</td>
<td></td>
<td>Timber, Saponnins, edible (leaves), starch (seeds)</td>
<td>Swampy ground</td>
</tr>
<tr>
<td>Baringtonia</td>
<td></td>
<td></td>
<td>East Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>conoides</td>
<td></td>
<td></td>
<td>to pacific</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myristica spp.</td>
<td>Pala hutan</td>
<td>Myristicaceae</td>
<td>Penninsular</td>
<td></td>
<td>Firewood, match sticks, medicine</td>
<td>Swampy ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Local name</td>
<td>Family</td>
<td>Origin</td>
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<td>Uses</td>
<td>Adaptation</td>
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</tr>
<tr>
<td>(a) Flooded</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td><em>Salacca conferta</em></td>
<td>Asam paya, Kelubi</td>
<td>Palmae</td>
<td>S. E. Asia</td>
<td>Stemless, leaves upto 6 m</td>
<td>Edible fruits</td>
<td>Wet places in forests, swampl</td>
</tr>
<tr>
<td><em>Salacca edulis</em></td>
<td>Salak</td>
<td>Palmae</td>
<td>S. E. Asia</td>
<td>—</td>
<td>Edible fruits</td>
<td>Swampy stream beds,</td>
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<tr>
<td><em>Metroxylon sagu</em></td>
<td>Rumbia</td>
<td>Palmae</td>
<td>S. E. Asia, Moluccas, Fiji</td>
<td>Stout tree, palm upto 10 m</td>
<td>Starchy food, fodder, leaves for thatching, matting</td>
<td>Swampy soil</td>
</tr>
<tr>
<td><em>Garcinia hombroniana</em></td>
<td>Manggis hutan, Beras</td>
<td>Guttiferae</td>
<td>S. E. Asia</td>
<td>—</td>
<td>Edible fruits, roots for medicine, timber</td>
<td>Coastal areas of high water table</td>
</tr>
<tr>
<td><em>Garcinia atroviolida</em></td>
<td>Asam gelugur</td>
<td>Guttiferae</td>
<td>S. E. Asia</td>
<td>—</td>
<td>Edible fruits, medicine, dye fixative</td>
<td>Swampy forests</td>
</tr>
<tr>
<td><em>Garcinia mangostana</em></td>
<td>Mangosteen, Manggis</td>
<td>Guttiferae</td>
<td>S. E. Asia</td>
<td>Excellent taste and quality</td>
<td>Edible fruit</td>
<td>High rainfall areas</td>
</tr>
<tr>
<td>(b) Non-flooded</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Acacia auriculiformis</em></td>
<td>—</td>
<td>Leguminosae</td>
<td>Australia, Papua New Guinea</td>
<td>Upto 30 m</td>
<td>Fuelwood, pulp wood</td>
<td>Acid soils, humid tropics</td>
</tr>
</tbody>
</table>

Contd.
<table>
<thead>
<tr>
<th>Species</th>
<th>Local name</th>
<th>Family</th>
<th>Origin</th>
<th>Characteristics</th>
<th>Uses</th>
<th>Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acaela mangium</em></td>
<td>—</td>
<td>Leguminosae</td>
<td>Australia, Papua New Guinea, Indonesia</td>
<td>Upto 30 m fast growing</td>
<td>Timber</td>
<td>Moist tropics, Acid soils</td>
</tr>
<tr>
<td><em>Calliandra calothyrsus</em></td>
<td>—</td>
<td>Leguminosae</td>
<td>Central and South America</td>
<td>Upto 10 m shrubby</td>
<td>Firewood, forage, erosion control, soil improver</td>
<td>Moist tropics</td>
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<tr>
<td><em>Casuarina equisetifolia</em></td>
<td>—</td>
<td>Casuarinaceae</td>
<td>Australia and Pacific Islands to India</td>
<td>Upto 35 m</td>
<td>Firewood, charcoal Warm tropics, timber for post-wood, coastal areas, salty lands</td>
<td>Humid tropics</td>
</tr>
<tr>
<td><em>Parkia speciosa</em></td>
<td>—</td>
<td>Leguminosae</td>
<td>S. E. Asia</td>
<td>Upto 15 m thin crown</td>
<td>Edible green pods</td>
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</tr>
<tr>
<td><em>Leucaena leucocephala</em></td>
<td>—</td>
<td>Leguminosae</td>
<td>Central America Mexico</td>
<td>Upto 18 m</td>
<td>Fuelwood, forage, timber, pulp wood, tropics edible pods, leaves, seeds</td>
<td>Dry to mesic tropics</td>
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<tr>
<td>Species</td>
<td>Plant part</td>
<td>Preparation</td>
<td>Plant type</td>
<td></td>
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</tr>
<tr>
<td><em>Nothopanax scutellarium</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Colocasia gigantea</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Bouea macrophylla</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anacardium occidentale</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lagenaria vulgaris</em></td>
<td>Fruit</td>
<td>Half-boiled</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Momordica charantia</em></td>
<td>Fruit</td>
<td>Raw/half-boiled</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pluchea indica</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cosmos caudatus</em></td>
<td>Leaf</td>
<td>Raw</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Gynandropsis gynandra</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Carica papaya</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ipomoea batatas</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Manihot esculenta</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Gnetum gnemon</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cymbopogon citratus</em></td>
<td>Stem</td>
<td>Raw</td>
<td>H</td>
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<tr>
<td><em>Mentha arvensis</em></td>
<td>Leaf</td>
<td>Raw</td>
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<td><em>Ocimum sanctum</em></td>
<td>Leaf</td>
<td>Raw</td>
<td>H</td>
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<tr>
<td><em>Cassia siamea</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
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<tr>
<td><em>Cassia obtusifolia</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>H</td>
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<tr>
<td><em>Psophocarpus tetragonolobus</em></td>
<td>Fruit</td>
<td>Raw/half-boiled</td>
<td>T</td>
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<td><em>Parkia speciosa</em></td>
<td>Fruit</td>
<td>Raw/half-boiled</td>
<td>T</td>
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<tr>
<td><em>Tamarindus indica</em></td>
<td>Fruit</td>
<td>Raw</td>
<td>T</td>
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<tr>
<td><em>Leucaena leucocephala</em></td>
<td>Fruit</td>
<td>Raw</td>
<td>T</td>
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<tr>
<td><em>Pithecellobium jiringa</em></td>
<td>Fruit</td>
<td>Raw/half-boiled</td>
<td>T</td>
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<tr>
<td><em>Sesbania grandiflora</em></td>
<td>Flower/shoot</td>
<td>Raw/half-boiled</td>
<td>T</td>
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<tr>
<td><em>Ardisia crenata</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>S</td>
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<tr>
<td><em>Myristica fragrans</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
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<td><em>Eugenia aromatica</em></td>
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<td>T</td>
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<td><em>Eugenia malaccensis</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
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<tr>
<td><em>Eugenia pseudosubtilis</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
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<tr>
<td><em>Decaspermum fruticosum</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>S</td>
<td></td>
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<tr>
<td><em>Barringtonia racemosa</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>T</td>
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<tr>
<td><em>Musa sapientum</em></td>
<td>Spadix/palm</td>
<td>Raw/half-boiled</td>
<td>H</td>
<td></td>
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<tr>
<td><em>Champereia Griffithii</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>S</td>
<td></td>
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<tr>
<td><em>Piper stylosum</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>H</td>
<td></td>
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<tr>
<td><em>Onospermum horrida</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>T</td>
<td></td>
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<tr>
<td><em>Cocos nucifera</em></td>
<td>Palm cabbage</td>
<td>Half-boiled</td>
<td>T</td>
<td></td>
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<tr>
<td><em>Passiflora foetida</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>H</td>
<td></td>
<td></td>
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<tr>
<td><em>Polygonum minus</em></td>
<td>Leaf</td>
<td>Raw</td>
<td>H</td>
<td></td>
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<tr>
<td><em>Stenochlaena palustris</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Murraya koenigii</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
<td></td>
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<tr>
<td><em>Evodia sp.</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>S</td>
<td></td>
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</tr>
<tr>
<td><em>Micromelum pubescens</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>S</td>
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Contd.
### Table 3—Contd.

<table>
<thead>
<tr>
<th>Species</th>
<th>Plant part</th>
<th>Preparation</th>
<th>Plant type</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ixora chinensis</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>S</td>
</tr>
<tr>
<td><em>Morinda citrifolia</em></td>
<td>Shoot</td>
<td>Raw</td>
<td>T</td>
</tr>
<tr>
<td><em>Solanum torvum</em></td>
<td>Fruit</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Solanum nigrum</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>H</td>
</tr>
<tr>
<td><em>Herpestis monniera</em></td>
<td>Leaf/shoot</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Hydrocotyle asiatica</em></td>
<td>Whole plant</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Oenanthe javanica</em></td>
<td>Leaf</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Artocarpus integrifolia</em></td>
<td>Young fruit</td>
<td>Half-boiled</td>
<td>T</td>
</tr>
<tr>
<td><em>Vitex pubescens</em></td>
<td>Shoot</td>
<td>Raw/half-boiled</td>
<td>T</td>
</tr>
<tr>
<td><em>Premna integrifolia</em></td>
<td>Shoot</td>
<td>Half-boiled</td>
<td>S</td>
</tr>
<tr>
<td><em>Curcuma domestica</em></td>
<td>Flower/shoot</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Alpinia galanga</em></td>
<td>Rhizome</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Kaempferia galanga</em></td>
<td>Leaf</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Phaeomeria speciosa</em></td>
<td>Flower</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Zingiber attensii</em></td>
<td>Rhizome</td>
<td>Raw</td>
<td>H</td>
</tr>
<tr>
<td><em>Zingiber officinale</em></td>
<td>Rhizome</td>
<td>Raw</td>
<td>H</td>
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</table>

T: Tree, S: Shrub, F: Fern, H: Herb

### CONCLUSIONS

In deciding priorities for genetic resources activities, the IBPGR (Anon., 1984) considered four important criteria, i.e. (i) The risk that genetically diverse materials may soon be lost, (ii) The economic and social importance of the species, (iii) The size and quality of existing collections, (iv) The recognised requirements of the users.

With the advent of modernisation, particularly the clearing of jungle areas for urbanisation and the growing of plantation crops such as rubber, oil palm and cocoa, the risk is high that the life support species discussed above may soon be lost. Compared to the high returns derived from the plantation crops, the economic importance of the life support species seems to be very minimal even though it does not follow that the social importance of the species is small, as evident in the case of the *ulam*. All things considered, including the recognised requirements of the users and the non-existence of collections presently, it is imperative that steps be taken in the near future and in the long-term to conserve these valuable plant resources.

### REFERENCES

LIFE SUPPORT SPECIES


LIFE SUPPORT SPECIES IN SRI LANKA

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University of Colombo, Colombo, Sri Lanka

INTRODUCTION

A study was carried out in order to ascertain the actual status of plant species that could be categorised as life support species under extreme conditions of drought. The survey was carried out in the North Western Province, North Central Province and the Central Province of Sri Lanka. This had two objectives, namely: (a) list species that are able to survive under drought conditions and (b) study, storage and utilisation of vegetables during drought conditions.

The sample survey was considered to be most appropriate during this year when Sri Lanka has undergone one of the worst dry periods after 36 years.

DROUGHT TOLERANT PLANT SPECIES

The parameter used in this preliminary assessment was a simple one -- plant species were considered drought tolerant if they were simply able to survive. The species thus identified were Canna edulis, Artocarpus heterophyllus, Artocarpus spp., Nelumbo nucifera, Nymphaea stellata, Mangifera indica, Anacardium occidentale, Carica papaya, Solanum melongena, Solanum indicum, Solanum xanthocarpum, Benincasa hispida, Cucurbita maxima, Cocinea cordifolia, Lagenaria siceraria, Cycas circinalis, Sesbania grandiflora, Moringa oleifera, Manihot esculenta, Amaranthus spinosus, Agave sisalana and Typha angustifolia. The local usages of these plants are given.

Canna edulis: This plant is used(134,503),(972,977) by villagers only under extreme and difficult conditions. The rhizome is usually consumed as starch after boiling. The plant is otherwise allowed to grow into large plantations in neglected and abandoned areas. It is extremely important to improve the starch content of this plant through selection and breeding. It is also grown by villagers as marginal ornamental plant. It also prevents soil erosion.

Artocarpus heterophyllus: This is an introduced species and it is a part of the village gardens in the island. It is also a component of the...
urban forests. The fruits are fragrant, tasty and yield starch at full maturity. The young fruit is eaten as a vegetable. The seeds of jackfruit, are stored by villagers as a source of starch and eaten when necessary after boiling. The plant is also used as cattle and goat feed in the villages, more so during the drought conditions when the grasses and other fodder plants fail to grow. The timber value of the tree cannot be overemphasised. Selections have been made in order to get short duration varieties.

*Nelumbo nucifera*: In the villages, the rhizomes are used as a source of starch. In Japan, it is considered as a delicacy.

*Nymphaea stellata*: The seeds of *Nymphaea stellata* are used as a grain, similar to rice. They also possess some medicinal properties.

*Carica papaya*: It is usually eaten as a fruit. Under extremes of drought, the fruit is used as a cooked vegetable.

*Solanum melongena*: This is a vegetable crop that has a long history. There are landraces that can withstand wilt resistance and a four year old plant yielding enough fruits for the household to have at least 3 or 4 curries in a week. *Solanum indicum* and *Solanum xanthocarpum* are both, similarly, able to withstand drought conditions and support life under stress conditions.

*Cucurbits*: A considerable role is played by several cucurbits as emergency vegetables. Their ability to survive under drought conditions and their good storage (of fruits over a period of time in the village environment) are added advantages.

*Cycas circinalis*: The young shoots and female cones provide a source of starch which is usually popular with village folk.

*Sesbania grandiflora*: This is an all purpose plant which provides leaves and flowers, used as a vegetable. The leaves are also a feed for the goat. The ability to fix nitrogen by this plant is an added advantage.

*Amaranthus spinosus*: This plant supplies the villagers with the green leaves, used as a vegetable.

Among others, *Agave* and *Typha* provide the fibres for the villagers during the drought conditions. *Typha* in particular is extremely important as the villagers make mats for sale, during periods of drought.

**Conclusions**

It is evident from above that there are a host of plant species in the tropics which have to be studied with different objectives. The questions posed are:
(i) Can the scientists provide the same plant with at least better productivity?

(ii) Can the plants of one region be transferred to another region?

(iii) Can the social system be adjusted to the best utilisation of the available resources?

The agriculturists are busy with their own problems, while the ecologists are busy with environment. If this is the case, is it not the concern of a special group of botanists and biologists to study these plants. The need to identify plant species that support life has to be surveyed in greater depth and should be utilised to support life. Water is one of the main concern of difficult lands and hence plant species that help water retention should also be included in this study.
SOME GUIDELINES AND METHODS FOR EXPLO­RATION AND UTILISATION OF LIFE SUPPORT SPECIES FOR NEPAL

BHARAT R. ADHIKARY

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INTRODUCTION

Nepal lies between India and China along the central Himalayas. It is a small country with an area of approximately 140,000 sq km, a length of 800 km (east-west) and a width of 130–240 km (north-south). It lies between 26°20'N and 30°10'N latitudes and 80°15'E and 88°10'E longitudes. The country is divided into five physiographic regions which roughly run parallel to one another from east to west. These are: (i) the High Himalayas—above 4000m (ii) the High Mountains—2000m to 4000m (iii) the Middle Mountains—1500m to 2500m (iv) the Siwaliks—300m to 500m; and (v) the Tarai—below 300m. It is predominantly an agricultural country with over 90% of the population engaged in farming. The system is a low input, rainfed and traditional one. The land holdings are very small, and the pressure on land is ever increasing with the increase in population. Rice is the most important food crop and an export item, followed by maize, wheat, potato, finger millet, barley, buckwheat, etc. There are also a variety of grain legumes, vegetables, fruits, etc. suited to the sub-tropical to cold temperate climates prevailing in various regions of the country.

CROP GENETIC RESOURCES

The great topographical and microclimatic variations combined with the localised traditional farming systems have produced a wide diversity of crop species and their landraces throughout Nepal. The diversity exhibited in terms of flora and fauna in this country has been amazing to many explorers (Bhattarai et al., 1987). Genetic Resources Programme started in 1971 beginning with the collection of 950 local landraces of rice with the assistance from IRRI and USAID (Adhikary, 1973). Similar efforts have been made in other important crops. In 1985, an integrated multicrop collection and conservation programme started with the establishment of the Plant Genetic Resources Unit under the Agriculture Botany Division at Khumaltar, Kathmandu. The Unit
runs a medium-term storage with an approximate capacity for 20,000 accessions.

Life Support Species

People in many parts of Nepal are known to use several wild plant species at the time of main crop failure. The famous examples of such crops are the “Gittha-Vyakur” (Dioscorea bulbifera and D. deltoidea). Several other plants are also used for their roots, shoots, leaves, etc. in many food deficit areas of the country on a regular basis. There are also many other uses for various products such as fibre, fodder, medicine, fuelwood, etc. (Regmi, 1982; Malla, 1982). No systematic study on the collection and conservation of such species have been undertaken so far.

Definition and classification

A wide variety of plant species may be termed as life support species in the sense that they provide subsistence living at the time of failure of the traditional crops and also provide for various other necessities. There are also many other domesticated and improved crops that are capable of withstanding a variety of adverse conditions and yield substantially better harvest than their other counterparts and hence can be considered as life support species. They can be classified into different categories according to the extent they are domesticated or simply according to their use.

Range of adaptation

Each life support species should be defined for the range of environmental conditions they are able to tolerate, e.g. the extremes of temperature, rainfall or water regime, relative humidity, soil pH, etc. Based on such data, Duke and Terrell (1974) have introduced the idea of Crop Diversification Matrix which can readily yield information on ecological niche/characters for any plant species. The method can be readily adapted for use in microcomputers.

Characterisation of environment

Due to overlapping agro-ecological conditions among various physiographic regions and the presence of numerous microclimatic pockets in countries like Nepal, it can be suggested that a more diagnostic approach to study plant environments in various localities be carried out. It should be followed by classifying or clustering similar environments into a broader, and not necessarily intact, agro-ecological regions. The basis of such classification may be both biogeographical and agroclimatic. A number of multivariate techniques may be employed with convenience.
Study of growth characteristics *in situ*

The natural habitats are the most suitable places to grow and exploit the life support species. Consequently, the most realistic information may be obtained only from the *in situ* observations. Growth characteristics and yield potentialities should be studied as functions of climatic and soil characteristics and, possibly, presence of other plant species in the vicinity, prevailing in the area. Growth characteristics in the extreme conditions of one or more of the factors should be especially investigated.

**Chemical evaluation**

Each life support species old, or newly introduced, must be thoroughly analysed for nutritive and other values and the possible presence of toxic substances at different stages of plant growth. New methods for safe and efficient utilisation should be devised and popularised.

**Genetic studies**

Field screening and identification of superior genotypes should be given due attention. Nature of inheritance of important characters by cytogenetic, biochemical and molecular techniques should be emphasised too.

**Conservation and exchange**

Sizable quantities of seeds should be maintained on short, medium or long-term basis either conventionally in case of seeds or by *in vitro* techniques for the unconventional materials like tubers, stems, etc. In case of the latter, farmers should also be encouraged to use any marginal land for planting and maintaining the life support species. Exchange of germplasm should be encouraged and facilitated, as in other crop species, at national and international level for use by concerned scientists. Computerised data base system and newsletters at each national headquarters should greatly facilitate communication among the scientists.

**REFERENCES**


MAINTENANCE OF GENE POOLS OF MEDICINAL PLANTS IN NEPAL

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INTRODUCTION

Nepal is rich in vegetational resources with nearly 7000 species of vascular plants, which includes over 600 species of medicinal plants. Medicinal plants are one of the important components of the vegetation in Nepal and play a key role as life-support species particularly in rural health care system on one hand and on the other, rural populations have been economically benefitted even in adverse conditions of the poor agricultural yield, substituting through the collection and cultivation and also trading of medicinal plants. However, over-exploitation and destruction of habitat has threatened the survival of the species of medicinal plants. This situation has demanded the need of conservation of medicinal plants for sustained use of their germplasm.

PRESENT ACTIVITIES

The Department of Medicinal Plants (DMP), H. M. G. of Nepal and Department of Wild Life Management and National Parks are concerned with the conservation of medicinal plants and wild life, respectively. Herbal Farms, Royal Botanical Gardens, Wild Life Preserves and National Parks are engaged in conservation activities of both flora and fauna in Nepal.

Five Wild Life Reserves and 6 National Parks of Department of Wild Life Management and National Parks situated in different climatic regions, i.e. from subtropical to alpine, have been ensured in fostering in situ conservation of medicinal plants. Ex situ conservation of medicinal plants is being carried out in Royal Botanical Garden, Godavari and Vrindavan Herbal Farm, Hetauda where it was started in 1983. Collection, maintenance, evaluation and documentation of the medicinal and aromatic plants for purpose of conservation and utilisation have been done at Vrindavan Herbal Farm. A total of 339 accessions of medicinal plants consisting of 175 species under 135 genera has been maintained at VHF. Forty four accessions were evaluated for different agronomical
characteristics. Considerable variation was found in some of the species.

**Constraints**

Despite the efforts made under National Programmes to ameliorate the genetic resources, the situation so far has not improved significantly. Nepal is also like other developing countries, in the process of losing the diversity of plants resulting in the genetic erosion of medicinal plants. The problems are getting aggravated due to the following reasons:

(i) Nearly 50,000 hectares of natural forests are being destroyed every year for agricultural and developmental purposes. At this pace, the forest will be deserted within 17 years (Malla, S.B., personal communication).

(ii) Many medicinal plants are being over exploited for commercial purposes leading to the rarity of such flora.

(iii) Rejection of medicinal crops on the basis of single chemical character is also causing great problem.

Thus, the present adverse situation demands the conservation of life supporting species by formulating suitable strategies and adopting practical approaches with long and short-term action plan. However, to act on this problem, the facts which need to be paid immediate attention are; (i) to bring awareness on conservation of species to the public at the grass root level and also to the decision makers (ii) to institutionalise the conservation activities and (iii) to draw attention for external and internal co-operation.

Medicinal plants occupy a very low profile in the IBPGR sponsored activities but it can catalyse the activity on conservation. Manpower to carry on the genetic resources work is also one of the constraints. Only two scientists from DMP have been trained in the IBPGR sponsored course on plant genetic resources. More personnel have to be trained in different areas of germplasm conservation in order to take up the work more effectively.

**SUGGESTIONS FOR ACTION PLAN**

In order to strengthen the activities of maintenance of gene pools of medicinal plants in Nepal, there is need to formulate immediate and long-term action plans, the essential features of which are given below:
Immediate action plan

1. Priorities on the collection of germplasm of economic cultivated medicinal plants from internal and external sources.
2. Germplasm collection and conservation of overexploited wild medicinal plants.
3. Study on behaviour of seed storage in medicinal plants to decide the long-term conservation strategy.
4. To carry out monitoring of seed viability during storage to facilitate the regeneration work.
5. Development of mid-term seed storage facility.
7. Priority on preliminary evaluation to speed up the screening work.
8. Strengthening of information and documentation system.
9. Human resources development through formal and informal training programmes.
10. Strengthening of chemical laboratory and standardisation of micro-analysis techniques.
12. Preparation of inventories of medicinal plants and their variants in in situ conservation areas.
13. Co-operation among the countries for exchange of germplasm of medicinal plants.

Long-term action plan

1. Investigation of medicinal plants through ethnobotanical/evaluation studies.
2. Development of long-term seed storage facilities for base collections.
3. Further evaluation and crop improvement through breeding programmes.
4. Collection of germplasm by close grid sampling in each zone of Nepal as follow up to the coarse grid sampling.
5. Extension of collection in the range of target species habitat.
CONCLUSIONS

Contribution of the medicinal plants from Nepal to the world market is less than 2%. To improve this situation and to provide better economy to rural people in adverse conditions, maintenance of gene pool indeed, forms one of the basis of life support. Present efforts on conservation of medicinal plants in Nepal and the available facilities are not adequate. Proper maintenance of the gene pool of medicinal plants thereby attaining the sustained use of gene pool is possible by extending the activities among the wider range of countries at least of this region alongwith the mutual co-operation. As Nepal is reputed in medicinal plant wealth, it is imperative to establish the gene pool centre for medicinal plants in Nepal which could be of global concern. The IBPGR, FAO, WHO and other donor countries can play a vital role in establishing such a germplasm centre by providing adequate assistances and other facilities in international context.
LIFE-SUPPORT SPECIES IN INLAND FLOODING CONDITIONS WITH SPECIAL REFERENCE TO BANGLADESH

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INTRODUCTION

Bangladesh is unique in possessing one of the largest deltaic plains of the world with extensive inland depressions mostly concentrated in the north-eastern region. Out of a total area of fifty five thousand square miles (1,42,487 sq. km) of the country, almost one eighth is occupied by littoral forests in the south, while the rest is comprised of more than forty eight thousand square miles (1,24,352 sq. km) of flood plains excepting the hills in the north-east and south-east. These low-lying plains are criss-crossed by innumerable rivers and creeks. During the rainy season, the extensive land depressions in the northeast of the country, locally known as haors or beels take the form of vast lakes. In the haor regions, i.e. Sylhet-Mymensingh, immediate measures should be adopted towards planned exploitation and utilisation of its vast plant resources. The efficiency of planning in this area has been greatly restrained by a lack of basic information on the spatial pattern of resources distribution. Floods during the monsoon season are a recurring feature in the haor landscape, affecting most sectors of economic life of the people. The rural poor who are seriously affected during floods depend for their food and medicine on plants that thrive in the flooded conditions. But systematic field studies are lacking on the quantitative data regarding the availability and utility of these plants. Comparison of the aerial photographs with LANDSAT imageries indicates that, at many instances, vast waterbodies of the haor region are already replaced by crop lands resulting in resource degradation (Chowdhury et al., 1977).

The objective of the present paper is to highlight those aquatic and marsh species that are of value to human survival under the stress condition of the inland flooding with a view to evaluate their potentialities and explore the possibilities of harnessing them by growing through small scale integrated rural systems or introducing them to artificial environment similar to the extreme one. The preliminary data presented here is gathered from visits to the various parts of Bangladesh in connection
with the botanical survey of the country. Some of these-plants are subjected to over collecting resulting in great threat to their survival, and adequate measures have to be taken immediately to save those species from danger. The specimens gathered for studies have been identified and conserved at the Bangladesh National Herbarium.

**Species Used in Stress Conditions**

The species that are known to be in use as food or medicine by the rural poor of Bangladesh under flooded conditions, are described.

*Achyranthes aquatica* R. Br. (Amaranthaceae). Chittagonese: Thoans

A stout floating herb rooting on the margins of ponds or river banks. The stems are boiled and fried or cooked with pulses. Occasionally also cultivated in household ponds in the southern districts.

*Alternanthera philoxeroides* (Mart.) Grisco (Amaranthaceae). Bengali: Malancho

It is found on the margins of ponds, *beels*, and rivers, floating and rooting at the nodes. The whole herb is cooked and eaten as a green vegetable. It is a native of Brazil, and is now naturalised in Bangladesh.

*Aponogeton* Thunb. (Aponogetonaceae). Bengali: Ghechu

The three scapigerous species, viz., *A. crispum* Thunb., *A. echinatum* Roxb., and *A. natans* (L.) Engl. & Drause which are abundant in the *haor* areas, have tuberous rootstocks in mud floating or submerged leaves. All the species are known by the local name ghechu and form one of the items of food of the rural poor in the N. E. Bangladesh. The rootstocks are either eaten raw or cooked and constitute an important food of people in the *haor* regions during the time of scarcity. The flower stalks are also used as vegetable.

*Ceratopteris thalictroides* Brogn. (Parkeriaceae)

A succulent tufted fern of marshy places. The entire plant including the fronds is cooked and consumed as a green vegetable.

*Colocasia esculenta* (L.) Schott. (Araceae). Bengali: Kachu, Kachu loti, Pani kachu. English: Taro

A marsh herb that thrives under waterlogged conditions. It is one of the most commonly and plentifully available plants whose corms, stolons, petioles and leaves are cooked. The starchy corms are used as a substitute for potato. Deliberate efforts should be made to make the waterlogged areas productive by growing taro in them.

This is a tree species which survives the violent cyclones and yields fruits in the monsoon season when the turbulent winds bring on the tidal bores. The fruits are acid to sweet and are available during the stress conditions consequent to cyclones. The seeds are soaked, then pounded and eaten. The fruits are also used as a medicine in diarrhoea.

_Enhydra fluctuans_ Lour. (Asteraceae). Bengali: _Helencha_

A floating herb that occurs in water bodies of all proportions extending even in littoral creeks. The whole plant is cooked and eaten as a pot herb.

_Eichhornia crassipes_ (Mart.) Solms (Pontederiaceae). Bengali: _Kachuripana_, English: Water Hyacinth

It is the most widespread exotic weed in the waterways including every water body small or large, in stagnant or flowing water. Although its use as human food is not so popular in Bangladesh, its flowers are sometimes fried and eaten. The leaves form a ready fodder for livestock during flooded conditions when no pasture is available.

_Euryale ferox_ Salisb. (Nymphaeaceae). Bengali: _Makhna_

This is very common in the larger beels and haors. The petioles, undersurface of leaves and peduncles are densely prickly. The root stocks are thick and lamina is orbicular and floating. The prickly spongy berries containing seeds with pulpy aril are sold in Dhaka markets, in north Mymensingh, and Sylhet where the seeds are consumed raw or roasted, with considerable relish. The seed flour is easily digestible and nutritious. The rhizomes, young leaves, petioles, and young pedicels are also eaten. This species is fast disappearing from the ponds of central Bangladesh where it was common three decades ago, due to over collecting, and needs conservation in situ in the haors of north, eastern parts of the country.

_Heritiera fomes_ Buch.-Ham. Syn. _H. minor_ Roxb. (Sterculiaceae). Bengali: _Sundari_

It is a dominant species in some areas of the mangrove forests and produces fruits profusely. The seeds are regarded as a famine food after proper treatment (Kunkel, 1983), but field data are lacking in Bangladesh.

_Hygrorhiza aristata_ Nees (Poaceae)

A floating grass with spongy, stoutish, diffusely branched stems and is most common in larger beels and moribund rivers. The grains are considered as famine food (Bor, 1960) but very little data are available.
on the food value. It also forms a good fodder for cattle especially during the flooded conditions when no pasture is available.


Very common on the margins of water bodies thriving under marshy conditions. The seeds can be used as a substitute of rice under famine conditions (Kunkel, 1983). The leaves, roots, and seeds are used in jaundice, dropsy, rheumatism and in diseases of urino-genital tract.


Normally a floating perennial in ponds and marshes but can also survive on wet muddy situations; sometimes also planted. It is one of the most commonly available and extensively used green vegetable.

*Musa* spp. (Musaceae)

The genus *Musa* which includes the banana and plantain is planted extensively in almost every homestead in the rural Bangladesh. During the floods, the false stems are used as rafts. The terminal part of the inflorescence (locally known as *Mocha*) is cured, and the white peduncle enclosed by the false stem (locally known as *Bherali, Kanjal, Thor or Aata*) is eaten raw or consumed after cooking.


Once widely distributed in the ponds and *beels* of Bangladesh, this attractive aquatic is getting scarce due to expansion of agriculture but is still plentiful in the larger *haors* of Mymensingh and Sylhet. The seeds having a nutty flavour are eaten raw. The rhizomes are also eaten. The petals are medicinal as cardiac tonic. The powdered rhizomes are prescribed for piles, dysentery and dyspepsia (Subramanyam, 1961). This species also needs conservation in situ in the *haors* of Sylhet and Mymensingh.


It is one of the most abundant of the hydrophytes on the waterscape of the lower Gangetic plain. The white flowered form is the national flower of Bangladesh. The petioles and the pedicels are eaten raw or cooked. The seeds are also eaten raw or made into *khoi* by first immersing the spongy fruit in water for some days to separate the seeds which are
then dried and fried along with sand. The khoi or the puffed seeds are then eaten as such or made into sweetmeats. The rhizomes, locally known as shalook are also eaten raw, roasted or cooked. The red flowered form is found only under cultivation.


This plant is consumed in the same way as the preceding species but it is getting scarcer. The species has to be conserved both *in situ* and *ex situ*.

*Nymphoides cristata* (Roxb.) O. Kuntze *Limnanthemum cristatum* Griseb. (Menyanthaceae). Bengali: *Sada Chand mala*

It is a floating aquatic which covers large areas of fresh water bodies mostly the *haors* and *beels*. The stems, fruits, and leaves are eaten cured or boiled (Watt, 1972). Its utility as a food plant is hardly known in Bangladesh but, considering its abundance and known use, it deserves further studies.

*Nipa fruticans* Wurmb. (Arecales). Bengali: *Golpata*

A palm with tufted, pinnate leaves, the stem being horizontal and concealed under the mud, forming characteristic vegetation on the intertidal zone of the littoral forests. Although this plant is regarded as having potentialities for exploitation as a source of human food, its use in Bangladesh for any other purpose than its leaves for thatching, is not authentically known. The very young fruits can be eaten as preserves, and the kernel used for sweetmeats. Stem is a source of sugar (Kunkel, 1983) but the field data is lacking.

*Oryza coarctata* Roxb. (Poaceae). Bengali: *Dhane*

A robust species growing in pure stands along the brackish water tracts of Sunderban region and the neighbouring districts. The grains are cooked and eaten like the cultivated rice by the local rural masses, but more data is needed to confirm the food potential of this grass.


A most common species that grows in dense stands of floating masses throughout the fresh water bodies of Bangladesh, often as a vigorous weed of marshy paddy fields. During flooded conditions, the grains are eagerly sought by the rural poor who collect them from under-water. The grains are substitute for cultivated paddy but further studies are needed on its food value.

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This aquatic species which is usually submerged but some times with partly floating leaves, is common in ponds, haors and beels. All parts of plant excepting roots are cooked and eaten. Fruits are also eaten raw. Its potential as a food plant of commerce is yet to be explored.

*Polygonum* spp. (Polygonaceae).

The genus has about 22 species in Bangladesh, almost all forming characteristic vegetation of the riparian marshes. Some species like *P. chinense* L., *P. microcephalum* Don., *P. orientale* L. are consumed as pot herbs or their raw acid leaves are chewed. Many of the species have antibiotic properties and are used widely by the rural people as a healing agent and as a pesticide.


A common aquatic found in fresh water ditches and lakes throughout Bangladesh. Its use as a food plant is apparently not known in Bangladesh and there are no reports of its being consumed here. But according to Watt (1972), the fleshy corms are an article of food in North America, and it is cultivated in China as a food plant. The bitter milky juice which the plant contains has to be expelled by boiling. There is ample scope for exploring its food value and exploitation in Bangladesh.

*Sonneratia caseolaris* (L.) Engl. (Sonneratiaceae). Bengali: *Shaila*, *Ora*

A common tree which thrives in the upper region of the partly saline waters of the littoral belt. The young acidic fruits are cooked and eaten.


It is very common in large ponds and beels with floating leaves and angular fruits often with two scabrous spines. The crop is also grown on a commercial scale for the starchy kernels of the nut that are eaten raw. The dried kernels are powderd and boiled with milk to prepare a dish called *Khirsha* by addition of sugar.

*T. maximowiczii* Korsh (Trapaceae).

This is very similar to the preceding species and especially abundant in the beels of central and northern parts of the country. The fruits, although much smaller and less palatable than those of *T. bispinosa*, are eaten raw in times of scarcity.
Typha angustata Bory & Chaub. (Typhaceae). Bengali: Hogla English: Cat’s tail

A robust gregarious plant in the marshy areas forming pure stands especially in the southern districts and extending into the littoral forests. Its use as a food is not so well known as its utility in the making of mats. The abundant pollen produced is used in the preparation of cakes and cookies in some southern districts bordering the littoral region. The rootstocks and young stems are also known to be consumed raw, roasted or boiled, but field records are lacking in Bangladesh. They are said to contain as much protein as corn or rice and more carbohydrate than potato. One hectare of Typha can yield over 7,000 kg of rhizomes (Majid, 1986). Further investigations on this species in Bangladesh are needed.

Zoysia matrella (L.) Merr. (Poaceae) Bengali: Uri, Urighas

It is a very common grass forming dense mats behind the sand dunes on the offshore islands. Although its importance as a sand binder is known, its potential as a food grain is yet to be investigated. The local people on the coast of Hatiya are known to consume the tiny grains as rice. Further data are needed.

REFERENCES

LIFE SUPPORTING PLANT SPECIES IN RELATION TO SOCIO-ECONOMIC CONDITIONS OF BANGLADESH

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INTRODUCTION

Bangladesh is a flood-ridden country. Besides floods etc., it is beset with drought and desertification. Expansion of drought conditions in the northern region of Bangladesh, is chiefly because of drying up of rivers due to heavy silting, decrease of water level and flow in most of the major rivers there like Jamuna and Padma. It is a common belief in the country that this is being caused as a consequence of decreased flow through the Farakka barrage. Similarly, salinity problem is becoming increasingly important because of shrimp and prawn culture in the southern coastal districts, which devours good agricultural lands and allows saline water to come in where fresh water was prevalent. Irrigation, though not on a very large scale in our country, is yet causing similar problems in the fertile inlands. Due to various reasons, water pollution also is a very common phenomenon. In such extreme conditions, obviously people face the problem of survival and eat the otherwise not so relishing and ‘unusual’ or ‘not used to’ species to keep their body and soul together. While not denying the above horizontal distribution of extreme conditions, requiring life support species, attention needs to be drawn to the fact that even in the best of the localities like densely populated villages, towns and the cities of Bangladesh, and perhaps also in other countries, there are people who require and do use some life support species, not necessarily rarely used species, but the commonly used fruits or vegetables.

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The poor people use plants or plant products to survive. These are mostly the rural landless and to a lesser extent the urban proletariat (mostly the first and rarely second generation of landless peasantry). Incidentally, out of these landless people come those who go to occupy and cultivate the char islands in dry season in the Bay of Bengal coast where tidal bores become the worst. The people here belong to the
bottom layer of the socio-economic stratification in Bangladesh, requiring use of some plants and plant products to survive nearly all around the year and throughout their life. In the villages, the worst situation is faced by the landless agricultural labourers for about three months between two crops when there is no work at all. They do get some wheat from work for relief agencies. But they will have to tide over the critical three months in question when continuous starvation extending even up to a week do occur. If it is the rainy season or soon after, they may use suitable plant species. But, in the dry lands not affected by flood water, i.e. highlands where jackfruit trees \((Artocarpus heterophyllus)\) grow, the village poor and also urban proletariat eat its delicious but relatively cheap fruits and also its seeds, fried or cooked. Thus, not only in certain rural areas but also in the cities, jackfruit becomes the life support species during the summer months and partly rainy season.

Another common vegetable, \textit{lau} or \textit{kadu} \((Lagenaria vulgaris)\), similarly becomes life support species in the villages as well as in the cities for the extreme poor. It is cut into very fine pieces and then cooked with little amount of rice, to fill the stomach. Those who have direct experience, know that jackfruit eaters keep better health than the \textit{lau} eaters. The reason is obvious. The former is more nutritious, but hardly any work on its nutritive aspect has been done in Bangladesh. Sweet potato \((Ipomoea batatas)\) is used just as \textit{lau} with little amount of rice or eaten after boiling in water or broiling. This is very nutritive, though to a Bengali not as tasty as rice. For months, many poor villagers live only on this. Potato \((Solanum tuberosum)\) also is used, like the sweet potato, but to a much lesser extent. People do not know or are not yet used to have potato as substitute for rice or use it in any other way than as described before, as more commonly as vegetable, cooked with meat or rice by those who can afford.

From the foregoing, it may be evident that in Bangladesh, the vertical social stratification and increasing pauperisation (ca 36\% in early Pakistan period to ca 67\% now) are more important and are directly related to the use of life support species, rather than extreme ecological conditions, and that the exotic species that may be found in such habitats are perhaps used to a lesser extent than the common fruits and vegetables. This needs further study.

**General Considerations**

It is evident from above that the life support species cannot be studied in isolation from the prevailing socio-economic conditions. It may be emphasised that in Bangladesh, there is a greater need to study the life support plants (and perhaps animals, like fish) from various
angles. While taxonomic and some ecological data are available on them, hardly any genetic or cytogenetic work has been done so far. There are many other such areas of study. Some sort of international cooperation is urgently needed in this matter.
PLANT GERMPLASM COLLECTION IN THAILAND

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Department of Agriculture, Bangkhen, Bangkok, Thailand

INTRODUCTION

Genetic resources which are the treasure of the earth, are used in developing new varieties to meet the present and future demands of man. The tropical forests comprise one of the world’s major genetic reservoirs. Unlike America and Africa, tropical Asia is not only consisted of a continental land mass but also of several islands and peninsular areas. The presence of barriers to gene flow as well as the environmental barriers have led to the formation of local endemic species (Lamoureux, 1975). The diversity of the resources is evident in various multi-volume treatments of useful plants from many parts in Asia.

With the pressure of rapid growth of population and the quest of socio-economic uplift, agricultural expansion and encroachment on forests and other habitats were inevitable. This caused increasing loss of germplasm and the number of endangered species continues to increase. So, several sectors had attempted to safeguard and utilise both wildlife and plant genetic resources solely or in a collaborated manner, as for example, UNESCO in the form of MAB and the ASEAN countries in the form of CITES. The areas of great plant genetic diversity or the areas where remnant population of rare or threatened animals occur, should be selected as nature reserves for safeguarding wildlife and for serving equally well as plant genetic resource centres. The process of establishment of reserve for both wildlife and plant germplasm would be facilitated if private sectors working separately could cooperate in their approach to appropriate governmental agencies.

The information on plant genetic resources is fragmentary. But, since the establishment of IBPGR in 1974, more and more information on plant germplasm was documented. The IBPGR, of course, was the pioneering agency to highlight the urgency of conservation of plant germplasm and help to strengthen the national and international capabilities. The role of IBPGR in conservation, exchange and promotion of world’s genetic resources is indeed pre-eminent. Equally important has been the role of IRCS operating all over the world for different crops, viz. rice (IRRI), wheat and maize (CIMMYT), cassava (CIAT), potato
LIFE SUPPORT SPECIES

(CIP) and sweet potato, tomato, mung bean, soybean and Chinese cabbage (AVRDC).

COLLECTION AND MAINTENANCE

Thailand is one of the tropical countries which is rich in wildlife and plants (2,000 species). The germplasm wealth of crop plants collected with the support of IBPGR and maintained in Thailand are listed in Table 1. Some species can perhaps be best conserved by growing them

Table 1. Germplasm holdings of crop plants

<table>
<thead>
<tr>
<th>Crops</th>
<th>Number of accessions</th>
<th>Crops</th>
<th>Number of accessions</th>
</tr>
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<tbody>
<tr>
<td>Cereals and coarse grains</td>
<td></td>
<td>Oil crops</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>2,348</td>
<td>Sesame</td>
<td>100</td>
</tr>
<tr>
<td>Maize</td>
<td>550</td>
<td>Castor</td>
<td>50</td>
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<tr>
<td>Sorghum</td>
<td>150</td>
<td>Cash crops</td>
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<tr>
<td>Grain legumes</td>
<td></td>
<td>Tobacco</td>
<td>250</td>
</tr>
<tr>
<td>Mung bean</td>
<td>834</td>
<td>Cotton</td>
<td>400</td>
</tr>
<tr>
<td>Vigna spp.</td>
<td>495</td>
<td>Kenaf</td>
<td>215</td>
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<tr>
<td>Winged bean</td>
<td>528</td>
<td>Jute and allied fibres</td>
<td>20</td>
</tr>
<tr>
<td>Soybean</td>
<td>681</td>
<td>Sugar crops</td>
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</tr>
<tr>
<td>Groundnut</td>
<td>1,068</td>
<td>Sugarcane and related grasses</td>
<td>250</td>
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<tr>
<td>Pigeon pea</td>
<td>49</td>
<td>Plantation crops</td>
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<tr>
<td>Chickpea</td>
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<td>Rubber</td>
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<tr>
<td>Lentil</td>
<td>169</td>
<td>Oil palm</td>
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<tr>
<td>Plantation crops</td>
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<td>Cocoa</td>
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<tr>
<td>Sugar crops</td>
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<td>Medicinal plants and spices</td>
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<td>Coffee</td>
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<td>Roots and tubers</td>
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<td>Amaranth</td>
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<td>Sweet potato</td>
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<td>Bitter gourd</td>
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<tr>
<td>Taro</td>
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<td>Cabbage</td>
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<tr>
<td>Amorphophallus spp.</td>
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<td>Eggplant</td>
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<tr>
<td>Curcuma spp.</td>
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<td>Onion</td>
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<td>Dioscorea spp.</td>
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<td>Morning glory</td>
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<tr>
<td>Costus spp.</td>
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<td>Tomato</td>
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<tr>
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<td>Hyacinth bean</td>
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<td>Rambutan</td>
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<td>Longan</td>
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<tr>
<td>Litchi</td>
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</tr>
<tr>
<td>Tamarind</td>
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</tr>
<tr>
<td>Banana</td>
<td>358</td>
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<td></td>
</tr>
<tr>
<td>Citrus</td>
<td>Few</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cashew</td>
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<td></td>
</tr>
<tr>
<td>Pineapple</td>
<td>5</td>
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</table>
in gardens like banana in Nakhon Ratchisima and fruit plants in Trang and a few can be kept in collection like stored seeds in the genebank as in the National Genebank of Thailand at TISTR and the Rice Seed Storage Laboratory at the Department of Agriculture. As for research on maize and sorghum, the centre was established in Nakhon Ratchisima, whilst Rayong served as the centre for root and tuber crops.

Collection missions

The expeditions were sent out to explore and collect the germplasm of plants throughout Thailand. It is difficult to mention in much detail about all the projects. But, to give an example, in *Saccharum* spp. 250 accessions were collected and separated into six groups, viz. *Saccharum officinarum, Saccharum spontaneum, Saccharum sinense, Erianthus* spp., *Sclerostachya fusca, and Narenga prophyrocoma.*

Species Adaptation and Uses

1. *S. officinarum*: This species was cultivated for its canes for chewing or squeezing and for juice was grown at a remarkably small scale with about 0.5 to 1 hectare at home gardens for family income. It appeared for sale in local markets in some provinces. The names given from place to place or from one province to another on the basis of the colour of the cane, were Nam Puing or Sweet Crisp, Ooi Kao, Ooi Hok, Tapao, Ooi Dum, etc. Forty accessions collected from all over the country were classified into four groups according to the general morphology of the vegetative parts:

   a. Mauritius group: This was the most prevalent type with red or purple stem of medium size. In the Central and the North region, it was called Mauritius, whilst in the South and the East, it was known as Ooi Daeng and Nam Puing or Sweet Crisp, respectively.

   b. Ooi Kao group: The culms in this group were about the same size as those of the Mauritius. But, the colour of the stem was very much different. There was a variation of colour from white, whitish green to yellow and hence the names Ooi Kao, or Ooi Luang were given accordingly.

   c. Tapao group: This group comprised three types known as Tapao, Ooi Hok and Ooi Lebkwai. The cane was very huge with thick stems and attaining a height of 6 metres. The tillering was considerably high. The colour of the stem was white, whitish yellow and yellow with pink stripes.

   d. Ooi Dum group: The culm size in this type was normally smaller than those of others and the colour was deep purple with purplish
green leaves. The midrib was also deep purple. The clone was reported to be of medicinal value and was being grown for this purpose.

2. *S. spontaneum*: This species was found in nearly all types of habitats from dry sandy areas, lower wet ground to stagnant waters of fresh water lakes and pools. Often the hilly tracts were completely devoid of *S. spontaneum* as in the northeastern region, except for the north in the area from Tak to Mae Sod, along the Thailand-Burma border. Since the topography of the northern part of the country included hills alternating with plains, and the hilly tracts were devoid of *S. spontaneum*, the species distribution was indeed discontinuous. Probably, due to the geographical isolation, distinct morphological forms seemed to occur in different areas. These forms were (i) very broad leaved, thin and with long stalk, (ii) very narrow leaved forms where the lamina is almost reduced to midrib and (iii) the thin slender stems with intermediate leaf width and stature. Among the three types, the large broad leaved forms appeared throughout, although the frequency of occurrence varied from area to area.

3. *S. sinense*: Three clones which morphologically resembled *S. sinense*, were found in the Southern region, one from Phattalung, second from the centre of township of Songkhla and the third collected on the way between Sadao and Padang Besar near Thailand-Malaysian border. Among them, the accession collected from Phattalung was the most important. The stools which were available in the location had 65 cane tillers. They were erect with semi-open tip, drooping canopy structure and attaining a height of 6.5 metres. The canes were purple in colour and very hard but rather sweet. These were grown mainly for ornamental purposes and usually fed to pigs and buffalos.

4. *Erianthus* spp: The accessions of *Erianthus* collected all over the country were separated into two groups, namely, *E. arundinaceum* and *E. procerum*. The first and the latter were usually called Kaem or Traeng and Samong or Kamong, respectively. They were sugarcane weedy species and grew wild from low to high altitudes. In some areas, they were found in large dense population and with frequent distribution. They were morphologically similar in nearly all respects. Thus, identification based on the vegetative parts was almost uncertain.

5. *Sclerostachya fusca*: The accessions of *S. fusca* were located and collected from seven sites. In most areas, *S. fusca* sparsely spread and co-existed with other related grass genera as well as *S. spontaneum*. 
The most extensive population of *S. fusca* was found in Surat Thani (south). Several kilometres were colonised exclusively by *S. fusca*. Two distinct forms could be separated, one with broad leaves and dense inflorescence and another with narrow leaves and lax inflorescence. Both forms occurred in the same locality.

6. *Narenga prophyrocoma*: This was discovered only in Chiang Rai. Four accessions were collected at two locations, one location between Chiang Rai and Mae Sai and another between Chiang Rai and Mae Chan. These areas were forest clearings where *S. spontaneum* grew extensively together. A large number of *N. prophyrocoma* stools were examined throughout the areas. Many of them were in flower. The plants were very robust, with heavy tillering and pubescent sheath and very long inflorescence stalks.

The genetic resources are made up of great diversity of plant species as are present today, ranging from wild ancestors to modern cultivars. The IBP (1966) and Harlan (1975) suggested the separation into three groups: competing wild species, land races and advanced cultivars. In order to obtain facts and figures from these, utmost attention is required to be paid to survey for exploration and collection, classification and description, preservation and conservation or maintenance, multiplication and rejuvenation, distribution or exchange, evaluation and utilisation.

**Conclusions**

All the activities are vital and interlinked. The effectiveness and efficiency of one activity are associated with those of the other activities. The germplasm should be used in the course of improvement of economic plants, otherwise the collections would be only of ephemeral value at the best. The effective use of genetic resources is not possible until they have been evaluated and documented and the information made available to the bonafide users. The information recorded and assembled in a base should be restricted in scope and confined to what is both useful and usable. The evaluation and availability of the desired germplasm is linked with the maintenance, multiplication or regeneration of the initial collection in adequate quantity.

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LIFE SUPPORT SPECIES FOR CRITICAL ENVIRONMENTS IN PAKISTAN

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INTRODUCTION

When a nation thinks of facing problems of the 21st century, it has to evolve a qualitative environment for the future generation. Life support species have an important role to play for the welfare of mankind, especially when natural resources such as land, water, nutrients and energy are likely to become limited due to the increased pressure of human and livestock population of the world. Life support species are those plants which are used by the people under extreme environmental conditions. These species have unique adaptation to environmental extremes and are valuable for human survival in these conditions. It is necessary that the basic information regarding their taxonomy, distribution, ecological characteristics, products (i.e. food, fuel, fibre, soil stabilisation, etc.) and their conservation factors are taken up by the local scientists. Like this, many species of economic value can be found out which are unutilised due to lack of attention.

There are various types of stresses that pose constraint in achieving adequate productivity levels to support the increasing population. The different types of stresses require different remedies. The floras and their utility for particular areas should be known so that certain species may be used as life support species at the time of need.

SPECIES LISTED

A glimpse of the situation in Pakistan on the life support species— their occurrence in different eco-climates, distribution and economic utility is given in Table I. The species listed pertain to hot and cold desert areas, salinity stress locations, adaptable to marsh lands, and some of the under-utilised types including cereals, minor millets and grain legumes. Their uses as food, forage and in medicine are listed.

To feed the hungry millions in the world, food production has to be increased and new resources of supply have to be tapped. A very high proportion of the world’s usable land is grassland. Since animals thrive on grass, it may be concluded that grass is a high grade food. The
grass proteins are often high grade and almost equal to the best animal proteins. These also contain carbohydrates as poly-fructosanes which are produced by union of fructose molecules. The number of fructose molecules joining to form a poly-fructosane molecule ranges from 15–50. Basically, fructose has the same nutritional value as glucose. Children and old people utilise fructose better than glucose. The polyfructosanes do not taste sweet and their colour is white. Ordinary flour mixed with about 20% of polyfructose makes ideal bread, which has a good taste and is readily digested. This is high time that we extract sugars and proteins from grasses as life support, in extremes of drought, desertification leading to famine.

There is a large variety of red algae available at the coast along Karachi. Polysaccharides can be obtained from some of the species which are important agents of medicinal/industrial use. The polysaccharides can be used in making cosmetics, glue, jellies, candies, toothpastes and as stabiliser in ice cream. Some of the red algae are of food value and are used as food in some countries.

The lichens which are in abundance in the hills are totally ignored. Some of the lichens like Parmelia and Lecanora can be used as food and fodder. Some lichens like Usnea, Cladonia and certain other lichens contain usnic acid which is a broad spectrum antibiotic and is useful in the treatment of various infections. These are also used in the preparation of ointments for wounds and burns.

**Future Thrusts**

1. There is an urgent need to explore the native flora of extreme environments.
2. A systematic cataloguing may be made of the life support species according to the habitats, and computerised.
3. The information regarding their taxonomy, distribution, ecological characteristics, products (i.e. food, fuel, fibre, medicinal value, soil stabilisation, etc.) and on their conservation be taken up at the earliest.
4. The germplasm of some life support species is under threat due to habitat loss. Their conservation should be done on priority basis.
5. The selected and prioritised species should be popularised among people for food, fodder, medicine and energy needs.
6. The germplasm of the life support species should be imported or exchanged with neighbouring countries and introduced in the local habitats to improve the economic conditions of local inhabitants.
7. Almost all plants can be life support species during the emergency conditions. It would be worthwhile to prepare a catalogue of the poisonous or toxic plants of particular habitats.

8. Post graduate students should be involved by using life support species for studies in their thesis/dissertation for increasing our knowledge.

9. The vast majority of under-utilised wild species should be studied through the use of biotechnology.

10. The useful genes of life support species be identified and utilised for crop improvement needs.
<table>
<thead>
<tr>
<th>Name</th>
<th>Distribution</th>
<th>Produce/content/medicinal use etc.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>Zizyphus nummularia</td>
<td>Common in hotter parts of the country, Sindh, Baluchistan, NWFP, Punjab, Lower Hazara</td>
<td>Fruits edible</td>
</tr>
<tr>
<td>Cucumis callosus</td>
<td>Karachi, Sindh, Bhat, Chitral</td>
<td>Fruits edible</td>
</tr>
<tr>
<td>Grewia tenax</td>
<td>Common desert shrub in rocky places</td>
<td>Fruits edible</td>
</tr>
<tr>
<td>Momordica dioica</td>
<td>In plains and lower hills of Sindh, Dir, Swat</td>
<td>Jangli karela is used as vegetable.</td>
</tr>
<tr>
<td>Cordia gharaf</td>
<td>Villages of Sindh, Baluchistan</td>
<td>Fruits edible</td>
</tr>
<tr>
<td>Coccinia grandis</td>
<td>Thar deserts, Las Bela, Swat, Khozdar, Madian, Salt range</td>
<td>Fruits edible</td>
</tr>
<tr>
<td>Salvadoria oleoides</td>
<td>Karachi, Sindh, Lower Baluchistan, Lower Kurram, NWFP, other parts of Punjab</td>
<td>Fruits edible</td>
</tr>
<tr>
<td></td>
<td>Punjab: Dera Ghazi, Khan, Multan, Jhang etc.</td>
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<tr>
<td>Pongamia pinnata</td>
<td>Planted in Punjab and Sindh</td>
<td>Yields edible yellow oil. The oil when applied externally cures herpes and eczema. Root (juice) cures ulcers and fistula.</td>
</tr>
<tr>
<td>Aloe barbadensis</td>
<td>It is planted in gardens of Sindh and Punjab</td>
<td>Leaves are aphrodisiac, cathartic, emmenagogue and anthelmintic.</td>
</tr>
<tr>
<td>Cyperus rotundus</td>
<td>Lahore, Swat, Chitral, Gilgit</td>
<td>The starchy underground tubers are eaten as foods.</td>
</tr>
<tr>
<td>Species</td>
<td>Description</td>
<td></td>
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<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td><em>Prospis cineraria</em></td>
<td>Common in Sind, Baluchistan and Punjab. The other common species are <em>P. juliflora</em> and <em>P. glandulosa</em></td>
<td></td>
</tr>
<tr>
<td><em>Ailanthus excelsa</em></td>
<td>Cultivated in Sind and Lahore</td>
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<tr>
<td><em>Saccharum munja</em></td>
<td>A large tufted grass of river flood plains. Baluchistan, Sind, Punjab, NWFP.</td>
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<tr>
<td><em>Crotalaria burhia</em></td>
<td>Widespread in dry areas of Sind, Baluchistan NWFP, Punjab and Salt Range.</td>
<td></td>
</tr>
<tr>
<td><em>Leptadenia pyrotechnica</em></td>
<td>Karachi, Sind, Baluchistan: Las Bela, Sibi. Punja: Multan, Bhakkar, etc.</td>
<td></td>
</tr>
<tr>
<td><em>Tephrosia filiformis</em></td>
<td>Sind, Jamshoro.</td>
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<tr>
<td><em>Acacia nilotica</em></td>
<td>Common throughout Pakistan.</td>
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<tr>
<td><em>Acacia senegal</em></td>
<td>Karachi: Dadu, Sukkar, Tharparkar, Las Bela; Thar desert</td>
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<tr>
<td><em>Acacia leucophloea</em></td>
<td>Nagar Parker Hills, Punjab</td>
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</table>

The plant is eaten raw as well as cooked. The rhizome yields oil which is used in perfumery and in manufacture of scapa. It cures dyspepsia, vomiting, cholera and fevers.

Swartz forage, leaves contain about 14% protein. Bark is boiled and eaten.

Forage for cattle, sheep and camel. Excellent for news print, match boxes, etc.

It is used for making ropes.

Fibre is extracted from the plant.

It is utilised for maning ropes.

It is used for making baskets.

It is used for making agricultural implements and furniture.

It is used as fuel, for making agricultural implements and furniture.

The gum is used in confectionery and in pharmaceutical preparations.

It is used as fuel and in making agricultural implements.

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<tr>
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<tbody>
<tr>
<td><strong>Datura innoxia</strong></td>
<td>Baluchistan, Punjab: Jhelum and Rawalpindi districts</td>
<td>All parts are intoxicant, narcotic, aphrodisiac, antispasmodic and anodyne.</td>
</tr>
<tr>
<td><strong>Citrullus colocynthis</strong></td>
<td>Common in sandy desert areas of Baluchistan, Sind and Punjab</td>
<td>The bitter roots are pungent, cooling, anthelmintic, carminative and antipyretic. Plant is useful for asthma, jaundice, bronchitis, rheumatism, etc.</td>
</tr>
<tr>
<td><strong>Moringa oleifera</strong> (Horseradish tree—Soanjna)</td>
<td>Native and cultivated in sub-Himalayan tract</td>
<td>Deserves due attention for its food and fodder values besides finding use in paper industry.</td>
</tr>
<tr>
<td><strong>Commiphora wightii</strong></td>
<td>Rocky places of Karachi and Sind</td>
<td>It is stomachic, demulcent, astringent, antiseptic, diuretic and expectorant.</td>
</tr>
<tr>
<td><strong>Withania somnifera</strong></td>
<td>Common shrub of desert areas of Sind, Karachi, Baluchistan, Punjab and NWFP</td>
<td>The alkaloid somniferine is aphrodisiac, abortifacient, deobstruent, alterative and stimulant.</td>
</tr>
<tr>
<td><strong>Euphorbia neriifolia</strong></td>
<td>Sind and Baluchistan. Almost throughout Pakistan. Plains to 900m</td>
<td>The latex is deobstruent and is used in ophthalmis. The ointment of turmeric and latex is useful for piles.</td>
</tr>
<tr>
<td><strong>Phyllanthus niruri</strong></td>
<td>Sind, Baluchistan, NWFP, Swat, Hazara, Punjab</td>
<td>The herb is useful for gonorrhoea and urinogenital diseases.</td>
</tr>
<tr>
<td><strong>Indigofera cordifolia</strong></td>
<td>Sind, Baluchistan, Salt Range Rawalpindi, Kotli, etc.</td>
<td>It is useful for diseases of lungs and kidneys.</td>
</tr>
<tr>
<td><strong>Clerodendrum phlomoides</strong></td>
<td>Karachi, Sind, Punjab: Salt Range, Multan, Changa Manga, Mangla, Jhelum etc.</td>
<td>The leaves are cholagogue and anthelmintic.</td>
</tr>
<tr>
<td>Species</td>
<td>Description</td>
<td>Location</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<tr>
<td><em>Cenchrus biflorus</em> syn. <em>C. setigerus</em></td>
<td>Common in deserts. Other common species are <em>C. ciliaris</em> L, <em>C. pennisetiformis</em>.</td>
<td></td>
</tr>
<tr>
<td>2. Cold desert</td>
<td></td>
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<tr>
<td><em>Casuarina equisetifolia</em></td>
<td>Karachi, Sind.</td>
<td></td>
</tr>
<tr>
<td><em>Eucalyptus citriodora</em></td>
<td>Many species of <em>Eucalyptus</em> like <em>E. rostrata</em>, <em>E. globulus</em>, <em>E. tereticornis</em> are common in gardens or by road sides.</td>
<td></td>
</tr>
<tr>
<td><em>Chenopodium foliosum</em></td>
<td>Chitral, Swat, Gilgit, Murree, Poonch</td>
<td></td>
</tr>
<tr>
<td><em>Cicer songoricum</em></td>
<td>Gilgit, Chitral, Astor eastward 3000-4500m</td>
<td></td>
</tr>
<tr>
<td><em>Aconitum heterophyllum</em></td>
<td>Chitral, Swat, Hazara, Murree</td>
<td></td>
</tr>
<tr>
<td><em>Polygonum viviparum</em></td>
<td>Common in marshy places of alpine zone Chitral, Swat, Gilgit, Pamirs-2700-5100m</td>
<td></td>
</tr>
<tr>
<td><em>Sedum tibeticum</em></td>
<td>Chitral, Swat in winter</td>
<td></td>
</tr>
<tr>
<td><em>Sedum roseum</em></td>
<td>Chitral, Gilgit: Balti 3600-5100m</td>
<td></td>
</tr>
<tr>
<td><em>Potentilla fruticosa</em></td>
<td>Karak Mt, Kashmir</td>
<td></td>
</tr>
<tr>
<td><em>Alopecurus himalaicus</em></td>
<td>Chitral, Swat, W. Tibet, Gilgit, 3000-4000m</td>
<td></td>
</tr>
<tr>
<td><em>Polypogon monspeliensis</em></td>
<td>Very common everywhere from plains to 3500m</td>
<td></td>
</tr>
<tr>
<td><em>Agropyron repens</em></td>
<td>Baluchistan, Kurram, Swat beyond Ushu, Chitral, Gilgit common at 2600-4600m</td>
<td></td>
</tr>
<tr>
<td><em>Tripogon purpurescens</em></td>
<td>Quetta, Kurram Dir, Swat, Mirpur 600-2200m</td>
<td></td>
</tr>
<tr>
<td><em>Potentilla fruticosa</em></td>
<td>Karak Mt, Upper Kishen Karghe Valley</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Species</th>
<th>Location and Elevation</th>
<th>Habitat Notes</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Phleum alpinum</em></td>
<td>Chitral, Swat, Dir</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Lespedeza sericea</em></td>
<td>Kashmir, Murree, Kagan, Hazara, Chitral, Kurram</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Bromus japonicus</em></td>
<td>Very common spring annual from plains to 3000m on road sides and near cultivation</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Calamagrostis epigeios</em></td>
<td>Astor: Doian, Gilgit, Nilter Skardu, Kagan Valley, etc. 2600-4500m</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Elymus dasystachys</em></td>
<td>Common in high, dry inner Himalayas Kurram, Chitral, Swat, Gilgit, Hazara, etc. 5000m</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Calamagrostis turkestanica</em></td>
<td>Gilgit 3000-5000m</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Dryzopsis lateralis</em></td>
<td>Commonest species at hills. Swat, Chitral, Kagan, Hunza, Murree, etc.</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Indigofera heterantha</em></td>
<td>Very common. Kurram, NWFP, Chitral, Swat. 1200-3600m</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Stipa capillata</em></td>
<td>Baluchistan: Ford Sandeman, Chitral, Gilgit-900-1200m</td>
<td></td>
<td>Forage</td>
</tr>
<tr>
<td><em>Anemone obtusifolia</em></td>
<td>Commonest anemone. Chitral, Swat, Hazara, Murree, Poonch, Kashmir-2100-4500m</td>
<td></td>
<td>The seed oil is used in rheumatism</td>
</tr>
<tr>
<td><em>Thalictrum foliosum</em></td>
<td>Chilral: Lowari Pass, Hazara, Changla Gali, Poonch, etc.</td>
<td></td>
<td>The roots are purgative, tonic, diuretic, febrifuge. It also cures dyspepsia.</td>
</tr>
<tr>
<td><em>Lonicera glauca</em></td>
<td>Upper Kurram, Chitral, Tirich Mir, Gilgit 3700-5000m</td>
<td></td>
<td>The seeds are given to horses and cattle for colic.</td>
</tr>
<tr>
<td><em>Corydalis racemosa</em></td>
<td>Common in Kurram-2100-3300m</td>
<td></td>
<td>It is used for the treatment of eye diseases.</td>
</tr>
<tr>
<td><em>Thymus serphyllum</em></td>
<td>Very common and very variable Dir, Chitral, Swat, Gilgit, Poonch-1500-4500m</td>
<td></td>
<td>It is useful for stomach disorders and other diseases of eye.</td>
</tr>
</tbody>
</table>
**Plantago himalica**
Hazara, Kagan Skardu, Ladak-2100-4500m
Baluchistan, Chitral, Kurram, Swat, Gilgit, Punjab-900-3300m

**Silene viscosa**

**Euphorbia thomsoniana**
Upper Murram Chitral, Swat, Gilgit
2700-3900m

**Polygonum tortuosum**
Chitral: Balti, Ladak, Rama

3. Semi-arid zones

**Boerhaavia coccinea**
In the plains up to 1200m Sind, Baluchistan, Kurram, Punjab

**Amaranthus viridis**
Common in the plains of Sind, Baluchistan and Punjab.

**Mucuna pruriens**
Mirpur, Udumphur

**Cocculus hirsutus**
Sind, Punjab

**Convolvulus microphyllus**
Karachi, Sind, Baluchistan, NWFP, Punjab

**Euphorbia thyrsifolia**
Karachi, Baluchistan

**Mucuna pruriens**
Mirpur, Udumphur

**Adhatoda vesica**
Karachi, Sind, Lower Baluchistan, NWFP, Dir, Chitral, up to 1200m

**Evolvulus alsinoides**
Widespread in plains and lower hills. Sind, Baluchistan, NWFP, Punjab: Salt Range, Pabbi Hills, Rawalpindi Hills, Attock, Lower Hazara, etc.

**Boerhaavia diffusa**
Almost everywhere in Pakistan on the plains and up to 1200m

The leaves are used to cure wounds. It is used as detergent.

It is used as detergent.

Thick roots are used as fuel.

The leaves are cooked and eaten.

It is used as vegetable.

Pods are cooked and eaten.
Leaves are used as food.

It is used as brain tonic.
It is used as galactogogue.

For the treatment of urinogenital disorders and for diseases of nervous system. The leaf-juice cures dysentery and diarrhoea.

It is powerful expectorant and anti-spasmodic.

It is used as a brain tonic.

The alkaloid punarnavine is febrifuge, emmenagogue and diuretic. Leaf-juice is useful for jaundice and liver

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<tbody>
<tr>
<td><strong>Ipomoea pastigridis</strong></td>
<td>Karachi: Malir, Swat, Pir Baba, Hazara, Garhi Habibullah, Rawalpindi, Jhelum, etc.</td>
<td>complaints. The roots are useful for gonorrhoea and dropsy. The roots are laxative.</td>
</tr>
<tr>
<td><strong>Coccus hirsutus</strong></td>
<td>Sind, Punjab</td>
<td>The leaf juice cures gonorrhoea. The roots cure cough and rheumatism.</td>
</tr>
<tr>
<td><strong>Abrus precatorius</strong></td>
<td>Sind, Kashmir</td>
<td>The seeds prevent conception in woman. The decoction of the leaves is useful for diarrhoea, gonorrhoea and for inflammation of bladder and urethra.</td>
</tr>
<tr>
<td><strong>Abutilon indicum</strong></td>
<td>Common throughout Pakistan</td>
<td>It is useful in bronchitis, asthma, pneumonia and scabies.</td>
</tr>
<tr>
<td><strong>Acalypha indica</strong></td>
<td>Common troublesome weed on roadsides and gardens.</td>
<td>It is useful in excessive menstruation, diarrhoea, dysentery, piles, rheumatism and inflammation of internal organs.</td>
</tr>
<tr>
<td><strong>Achyranthes aspera</strong></td>
<td>Common herb in the plains of Punjab, Sind and NWFP</td>
<td>Seeds are anthelmintic and carminative. Plant also cures flatulence and bilious disorders.</td>
</tr>
<tr>
<td><strong>Cuscuta reflexa</strong></td>
<td>A total parasite on other angiospermic plants. Common throughout Pakistan</td>
<td>Leaves cure rheumatism, neuralgia, stiff neck and ear diseases. Latex is useful for bleeding wounds, piles, scabies, eczema, itch, herpes, etc.</td>
</tr>
<tr>
<td><strong>Gynandropsis gynandra</strong></td>
<td>A common weed</td>
<td>Useful for leucoderma, flatulence and for intestinal worms. Seed paste kills head lice.</td>
</tr>
<tr>
<td><strong>Jatropha curcas</strong></td>
<td>Azad Kashmir</td>
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</tr>
<tr>
<td><strong>Vernonia cinerea</strong></td>
<td>A herbaceous plant distributed throughout Pakistan</td>
<td></td>
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<tr>
<td>4. Saline areas</td>
<td></td>
<td>It is a manure crop and improves the barren land. Seeds are rich source of</td>
</tr>
<tr>
<td><strong>Sesbania aculeata</strong></td>
<td>Baluchistan, Kurram, Chitral, Swat, Hazara Punjab. Common plant of saline areas</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Origin and Description</td>
<td></td>
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</tr>
<tr>
<td><em>Salvadora oleoides</em></td>
<td>Karachi, Sind, Lower Baluchistan, Lower Kurram NWFP, Punjab, Salt Range. Fruits and seeds are eaten.</td>
<td></td>
</tr>
<tr>
<td><em>Salvadora persica</em></td>
<td>Karachi, Sind: Sewan, Punjab: Dera Ghazi Khan, Multan, Jhang, etc. The berries are lithoentropic, fattening, deobstuent and diuretic. Bark juice is emmenagogue. It is used as vegetable.</td>
<td></td>
</tr>
<tr>
<td><em>Chenopodium ambrosiodes</em></td>
<td>Baluchistan, Peshawar, Dir, Swat, Rawalpindi. The strongly scented weed seems only to be found by the road sides and about habitations.</td>
<td></td>
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<tr>
<td><em>Capparis decidua</em></td>
<td>Common in deserts and arid regions of Pakistan.</td>
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</tr>
<tr>
<td><em>Sueda fruticosa</em></td>
<td>Common in deserts and arid regions of Pakistan. It is burnt and ash is used as detergent by locals.</td>
<td></td>
</tr>
<tr>
<td><em>Portulaca oleracea</em></td>
<td>A common weed in the plains and hills up to 2100m. Sind, Baluchistan, Gilgit, Hazara. It is used as vegetable.</td>
<td></td>
</tr>
<tr>
<td><em>Salix brachyata</em></td>
<td>Common at high levels in the alpine zone, Hazara, Kagan 3000-4600m. Fodder for cattle.</td>
<td></td>
</tr>
<tr>
<td><em>Sporobolus helvolus</em></td>
<td>Sind, Karachi, Baluchistan: Quetta and the deserts of Multan and Faisalabad. Yields forage.</td>
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<tr>
<td><strong>Dactyloctenium scindicum</strong></td>
<td>Sind, Karachi, NWFP: Kohat, Bannu, Peshawar. Baluchistan: Quetta Punjab: Lahore, Attock, Khewra, etc.</td>
<td>A desert species of alkaline soils</td>
</tr>
<tr>
<td><strong>Rhynchosia minima</strong></td>
<td>Everywhere in the plains and up to 1200m</td>
<td>Widespread in arid regions. Sind, Karachi, Punjab: Lahore, Gujranwala, etc.</td>
</tr>
<tr>
<td><strong>Diplachne fusca</strong></td>
<td>Throughout Pakistan ascending to 1600m</td>
<td>Common weed in wastelands of Sind and Punjab</td>
</tr>
<tr>
<td><strong>Eleusine indica</strong></td>
<td>Baluchistan, NWFP, Punjab: Khawra, Taxila, Jhelum. Plains to 2700m</td>
<td>Common weed in wastelands of Sind and Punjab</td>
</tr>
<tr>
<td><strong>Kochia indica</strong></td>
<td>Common, Sind, Punjab: Rawalpindi, Hassan Abdal, Abbottabad, Swat: Mangora, Marguzar. Plains to 2800m</td>
<td>It is astringent, cooling, diuretic and antiscorbetic.</td>
</tr>
<tr>
<td><strong>5. Marshlands</strong></td>
<td>Sindh, Baluchistan, NWFP: Peshawar, Kohat. Punjab: Rawalpindi, Swat: Mangore. Lower Hazara, Poonch. Commonly found in deep soils.</td>
<td>South Waziristan</td>
</tr>
<tr>
<td><strong>Lemna minor</strong></td>
<td>Common in Sind, Karram, Punjab: Pakpattan, Multan, Lahore, Rawalpindi, etc.</td>
<td>Common in Sind, Karram, Punjab: Pakpattan, Multan, Lahore, Rawalpindi, etc.</td>
</tr>
<tr>
<td><strong>Alternanthera spp.</strong></td>
<td>Sind, Karachi, Punjab: Wazirabad to Sialkot-in village ponds</td>
<td>Common in Jhelum district and Salt Range</td>
</tr>
</tbody>
</table>
UNDER-UTILISED PLANTS PROGRAMME IN INDIA—
CONCEPT AND FUTURE PERSPECTIVE

BHAG MAL

National Bureau of Plant Genetic Resources, Pusa Campus,
New Delhi, India

INTRODUCTION

India with its diverse edapho-climatic conditions and agro-ecology possesses immense plant diversity and serves as a reservoir of several plant species which are relatively less known or unknown and are yet to be domesticated and utilised for the benefit of mankind. Several of these plant species do not require high input technology and can thrive well on marginal and sub-marginal lands and problematic soils. There are about 158 million hectares of wastelands in India under different categories, viz. sand dunes, ravines, water logged, saline/alkali, water eroded, wind eroded, degraded forests, riverine and land affected by shifting cultivation (Singh, 1986). These wastelands are not suitable for intensive crop production and can, therefore, be put to use under newer plant species. It is expected that besides the traditional needs and markets, new raw materials will also be required in future. Further, the changing conditions are already creating demands for new products from previously under-exploited plants.

With alarming increase in human population and depletion of natural resources, it has been felt necessary to explore the possibility of use of new plant resources having potential for food, fodder, energy and industrial uses. With this aim in view, the work on collection, introduction, domestication and utilisation on new plant species was initiated at the Indian Agricultural Research Institute, New Delhi in early sixties. Later on, the work on some under-utilised plants of economic value was extended to other research centres located in Agricultural Universities and the Research Institutes. In order to give further impetus to research in this direction, an All India Coordinated Research Project on Under-utilised and Under-exploited Plants was initiated in 1982 during Sixth Five Year Plan.

In the present paper, an attempt has been made to give an over view of the under-utilised plants programme including objectives, infrastructure, plant species embraced and the significant achievements. Specific problems/limitations vis-a-vis research needs in a few important species have been highlighted and the future research thrusts have been pointed out.
Objectives

The major objectives of the programme inter-alia are:

(i) To find out new plant resources of food, fodder, fuel, energy and industrial uses.
(ii) To identify superior genotypes of these new plants for different agro-climatic regions.
(iii) To improve/develop plant types to have economic returns of their useful products.
(iv) To standardise the package of agronomic practices.

Infra-structure

The All India-Coordinated Research Project on Under-utilised and Under-exploited Plants is based at National Bureau of Plant Genetic Resources. Presently, there are 15 regular research centres and 10 voluntary centres of this Project including 6 regional stations of National Bureau of Plant Genetic Resources. The Project Centres are located in different agro-climatic regions of the country and are entrusted with the responsibility of germplasm collection, evaluation and maintenance as well as for conducting multi-locational trials with respect to specific plant species important for a particular area or region.

Plant species embraced under the programme

The major responsibility of carrying out the work on specific crops has been assigned to different centres (Table 1). The important plant species on which the work is currently in progress under the Coordinated Project are listed below:

I. Food Plants

Grain amaranths (*Amaranthus* species), chenopods (*Chenopodium album*), buckwheat (*Fagopyrum esculentum*), winged bean (*Psophocarpus tetragonolobus*), rice bean (*Vigna umbellaia*), bambara groundnut (*Vondezia subterranea*), paradise tree (*Simaruba glauca*).

II. Fodder Plants

Ipil Ipil (*Leucaena leucocephala*), Hardwickia binata, *Colophospermum mopane*, *Dichrostachys nutans*, *Cassia sturtii*, *Albizzia amara*, *Acacia tortilis*.

III. Energy Plants

*Casuarina* species, bamboo, sugarcane (*Saccharum officinarum*), sweet potato (*Ipomoea batatas*), *Dioscorea* species.
Table 1: Centre-wise distribution of crops

<table>
<thead>
<tr>
<th>Centre</th>
<th>State</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. University based centres</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hisar</td>
<td>Haryana</td>
<td>Jojoba, guayule, Euphorbia, Jatropha</td>
</tr>
<tr>
<td>Sardar Krushinagar</td>
<td>Gujarat</td>
<td>Guayule, Euphorbia, Jatropha, grain amaranths</td>
</tr>
<tr>
<td>Muttupayyam</td>
<td>Tamil Nadu</td>
<td>Jojoba, guayule, Casuarina</td>
</tr>
<tr>
<td>Bangalore</td>
<td>Karnataka</td>
<td>Winged bean, chenopods, grain amaranths, bambara groundnut</td>
</tr>
<tr>
<td>Bhubaneshwar</td>
<td>Orissa</td>
<td>Grain amaranths, chenopods, winged bean, bambara groundnut</td>
</tr>
<tr>
<td>Ranichauri</td>
<td>Uttar Pradesh</td>
<td>Winged bean, grain amaranths, chenopods, buckwheat</td>
</tr>
<tr>
<td>Rahuri</td>
<td>Maharashtra</td>
<td>Guayule, jojoba, Jatropha, Euphorbia</td>
</tr>
<tr>
<td>Ranchi</td>
<td>Bihar</td>
<td>Winged bean, grain amaranths, rice bean</td>
</tr>
<tr>
<td><strong>B. Institute based centres</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delhi</td>
<td>Delhi</td>
<td>Winged bean, grain amaranths, rice bean, <em>Simaruba glauca</em></td>
</tr>
<tr>
<td>Jodhpur</td>
<td>Rajasthan</td>
<td>Jojoba, guayule, bambara groundnut, <em>Simaruba glauca</em></td>
</tr>
<tr>
<td>Jhansi</td>
<td>Uttar Pradesh</td>
<td><em>Leucaena</em>, rice bean, winged bean</td>
</tr>
<tr>
<td>Trivandrum</td>
<td>Kerala</td>
<td>Sweet potato, <em>Dioscorea</em> spp.</td>
</tr>
<tr>
<td>Lucknow</td>
<td>Uttar Pradesh</td>
<td>Sugarcane, winged bean, guayule</td>
</tr>
<tr>
<td>Shillong</td>
<td>Meghalaya</td>
<td>Rice bean</td>
</tr>
<tr>
<td>Basar</td>
<td>Arunachal Pradesh</td>
<td>Bamboo, rice bean</td>
</tr>
<tr>
<td><strong>C. Voluntary centres</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shimla</td>
<td>Himachal Pradesh</td>
<td>Grain amaranths, buckwheat, chenopods, <em>Cuphea</em></td>
</tr>
<tr>
<td>Almora</td>
<td>Uttar Pradesh</td>
<td>Grain amaranths, rice bean, <em>Simaruba glauca</em></td>
</tr>
<tr>
<td>Bhowali</td>
<td>Uttar Pradesh</td>
<td>Grain amaranths, buckwheat</td>
</tr>
<tr>
<td>Akola</td>
<td>Maharashtra</td>
<td>Grain amaranths, bambara groundnut, <em>Simaruba glauca</em></td>
</tr>
<tr>
<td>Trichur</td>
<td>Kerala</td>
<td>Rice bean, <em>Leucaena, Simaruba glauca</em></td>
</tr>
<tr>
<td>Bhavnagar</td>
<td>Gujarat</td>
<td>Guayule, jojoba</td>
</tr>
<tr>
<td>Burdwan</td>
<td>West Bengal</td>
<td>Winged bean, rice bean</td>
</tr>
<tr>
<td>Urlikanchan</td>
<td>Maharashtra</td>
<td><em>Leucaena, Euphorbia</em>, guayule</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>Andhra Pradesh</td>
<td><em>Euphorbia, Jatropha</em>, fodder trees</td>
</tr>
</tbody>
</table>

**IV. Hydrocarbon and Industrial Plants**

Guayule (*Parthenium argentatum*), jojoba (*Simmondsia chinensis*), *Euphorbia* species, *jangli arandi* (*Jatropha curcas*).
Significant achievements—past efforts

Sizable germplasm comprising over 5,300 accessions of grain amaranths, buckwheat, chenopods, winged bean, rice bean, bambara groundnut, Leucaena, guayule, jojoba, Euphorbia, Casuarina, Jatropha curcas, bamboo and tumba (Citrus colocynthis) assembled from indigenous and exotic sources was evaluated for various traits. As a result of concerted efforts, promising varieties were developed in a few selected crops (Thomas, 1987). Selection IC 42258-1 was identified the best giving 20-25 q/ha grain yield and was released as ‘Annapurna’ for hilly regions. Winged bean selections viz., EC 38821 A, EC 38821 B, EC 38955 and IIHR Sel. 13 were identified promising based on multi-localational trials and were recommended for pre-release multiplication. The cultivar Arizona-2 (ex USA) of the rubber plant, guayule (Parthenium argentatum) with good quality latex has been recommended for release. EC 33198 (ex USA) of liquid wax yielding plant, jojoba (Simmondsia chinensis) was also identified promising and recommended for large scale cultivation.

Based on multi-localational testing, other promising selections were also identified in different crops. The important ones among them include Kulu Gangari of buckwheat, NC 58613 of Chenopodium album, dwarf mutant of winged bean, K-8, Silvi-4 and K-28 of Leucaena leucocephala, Krushinagar No. 2 of Jatropha curcas, Sabarmati-1 of Euphorbia caducifolia, Chandisar-1 of E. tirucalli, HG-8 of guayule and EC 99690 and EC 99691 of jojoba. The work on tuber crops and sugarcane for their use as alternate source of energy resulted in the identification of promising types. Sugarcane genotypes CoLK 7001, CoLK 8001 and CO 1148 showed maximum bioenergy and ethanol producing potential. Variety Boki-9 of Dioscorea rotundata was the best among high starch yielders.

Specific problems/limitations and research needs

The individual crops have specific problems/limitations which come in their way in becoming popular with the farmers. The limitations and research needs for under-exploited tropical plants have been reviewed (Anonymous, 1975). Specific research programmes need to be taken up to overcome these problems. These are briefly highlighted here.

In winged bean (Psophocarpus tetragonolobus), there are problems of viny growth habit, non-synchronous pod ripening and long duration of flowering and maturity. The research efforts are needed for development of early, short duration varieties with synchronous pod ripening and for standardisation of agronomic practices that give optimum yields.
Determination of possible toxicants and antinutrition factors in mature seeds also needs to be taken up.

Lodging at maturity, seed shattering and requirement of hand labour for threshing and winnowing are the major limitations in grain amaranths. Therefore, there is need for development of lodging resistant and non-shattering varieties as well as evaluation of composition and nutritive potential of available germplasm. Seed size needs special agronomic attention due to its influence on seed quality. Research emphasis on rotation and cropping patterns and comparisons with other crops grown in the same region also need priority attention.

The limitations in buckwheat (*Fagopyrum esculentum*) are lodging, shattering of grains at maturity, poor response of the crop to fertilizers and poor market availability for buckwheat products. These limitations are to be overcome through development of lodging resistant, non-shattering and fertilizer responsive cultivars, extending its cultivation to non-traditional areas and developing suitable agronomic practices for higher yields.

Jojoba (*Simmondsia chinensis*) suffers with several problems viz., lack of abundant flowering plant types, lack of high seed yielding varieties, difficulty in identification of male and female plants at early stages, determination of male-female planting ratio and sensitivity to frost. The research needs in jojoba are (i) selection and breeding for productivity, hermaphroditism, cold tolerance and early maturation (ii) finding out genetic markers/sex linked characters for sex identification at seed or seedling stage and (iii) development of commercial methods of repetitive propagation for rapid multiplication of desirable varieties.

The major problems in guayule (*Parthenium argentatum*) are poor seed germination, susceptibility to wilt disease, susceptibility to water stagnation and inadequate processing technology for rubber extraction. The research efforts are needed for standardisation of procedures for breaking seed dormancy, development of wilt resistant varieties, determining efficient and economic procedure for rubber extraction, working out the economics of production and quantification and use of byproducts.

Similar problems/limitations do exist in several other plant species which need to be identified and research efforts to be made to overcome these difficulties so as to utilise these less known yet economically potential species to the fullest extent.

**Future Thrust**

The number of accessions evaluated indicates that the germplasm collection is meagre. Therefore, there is an urgent need for acquisition of
diverse germplasm from various sources. Greater emphasis needs to be given for exploration and collection of material from centres of origin/diversity of particular species. Comprehensive information on genetic diversity available on less known cultivated food plants has been synthesized (Arora, 1985) which needs to be utilised. The salient points on which immediate attention is to be given for the success of under-utilised plants programme are briefly enumerated below:

1. Exploration and collection of diverse germplasm from the centres of origin/diversity will be intensified with respect to the under-utilised and under-exploited plants. Exploitation of wild and weedy relatives possessing several useful genes will also be taken up for their possible use in the plant improvement programmes.

2. The evaluation of germplasm should not confine to a few characters only. Detailed evaluation for production and quality traits is to be sought for. Germplasm collections need to be evaluated over locations and years with a view to assess the genotype × environment interactions. Assessment of genotypes is also required to be done as per their projected use. Their likely incorporation in the farming systems will also be investigated.

3. Greater emphasis must be laid on multi-locational adaptability trials in order to assess the suitability of particular plant species under different agro-climatic regions and to study the prospects of their cultivation.

4. Agronomic investigations aimed at developing suitable package of practices in terms of sowing/planting time, plant-spacing, soil types, moisture regime and fertilizer use are required to be given due attention. Large scale trials are planned to be conducted for economic evaluation.

5. Exploitation of local germplasm of specified indigenous crops needs to be done at different centres.

6. Research efforts are required to be intensified for conducting basic studies wherever necessary, for example, seed dormancy in guayule and sex determination expression in jojoba.

7. Development of high yielding varieties through planned breeding programmes will have to be initiated for the specified crops at specified centres.

8. The entire available germplasm of these under-utilised crops must be conserved for future use and for which the facility of long-term storage now exists at National Bureau of Plant Genetic Resources, New Delhi.
9. Any amount of research efforts on these plants is not going to make much headway unless the technology is transferred to the ultimate user. Greater thrust is, therefore, required to be given on this aspect through appropriate extension network.

REFERENCES


INTRODUCTION

To meet the challenge of shortage of food, fodder and fuel, scientists all over the world have now started looking for alternate sources from some of the under-utilised plant species available in different areas. In India, work in this regard was initiated by the Indian Council of Agricultural Research under an All India Coordinated Research Programme on under-utilised and under-exploited plants. Initially, the work under this project started with food plants (winged bean, amaranth and Chenopods), fodder plants (Leucaena and Eupatorium), industrial and hydrocarbon plants (jojoba, guayule and Euphorbia species) and energy plants (sugarcane, bamboo, tapioca, etc.). Recently, Eupatorium and tapioca have been dropped from the programme and some more plants have been added such as rice bean, bambara groundnut and buckwheat in food plants; Jatropha curcas in hydrocarbon, sweet potato and Coleus in energy and Simaruba and tumba in the oil yielding plants.

SALIENT FINDINGS

Food Crops

Winged bean: This multipurpose legume crop was first introduced in India in 1799 at the Calcutta Botanical Garden. It is a backyard crop, mainly in the humid, sub-tropical region and is rich in protein. Seeds contain 8% oil and 30.0 to 39.0% protein. The NBPRGR started introduction of exotic germplasm from mid sixties and has built up over 200 germplasm collections mainly from Ghana, Nigeria, Papua New Guinea, Australia, Philippines, Thailand, Indonesia, Sri Lanka and India. Indigenous variability particularly from north-eastern and peninsular region has been collected. Evaluation work was undertaken at Akola, Trichur, Delhi and high yielding selections were made for vegetable and grain purposes. Papua New Guinea and Burma have good tuber yielding types, which have high potential for the tribal belts in north-east and central India, wherein roots are consumed at present as a protein rich
food. A catalogue on winged bean has been brought out by the NBPGR. The main centre for the maintenance of winged bean germplasm is the NBPGR Regional Station at Akola.

The main constraints in winged bean cultivation are, its long duration, and tall viny nature. The University of Agricultural Sciences, Bangalore has developed a dwarf type which does not need any staking. The under-utilised programme has identified four promising selections, namely, GRWB 23, EC 38821-B, EC 38955 (GRWB 10A) and IIHR-13 for large scale testing and pre-released multiplication. These selections have shown great potential, particularly in the peninsular and northeastern region.

Grain amaranth: Grain amaranth, a potential pseudo-cereal, is a rich source of protein. Three species, namely, Amaranthus hypochondriacus, A. caudatus and A. cruentus are important. The former one is widely distributed particularly in India. A. edulis, an introduction also shows promise as a grain crop. About 3,000 germplasm collections were built up under the coordinated programme. The hill types (2700) are being maintained at NBPGR Regional Station, Shimla which is the main centre for grain amaranth. The germplasm for the plains are maintained at NBPGR Regional Station, Akola. A catalogue on 800 germplasm collections has been brought out. Good variability is observed both in the exotic and indigenous material.

Under the coordinated trials, 10 varieties were tried and IC 42258-1 (Annapurna) from NBPGR (Shimla) was identified and recommended for release for large scale cultivation. Its yield ranges from 22-26 q seed/ha and protein percentage is high (14.5%). with high essential amino acids.

Chenopods: Chenopodium album is also an important pseudo-cereal, particularly for the hilly areas. Variability in plant height, leaf size, days to flower and maturity and inflorescence size and seed yield, was observed in Indian collections. Chenopodium quinoa, an introduction, has shown promise as a grain crop both at Delhi and Shimla locations.

Buckwheat: It is also a potential pseudo-cereal particularly for temperate habitats. A total of 153 germplasm collections have been built up and evaluated. Fifty lines have been identified for further testing. 10 varieties are being tried at 8 locations for identifying high yielding types. IC 13374 has shown good yield potential and wide range of adaptability.

Rice bean: Programme on genetic resources of rice bean was started in 1960 and collections were made from Nepal, Sikkim and northeastern region. Most of the collections were late under Delhi conditions
and, therefore, crosses were made between a very early Chinese variety and a bold seeded variety from Mysore and a yellow seeded variety from Nepal. More than 200 selections were identified as promising, being early and high yielding. From these selections, CxM12-1 was recommended for large scale cultivation, which was the first cross bred variety in India in this crop. It is resistant to yellow mosaic of mung bean and urid bean and is free from stored grain pests.

Rice bean is a protein rich pulse, both for the hills and the plains. Over 500 germplasm collections of rice bean have been built up by NBPGGR, exhibiting wide range of variability in plant traits as plant habit, days to flower and mature, seed colour, size, yield/plant, seeds/pod, and protein content etc. Under the coordinated project, 10 varieties have been tested, in collaboration with the Pulse Project. Variety ‘Rajmung’ has been released from the germplasm supplied by NBPGGR.

Bambara groundnut: It is a leguminous crop of the African continent. It forms pods and seeds just beneath the ground, like groundnut. It has potential as a new crop in arid tracts. NBPGGR has introduced 60 collections of this crop from Nigeria and Africa.

Industrial plants

Jojoba (Simmondsia chinensis): In India, it was first introduced in 1965 from USA. It is a dioecious perennial, evergreen shrub, which is drought and salt tolerant. Jojoba seeds are a source of liquid wax which varies from 40–58% and is similar in chemical composition to that of the sperm-whale oil. Efforts of NBPGGR for introduction of jojoba since mid sixtees have resulted in the establishment of thirteen germplasm collections which have been evaluated at NBPGGR Regional Station, Jodhpur. These collections differ in plant height (100–250cm), flowering habit, leaf shape, size and seed yield/plant (20g to 500g—1st year). EC 33198 (Ex USA) in jojoba has been identified as the most promising type with good seed production and has been recommended for large scale cultivation. One female plant of EC-33198, is the oldest jojoba plant, at NBPGGR Regional Station, Jodhpur and the first plant to produce large quantity of seeds (8 kg). Work on salt-tolerance and bio-chemical aspects is being done at Bhavnagar and on vegetative propagation through tissue culture techniques is in progress at NBRI, Lucknow.

Guayule (Parthenium argentatum): Guayule, native of north-central Mexico and south-western USA is a hardy, drought tolerant perennial shrub. It holds a great promise as a potential source of natural rubber
in the wastelands. In India, introduction of guayule germplasm was initiated by NBPG from Mexico and USA in 1976. Research work on guayule started in 1978 at the National Botanical Research Institute, Lucknow and the Central Arid Zone Research Institute, Jodhpur. In 1982, work on guayule under the ICAR project was started at Haryana Agricultural University, Hisar, Bhartiya Agro-industrial Foundation, Pune, Tamilnadu Agricultural University, Mettupalayam, and Gujarat Agricultural University, Sardar Krushinagar. Adaptability and varietal trials of promising germplasm collections of guayule were conducted at different centres. Performance of the variety Arizona-2 was the best at Jodhpur. HG-8 and HG-9 collections from Arizona performed well under Hisar conditions. Argentatum G-4 was identified as promising at Sardar Krushinagar. These varieties showed good biomass production with rubber content varying from 6 to 9%. Agronomic studies revealed that 60 cm x 60 cm spacing was the best at Hisar, while 100 cm x 100 cm gave the best results under Jodhpur conditions. Also, increase of phosphorus application from P30 to P60 and nitrogen from N40 to N120 resulted in increase of plant height, stem girth and plant canopy but reduction in primary branches. The maximum rubber content (10.3%) and resin content (9.10%) were observed in EC 148913. HG-9 and HG-7 had rubber content of 8.69% and 8.5% respectively. Arizona-2, at the 30 month growth stage, showed 6-8% rubber content at Jodhpur.

Multi-locational coordinated varietal trials of 14 varieties and coordinated agronomic trials were conducted at different centres. Adaptive trials of promising varieties of guayule have been initiated at Delhi, Hisar and Jodhpur. The feasibility studies indicated that guayule is more suited to semi-arid regions like Hisar compared to arid regions of Jodhpur.

Hydrocarbon plants

A large number of indigenous plants have potential as petrocrops. Important among these are Euphorbia species and Jatropha curcas. These are rich sources of hydrocarbon and are substitute to petroleum like fossil fuel. Germplasm collection and evaluation of Euphorbia species and Jatropha species had been initiated at GAU (Gujarat), BAIF (Pune) and NBPG (Jodhpur).

Thirty seven germplasm collections of Euphorbia cauducifolia have been made during 1983-84 and are established at GAU, Sardar Krushinagar. These are being evaluated for biomass production. E. antisypilitica, a source of commercial candelilla wax, introduced from Mexico, has been successfully established at Jodhpur. E. tirouzalli (Milk
bush) is naturalised in India and is common in drier parts of Bengal and South India. Among others, *E. cathyris* of Mediterranean region is a rich source of hydrocarbon. Amongst the Indian *Euphorbia* species widely growing in rocky habitats/rocky hills, *E. nivula, E. nerifolia, E. pulcherrima* and *E. trigona* are important.

*Jatropha curcas* is also found growing in semi-arid regions throughout India and has great potential as a hydrocarbon source (1250/kg seeds/ha.). Seven collections of *Jatropha* are maintained at GAU Centre. Agronomic experiments are also in progress at BAIF (Pune) centre. In spacing trials at Pune, maximum average height was obtained with 1m × 1m spacing, produced maximum branches with 1.5m × 1.5m spacing and the highest seed yield with 2m × 1.5m spacing. Seeds of *Jatropha* contain 30 to 40% oil which can be used as lubricant.

**Fooper plants**

Germplasm collections of *Leucaena* are being evaluated at IGFRI (Jhansi), BAIF (Pune), NBPGR (New Delhi and Trichur). Adaptability trials on fodder and fuel aspects are in progress at CAZRI (Jodhpur), UAS (Bangalore), NBPGR (Trichur) and HAU (Hisar). Hybrid *Leucaena* has been developed at BAIF (Pune) which has a very high fodder value, low mimosine content and is fast growing. This plant needs testing for fodder and fuel at different locations.

**Energy plantation crops**

Germplasm collections of *Casuarina* (20) have been maintained and are under evaluation at TNAU (Mettupalayam centre). Among bamboos, germplasm collections (45) have been made from north-eastern states and are being established at ICAR Research Complex for North-eastern Region (Basar Centre). About 113 species of bamboos are known to occur in India and 58 species belonging to ten genera have been collected from north-eastern region which exhibits great diversity. About 150 different types of bamboos exist in the north-eastern region. A beginning has been made by collecting 5 species (*B. pallida, D. hamiltonii, Melocanna bambusoides, Pseudostachyum polymorphus* and *Teinostachyum dulloa*). It is also essential to exploit the edible bamboos, particularly in the tribal belts.

Other important plants include *Simaruba glauca* which has a high potential for its edible oil and *tumba* (*Citrullus colocynthis*) which has a tremendous potential. The dried pulp of unripe fruit constitutes the drug ‘Colocynth’. The seed oil is brownish yellow and contains an alkaloid, a glucoside and saponin. The germplasm evaluation comprising 20 entries is in progress at Jodhpur. Multilocational evaluation of these two species is also being done at different centres.
LIFE SUPPORT SPECIES USED BY RURAL PEOPLE UNDER EXTREME ENVIRONMENTAL CONDITIONS

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INTRODUCTION

The vane of human civilisation is rooted in the exploitation of vegetation. During ancient times the entire human life support system was based on judicious use of the native plants. World's ancient pre-christian advances civilisations of India, China, Mexico and Middle East were based on the earlier awareness of people who exploited native plant resources to the maximum. These ancient civilisations are credited with the evaluation of all the major food, forage, fibre and fruit crops. In this country, the plant-man relationship was so intense and pious that the great earlier scholars of botany, viz. Charak and Susrut were of the view that there does not exist on this planet a plant without use in human welfare.

India (8°–35°N and 60°–97.5°E) exhibits great variation in its climate, soil and physiography. It has a very rich endemic flora. Of the total over 15,000 species, more than 60% are endemic (Arora et al., 1983). Apart from natural richness of vegetation, it has enormous wild edible plant wealth (Singh and Arora, 1978). The information on the nature and extent of genetic diversity of economic plant available in India is given by Mehra and Arora (1982), Paroda and Arora (1986). The present paper highlights the genetic wealth of various life support species and their economic value for human welfare under extreme environmental conditions of tropical, subtropical and temperate regions in the country. It is also of paramount importance that advance planning is made to preserve and propagate all these life support species to meet the exigencies of the future.

LIFE SUPPORT SPECIES AND THEIR VALUE TO HUMAN SURVIVAL

India represents almost all the environmental conditions of the world. It includes all stress conditions such as arid, semi-arid, hot and cold desert, saline, alkaline, acidic, toxic soils, marshy and flooded areas. Plant genetic resources having potential economic value which are
referred to as life support species, might be the most suitable introductions in these extreme environmental conditions.

The rural people in these stress environments make use of native vegetation to cope with their needs for food, forage, fibre, medicine, etc. during the time of emergency. These species are well adapted to adverse situations. Their distinct adaptation to environmental extremes and their values to human survival in these conditions have not received sufficient attention. Many of these life support species are under threat of extinction because of their over-exploitation or increasing biotic interference. A comprehensive list of promising plant genetic resources particularly of forage value adaptable to environmental extremes is given by Singh and Bhag Mal (1987). A brief account of life support species under different extreme environments are enumerated below:

**LIFE SUPPORT SPECIES OF HOT DESERT**

Ecological survey of Indian desert reveals that this area fails to provide the traditional milieu of production in agriculture but it is rich in number of plant species which are of tremendous economic value. Desert plants of promising economic value are utilised by local rural people for multifarious needs during the time of emergency. Several workers (King, 1869; Watt, 1889; Gupta and Kanodia, 1968; Bhandari, 1974 and Saxena, 1978) have documented famine food plants of the Indian desert.

**Food plants**

Indian arid zone is well known for its famine and drought and the local inhabitants have to subsist on non-conventional food plants. Natural flora provide some unusual fruits eaten during scarcity, viz. *Grewia tenax*, *Zizyphus nummularia*, *Cordia gharaf*, *Coccinia grandis*, *Cucumis callosus*, *Momordica dioica*, *Salvadora oleoides* and *S. persica*. Starchy roots and tubers used during famine are *Cyperus rotundus*, *Asparagus racemosus* and *Ceropegia bulbosa*. Fleshy leaves of *Aloe barbadensis* are eaten. Seeds of *Citrullus lanatus* are mixed with bajra for increasing the quality of bread. Also, *C. lanatus*, *Salvadora oleoides*, *S. persica* and *Pongamia pinnata* need to be exploited for their edible oil. In *C. lanatus*, a single fruit yields 107-140 seeds. On an average 1.0-2.5 kg seed is generally obtained from a creeper; the seeds contain 20-40% edible oil. In *S. oleoides* and *S. persica*, evergreen small trees are restricted to highly saline soils; the seeds contain 40-58% greenish yellow fat. In *Pongamia*, seeds contain 27-39% oil.
Forage plants

Some of the tree and shrub species which provide top feed to the cattle, sheep and camel during the lean period, are Prosopis cineraria, Z. nummularia, Ailanthus excelsa, Salvadora oleoides and S. persica. The crude protein content of the leaves of P. cineraria and Z. nummularia is reported to be 13.9% and 14%, respectively (Saxena, 1978).

Plants for fibre, mats, timber wood

Leptadenia pyrotechnica, Crotalaria burhia and Saccharam spp. are locally utilised for making ropes. The riverine plants Tephrosia filiformis and Carex sp. are utilised for making baskets. The limited number of tree species like Tecomella undulata, Acacia nilotica, A. cupressiformis, A. senegal, and A. leucophloea are utilised by local people for making agricultural implements and furniture.

Medicinal plants

In the Indian desert, the unique plants with high economic and medicinal value are Commiphora wightii, Citrullus colocynthis, C. lanatus, Datura innoxia, Withania somnifera, Euphorbia antiquorum, E. nerifolia, Phyllanthus niruri, Indigofera cordifolia and Clerodendrum phlomoides.

Life Support Species of Cold Desert

The cold desert and sub-desert lies in the north of Great Himalayas. The main life support species used by the local rural people for different purposes are:

Food plants

Leaves of many plant species like Allium sphaerocephalum, A. leptophyllum, Aconitum heterophllum, Chenopodium blitum, Cicer songaricum, Polygonum viviparum, Sedum rhodiole, S. tibeticum, Scorzonera mollis, are eaten by the natives of Ladakh and Lahaul both in raw and cooked form. Root stocks of A. sphaerocephalum have high edible value. Fruits of C. blitum are used like strawberry. Leaves of Potentilla fruticosa are used as a substitute for tea.

Forage plants

Fodder value of 33 indigenous grasses and 25 legumes of Ladakh region is given by Misri and Singh (1986). The main life support species used for sheep and goats as forage are: Agropyron cognatum, Agrostis gigantea, Alopecurus hispaulicus, Artemisia parviflora, Astragalus candelleanus, Bromus gracilimus, B. oxyodon, B. tectorum, Calamagrostis eurodensis,
Koeleria cristata, Lespedeza sericea, Phleum alpinum, Polygonum tortuosum, Potentilla fruticosa, P. salessovii, Polypogon monspeliensis, Tanacetum senecionis and Tripogon purpureascens.

The forage plants for other large domestic animals of this tract like horses, yak, etc. are Agropyron spp., Bromus japonicus, Calamagrostis epigeios, C. turkestanica, Elymus dasystachys, Indigofera heterantha Oryzopsis lateralis and Stipa capillata.

Medicinal plants

Local rural people of these areas usually look for plant species for their health purposes. Roots of Thalictrum foliolosum are used in the treatment of dyspepsia. It is used as a tonic, purgative, diuretic and febrifuge. Seed oil of Anemone obtusifolia is used in rheumatism. Root of P. vivigenia is employed to make a gargle for sore throat and a wash for ulcers. Seeds of Lonicera glauca are given to horses for colic. A tisane is prepared from Gentiana decumbens and used as a stomachic. Yellow sap from Corydalis ramosa is used for the treatment of eye disease. Plant of Thymus serphyllum is also employed in the treatment of eye and stomach disorder. Leaves of Plantago brachyphylla are used in wounds. Root bark of Arnebia tibetana is used in cure of eye disease and coughs.

Plants of miscellaneous use

Roots and leaves of Euphorbia thompsoniana, Lychnis indica and Silene griffithii are used as detergent. Yellow dye used from Polygonum tortuosum and the thick roots of T. senecionis provide fuel. The fibre plants of the area are Calamagrostis epigeios, C. turkestanica and Stipa capillata etc.

LIEE SUPPORT SPECIES OF SEMI–ARID TROPICS

A vast area of the country comes under semi-arid zones. Though this constitutes developed area of the country, the rural people at different places, make use of several plant species for their basic need.

Food plants

The leaves of Boerhaavia diffusa, Bryonia laciniosa, Triumfeta rhombifolia, Cocculus hirsutus, Amaranthus viridis and Leptadenia reticulata are used as vegetable. Pods of Mucuna pruriens are also cooked and eaten.

Forage plants

Due to the shortage of conventional forage, feed and increasing price of the commodity, rural people of this tract always look for wild plants of forage value for increasing livestock population. Number of
plant species are used for this purpose, viz. *Boerhaavia diffusa*, *Borreria stricta*, *Cassia mimosoides*, *Gomphrena globosa*, *Heylandia latibrosa* and *Rivea hypocrateriformis*, etc. All these plants are considered as weeds of wastelands and grasslands of this tract (Gupta et al., 1985). Studies on chemical and nutritional aspects of these species as promising non-conventional forages has been highlighted (Gupta, 1980).

Chemical evaluation of many species, viz. *Acacia leucophloea*, *Borreria stricta*, *Heylandia latibrosa*, *Cassia mimosoides* and *Gomphrena globosa* has indicated that these species can be very well exploited for forage purpose.

**Fibre plants**

Rural people of the tract are utilising many wild species of native flora for extracting fibre, such as *Sida carpinifolia*, *S. rhombifolia*, *S. cordifolia* and *Triumfetta rhomboidea* etc.

**Medicinal plants**

The rural people of semi-arid tract use seeds of *Mucuna pruriens* and leaves of *Euphorbia thymifolia* and *E. hirsuta* in the treatment of urinogenital complaints. *Euphorbia* plants are also used in promoting milk formation in women. *Convolvulus pluricaulis* and *Evolvulus alsinoides* are very commonly used as brain tonic. Leaves of roots of *Adhatoda vasica* are used with ginger for the remedy of cough. Roots of *Boerhaavia diffusa* are extensively used for the cure of bronchitic asthma. *Cassia occidentalis* is used in skin disease. Ash of *Lepidagathis trinervis* is employed as an application to sores. Roots of *Ipomoea pestigridis* are considered to be as laxative and purgative. *Linaria ramosissima* is used as a remedy for diabetes. *Sida* spp. are also used in nervous and urinary diseases and in fever. The juice of the leaves of *Cocc ulus hirsutus* mixed with water has the property of coagulating into a green jelly-like substance. This jelly is applied externally for cooling purposes and also taken internally as a cure for gonorrhoea.

**Life Support Species of Saline Areas**

Saline and alkaline lands are mainly located in arid and semi-arid zone of tropical India. Many of these plant species which are well adapted to these stress areas can be profitably grown for their economic utilisation.

**Food plants**

Use of *Salvadora oleoides* and *S. persica* has already been stated earlier under the plants of hot desert. *Cressa cretica*, frequent on the
coastal salt land is eaten during famine. *Salicornia brachiata*, a gregarious herbaceous shrub growing at Sunderban and on coasts on the margins of salt lakes, also used as food and fodder. *Chenopodium album*, *Portulaca oleracea* and *Trianthema portulacastrum* are used as vegetables.

**Forage plants**

Magoon and Shankarnarayan (1974) have given a scientific approach for the economic utilisation of these lands by growing forage species in successional manner. Number of plant species growing in these areas are used as fodder; they are *Salicornia brachiata*, *Kochia indica*, *Haloxylon recurvum*, *Alhagi camelorum*, *Dactyloctenium sindicum*, *Sporobolus helvolus*, *S. oleoides*, *S. marginatus*, *Rhyzosia minima*, *Crotalaria philippia*, *Eleusine indica*, *Diplachne fusca* etc. Besides these plants, the Australian salt bushes (*Atriplex halimoides* and *A. numularia*) are also being used for forage in saline desert.

**Other useful plants**

Leaves of *Pluchea indica* are used as astringent and in case of fever. Dry plants of *Kochia indica* are used as fuel and leaves of these plants are given in case of weak heart. *Prosopis juliflora* exudes gum from their wounds during summer.

**LIFE SUPPORT SPECIES OF MARSHLANDS/FLOOD AREAS**

Marshlands and swamps are usually met in eastern and peninsular India with diverse edaphic conditions. Some life support species of these lands are given below:

*Jussiaea repens*, *Alternanthera sessilis*, *Hygropyza aristata* and *Monochoria hastata* are used as vegetable. Leaves of *Lemna minor*, *J. repens* and *Polygonum orientale* are having cooling properties; are diuretic, antiscorbutic, astringent and also used in cutaneous diseases. Leaves of *Hygropyza aristata* and *Pistia stratiotes* are made in paultice and applied to haemorrhoides. They are also used in various ways for the treatment of asthma, cough, dysentery and ringworm. Roots of *Polygonum glabrum* are used as an astringent and as a cooling agent. Seeds are used to relieve gripping pains of colic. Leaves of *Monochoria hastata* are used for curing boils, while roots of *M. vaginallis* is chewed for toothache and the bark is eaten with sugar for asthma. *Ammannia senegalensis* is used as a blistering agent. Juice from the leaves of *Ipomoea aquatica* is laxative and *Hygrophylla auriculata* is used in jaundice, dropsy, rheumatism and diseases of urinogenital track.
FUTURE THRUSTS

The salient points which need immediate attention in the context of genetic wealth of various life support species under extreme environmental conditions are briefly enumerated below:

1. Introduction and selection of superior strains with suitable management practices can lead to develop strong agro-industrial base in the region. Thus there is an urgent need to explore the whole native flora for food, forage, oil, gum, waxes, medicine, etc. to identify life support species of potential economic value.

2. Studies on chemical analysis may reveal new vistas for exploitation of certain products such as drugs, fertilisers, waxes, oil, etc. and hence need attention.

3. Concerted efforts to develop genetically superior strains through breeding efforts need to be made.

4. *In situ* conservation of genetic wealth of extreme environments through botanical gardens can help in preserving several species which are facing extinction and are less important today but may be of much value in future.

5. Greater thrust is required to be made for introduction of few highly priced life support species of the habitat which may improve the economic conditions of local inhabitants.

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ETHBOTANICAL ASPECTS OF LIFE SUPPORT SPECIES—SOME EMERGENCY AND SUPPLEMENTARY FOODS AMONG ABORIGINALS IN INDIA

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INTRODUCTION

Ethnobotany deals with relationship of the people with the plants around them. ‘Life Support Species’ in this context include species which the aboriginal societies consume as their main staple diet and also such species which they grow in limited areas or collect and use as supplementary or emergency foods. Ethnobotanical studies provide valuable data on life support species. Field work among the aboriginal societies in central, south-eastern and eastern India, survey of a few tribal markets, and scrutiny of some ethnobotanical literature have brought on record several hundred wild edible plants. These include about one hundred such edible species, which have not yet found place in major books on economic or edible plants, like Wealth of India (1948–72), Singh and Arora (1978) for this region, and Tanaka (1976) for the world.

Evaluation of data on these edible species is being done to bring out:

1. The species eaten by more than one human society, or in more than one locality.
2. The species whose products are sold in tribal markets.
3. The species which are not so far reported to be cultivated.

ROLE OF ETHNOBOTANY

The role of ethnobotany in matters relating to life support species actually goes far beyond emergency food plants. The species providing shelter and remedies for ailments to aboriginals or to their animals and species providing for many other basic needs of daily life are very much a subject of ethnobotany.
The aboriginal people conserve numerous land races and wild relatives of crops and contribute to continued survival of such life support species. They do it not only by still growing traditional varieties but also through taboos, myths and faith about forests, trees and plants.

Field work in ethnobotany and a probe into ethnographic literature constantly bring to light newer facts about the folk-beliefs and practices in relation to life support species. Yet, a lot more needs to be done than has so far been attempted during the recent interest in such studies in India.

**Plants Used as Emergency Foods**

Some examples of plants reported to be consumed as emergency or supplementary foods among aboriginals and rural people, and which are not widely known are given below. The names of plants are arranged alphabetically. The botanical name is followed by name of family, local name(s), uses etc.

*Allium platyspathum* Schrenk (Liliaceae). ‘Kamar’. Its bulbs and fresh leaves are largely used in Ladakh as substitute for onion. (Kaul et al., 1985).


*Arisaema murrayi* (Graham) Hook. (Araceae). ‘Sapcha banda’, ‘Vajra math’, ‘Snake root’. Its leaves and petioles are thoroughly washed in running water for removing toxic elements, then cooked with *Garuga pinnata* (Kikad) leaves, and eaten in Maharashtra (Gunjatkar and Vartak, 1982).

*Asparagus curillus* Buch.-Ham. ex Roxb. (Liliaceae). ‘Keru’, ‘Jhiran’. Its tender shoots are largely used as vegetable in Kumaon Himalaya. They are also sold in hill markets.

*Caralluma tuberculata* N. E. Br. (Asclepiadaceae). ‘Charungli’, ‘Chungan’. The plants are first smeared with common salt, kept for an hour, and then washed four or five times with water. This enables the bitter elements to get largely leached away. It is consumed in the form of pickle or as vegetable. The local people sometimes eat it raw also; it is believed to have tonic properties. The plant persists throughout the
year and comes occasionally for sale in Jammu market in the end of February or beginning of March (Atal et al., 1980).

*Cassia fistula* Linn. (Caesalpiniaceae). ‘Amaltas’, ‘Cinar’. Its flowers are used as vegetable by the tribals in Santhal Pargana (Jain, 1967).

*Cayratia trifolia* Linn. (Vitaceae). ‘Dukar-vel’, ‘Tamnya’, ‘Ambatvel’, Cider drunk, Fox-grape. Its young leaves and stems are boiled and eaten either alone or with other vegetables, along with fish in Assam and Manipur. Ripe fruit is pleasantly acrid; its cooked vegetable is very popular among tribals in Maharashtra (Gunjatkar and Vartak, 1982).

*Celastrus paniculatus* Willd. (Celastraceae). ‘Malkangni’, ‘Manotige’, ‘Pemg’. Its ripe fruits are eaten by the tribals of Midnapur district in West Bengal (Maji and Sikdar, 1982). The Halbas of Madhya Pradesh use its flowers as vegetables and the Marias use young fruits as vegetable (Jain, 1963).

*Cenchrus setigerus* Vahl (Poaceae). ‘Dhaman’. The seeds are ground and used as food by people of Jaisalmer in Rajasthan during famine (Bhandari, 1974).

*Centaurea iberica* Trev. ex Spreng. (Asteraceae). ‘Krets’. Its leaves are used as vegetable in Kashmir (Dar et al., 1984).


*Chasalia curviflora* Thw. (Rubiaceae). Its leaves are cooked and eaten as a vegetable by Lepchas (Gunjatkar and Vartak, 1982).

*Chlorophytum laxum* R. Br. (Liliaceae). ‘Kulai’. Its leaves are used as a common vegetable in Maharashtra during monsoon (Gunjatkar and Vartak, 1982).

*Cirsium wallichii* DC. (Asteraceae). ‘Kandara’. The pith of the stem is eaten in Garhwal Himalaya (Malhotra et al., 1985).

*Cochlospermum religiosum* (Linn.) Alston. (Cochlospermaceae). ‘Galgal’ ‘Hupu’. Its flowers are used as vegetable by the tribals in Bastar in Madhya Pradesh. The flowers are mixed with rice and then cooked (Jain, 1967).

*Cordia dichotoma* Forst f. (Boraginaceae). ‘Lasora’, ‘Bohare’. Its young leaves are used as vegetable by the tribals in Bastar and Mandala district of Madhya Pradesh (Jain, 1967).
Cyanotis adscendens Dalz. (Commelinaceae). ‘Govali’, ‘Kena’. Its leaves are eaten as a pot herb in Maharashtra (Gunjatkar and Vartak, 1982).

Cyanotis tuberosa Roem. and Schultes (Commelinaceae). Its tender shoots and leaves are largely used as vegetable, by the tribals in northeastern India (Arora, 1981).

Dactyloctenium sindicum Boiss. (Poaceae). ‘Tantia Ghas’. Its grains are used as scarcity food in Jaisalmer district in Rajasthan. But the grains are reported to cause some stomach upset (Bhandari, 1974).

Dendrocalamus sikkimensis Gamble (Poaceae). ‘Bhalubans’. The sheaths from young shoots are boiled and then used as vegetable. They are also sold in markets of Sikkim at Rs 3.0 per kg during May to July (Hajra and Chakraborty, 1981).

Dentella repens (Linn.) Forst. (Rubiaceae). ‘Helencha-shak’. Its leaves are used as vegetable by the tribal people in Purulia district in West Bengal (Jain and De, 1966).

Dioscorea melanophyma Prain and Burkill (Dioscoreaceae). ‘Tarur’, ‘Tikhun’. Its tuberous roots are a staple food of the Banrajis in Kumaon region.

Dioscorea tomentosa Koen. (Dioscoreaceae). ‘Tinpatri’. Its tuberous roots are used as vegetable in Purulia district in West Bengal (Jain and De, 1966).

Diospyros peregrina (Gaertn.) Gurke (Ebenaceae). ‘Tendukala’, ‘Makadkenda’, ‘Arak’. Its young leaves are used as vegetable by the tribals in Bastar district in Madhya Pradesh (Jain, 1967).

Dipsacus mitis D. Don (Dipsacaceae). ‘Wopal-Hakh’. Its young plants and leaves are used as vegetable by local people in Jammu and Kashmir. Before cooking, the leaves are thoroughly boiled and pressed. Sun-dried leaves are consumed during winter months, when fresh vegetables are scarce. In Kashmir valley, it is used by Hindus specially on occasions of death anniversaries (Kaul et al., 1982).

Edgaria darjellingensis Cl. (Cucurbitaceae). Its young buds are used as a curry in Kurseong region in West Bengal (Sen et al., 1985).

Elaeagnus conferta Roxb. (Elaeagnaceae). ‘Malindo’. Its ripe fruits are eaten in Sikkim. These are also sold in Sikkim markets around March at 50 p. each or Rs 2.0 per kg (Hajra and Chakraborty, 1981).

Eremurus persicus Boiss. (Liliaceae). ‘Hoal-saag’. Its leaves and young scales are cooked as vegetable in Jammu and Kashmir during March and April, when plants are in abundance. Long, soft and peeled
leaves are washed and pressed in boiling water before cooking. In urban areas, 'Hoal Sag' is considered a delicacy (Kaul et al., 1982).

*Grewia tiliarefolia* Vahl (Tiliaceae). 'Dhaman', 'Kohela', 'Tallachettu'. Its young leaves are used as vegetable by the tribals in Bastar district in Madhya Pradesh (Jain, 1967).


*Indigofera cassioides* Rottl. (Fabaceae). ‘Nerali’, ‘Nichardi’, ‘Chimnatri’, ‘Merdi’, ‘Kathi’. Its flowers and flower-buds are used as vegetable in Pune district in Maharashtra. (Gunjatkar and Vartak, 1982). The people of Morni and Kalesar hills in Haryana, use its flower buds and pods as vegetables. They also collect the fruits and sell them in the market (Jain, 1984).

*Lastrea crenata* Bedd. (Thelypteridaceae). ‘Golden Hair Fern’. Its young leaves are used as vegetable after cooking in Maharashtra (Gunjatkar and Vartak, 1982).

*Leeanthus peduncularis* (Royle) Wedd. (Urticaceae). ‘Chaulu’. Its fresh leaves are mixed with flour and cooked; they are eaten in the Garhwal Himalayas (Malhotra et al., 1985).

*Melanthesa turbfnata* (Koen. ex Roxb.) Wight. (Euphorbiaceae). ‘Jirual’. Its flowers are used as vegetable in Purulia district, West Bengal (Jain and De, 1966).

*Melothria perpusilla* Cogn. (Cucurbitaceae). ‘Bankundri’, ‘Birkudri’. Its fruits are used as vegetable in Purulia district, West Bengal (Jain and De, 1966).

*Melothria zeylanica* Cl. (Cucurbitaceae). ‘Gam’. Its whole plant is used as vegetable in Mahabaleshwar in Maharashtra (Sen et al., 1985).

*Merremia vitifolia* (Burm. f.) Hall. f. (Convolvulaceae). ‘Navalichavel’. Its tuberous roots are eaten raw in Maharashtra (Gunjatkar and Vartak, 1982).

*Ougeinia oojeinensis* (Roxb.) Hochr. (Fabaceae). ‘Kala Palas’. Its flowers are largely used as vegetable in Pune district in Maharashtra. The flowers are first boiled and then mixed with cooked rice (Gunjatkar and Vartak, 1982).

*Phytolacca latbenia* (Moq.) Wall. (Phytolaccaceae). ‘Jarak’. The plant is reported to be poisonous, but after boiling it is used a vegetable in Kumaon Himalaya.
Polygonum nepalense Meissn. (Polygonaceae). ‘Birsai’. Its whole plant is largely used as vegetable by the Toto tribe of Jalpaiguri district in West Bengal (Das et al., 1983).

Ranunculus arvensis Linn. (Ranunculaceae). ‘Gager-kande’. The young leaves are used as a vegetable in Kashmir. Before cooking, they are thoroughly boiled in water and the water fully removed by pressing (Kaul et al., 1982).

Ranunculus muricatus Linn. (Ranunculaceae). ‘Chingir’. Its leaves are used as vegetable in the hilly areas of Jammu and Kashmir. The leaves are first boiled in water. The water is removed and leaves are fried (Kaul et al., 1982).

Rumex nepalensis Spreng. (Polygonaceae). ‘Shyame’, ‘Bhilmora’. Its leaves are used as vegetable in Kumaon Himalaya.


Silene indica Roxb. ex Otth. (Caryophyllaceae). ‘Tomrhib’. Its young plants are cooked and used as vegetable by Garhwal people (Malhotra et al., 1985).

Sisymbrium loeselii Linn. (Brassicaceae). ‘Dand-Hakh’. Its leaves are used as vegetable during spring season in temperate areas of Jammu and Kashmir. Before cooking the leaves are washed with boiling water, which leeches out the bitter elements (Kaul et al., 1982).

Smilax prolifer Roxb. (Smilacaceae). ‘Ramdatun’, ‘Mitrilaha’. Its unripe fruits are used as vegetable by tribals in Bastar district in Madhya Pradesh (Jain, 1967).

Smithia hirsuta Dalz. (Fabaceae). ‘Pivla’, ‘Kaula’. Its leaves are used as vegetable in Maharashtra (Gunjatkar and Vartak, 1982).

Smithia purpurea Hook. (Fabaceae). ‘Kaula’, ‘Nila barka’. Its leaves are largely used as vegetable in Maharashtra. They are sun-dried and stored for use all round the year (Gunjatkar and Vartek, 1982; Nilegaonkar et al., 1985).

Suaeda fruticosa Forst. (Chenopodiaceae). ‘Moras’, ‘Luni-ni-Bhaji’. Its tender shoots and leaves are used as vegetables in the Salsette island in Maharashtra. They are also sold in the market (Shah, 1984).

Tectaria coadunata (Hook. and Grev.) C. Chr. (Aspidiaceae). ‘Kukhurey’. Its tender shoots (fronds) are cooked and eaten as vegetable in West Sikkim (Bennet, 1985).
**LIFE SUPPORT SPECIES**

*Tetrastigma muricatum* Planch. (Vitaceae). 'Moja-hei'. Its tender leaves and twigs are largely used as vegetable in Manipur. They are also sold in the market from April to June at 50 p. per bundle (Singh and Singh, 1985).

*Triglochin* spp., *T. maritima* Linn. and *T. palustris* Linn. (Scheuchzeriaceae). 'Gaike'. The Ladakhis and Tibetans use the underground small tubers as vegetable. These tubers are eaten after roasting and are considered to be highly nutritive (Kaul et al., 1985).

*Tulipa clusiana* DC. (Liliaceae). 'Keinshur'. In Kishtwar and Poonch, the bulbs are used as vegetable either raw or after frying (Kaul et al., 1982).

*Tupistra nutans* Wall. (Liliaceae). 'Nakima'. Its flowering spikes are used as vegetable. They are also sold in the market from September onwards (Hajra and Chakraborty, 1981).

*Xyli a xylocarpa* (Roxb.) Taub. (Mimosaceae). 'Irul', 'Kadai', 'Tangan', 'Kadam'. Its seeds are largely eaten after roasting by the tribals of Bastar district in Madhya Pradesh (Jain, 1963, 1967).

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LIFE SUPPORT SPECIES FOR MEDICINAL USE IN INDIA

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INTRODUCTION

The Asia and the Pacific region comprises of a large number of ancient nationalities, considered as the early cradle of human civilisation. The earliest treaties on Indian Materia Medica, the Charak Samhita (1,000 B.C.) recorded use of over 1100 drug plants and most of these are gathered from wild growing populations to meet the bulk demand of medical profession (Gupta, 1980). Important native life support species have come to be recognised as a source of valuable phytochemicals having growing demand in the country and abroad. A great diversity in these species still exists in specific environments where centuries of natural selection has operated to produce specific plant life containing desired chemicals in different forms and composition. Obviously, the collection, evaluation and conservation of native germplasm of these species should receive priority in context of our national needs.

Most of the medicinal plants are gathered from forests except where bulk demand for the raw material and their products is generated to sustain cultivation. In the field of bulk drugs, pharmaceuticals and their derivatives, there is a continuous search for new and more potent sources such that a species may lose relative importance in raw material trade depending upon the content, composition and contemporary uses. For example, Rauwolfia roots were the raw material of choice in treatment of hypertension for over two decades but lost ground in favour of periwinkle roots because of high content of ajmalicine as the latter is reputed to possess better potency and safe limits. Similarly, demand for an old remedy, liquorice rhizome and its total extract has registered a large demand for its added use in confectionery industry. The list of major life support species for medicinal use is, therefore, never static. A brief account on the salient features of cultivation technology including limitations noted in the productivity of twelve medicinal species is given here. These are grouped under five categories based on their end uses, e.g. Bulk Laxatives (psyllium and senna), Cardiotonics (Rauwolfia, periwinkle, foxglove, squill and gum-gugal), Steroidals (Dioscorea and Solanum spp.), Antimalarial (Cinchona), Expec-
torants and Emetics (liquorice, ipecac) because of priority given by W.H.O. (World Health Organisation) to these areas of diseases in the tropics. Incidentally, these crops have larger area under cultivation in the country.

**Bulk Laxatives**

*Psyllium (Plantago ovata Forsk.)*

This is an annual herb, native of Persia; it remains in field for about 4 months during cold weather. Large areas consisting of poor sandy to sandy-loam soils (30,000 ha.) are under this crop in north Gujarat and the cultivation is being extended to border districts of south-western Rajasthan. The seed-husk is emollient and laxative having world-wide demand. The co-ordinated Project on Medicinal and Aromatic crops, at its Anand station, collected 80 accessions from north Gujarat and evaluated them for 13 agro-botanical and yield characters. The crop has high percentage of male sterile plants. An exotic line (EC 124355) gave as high as 40 to 50 percent male sterile plants with high polyphenol content (3.53%) in the leaves as compared to normal plants (3.03%). A positive correlation between this and its resistance against downy mildew disease has been indicated. Two varieties, namely, ‘Gujarat Isabgol-1’ and ‘Gujarat Isabgol-2’ have been evolved at this centre. More collections from wild growing populations in Iran and Iraq are required to broaden genetic variability mainly for higher spike number, seed size, husk content, fertilizer responsiveness, resistance to seed shattering and downy mildew disease.

*Senna (Cassia angustifolia Vahl)*

A small, perennial leguminous herb, native of Arabia, is extensively grown (10,000 ha.) both as rainfed and irrigated crop over marginal lands in coastal Tamil Nadu. The crop remains in field for 130 days, yielding 2 to 3 stripping of leaf and pod crop. The foliage and pod shell possess anthraquinone derivatives (sennosides) used in household remedies and in most laxative medicines. A collection (EC 19658) made from Kutch (Gujarat) during 1973 showed early flowering and higher tolerance to saline-alkaline conditions. An exclusively leaf producing type has been developed from late flowering selections at Anand. This produces equally high foliage yield at 100 days growth stage and is now under multilocal testing. Several agronomic parameters have been studied and suitable changes incorporated in cultivation practices. Similarly, rapid method for estimation of sennosides content and its drug profile has been evolved. The genetic material from wild populations in Arabian peninsula is needed mainly for quality traits and resistance to damping...
off disease (*Macrophomina phaseoli*). The use of solar driers need to be perfected for rapid drying of this crop as high loss in potency of produce is reported in stored material (Muggenburg, 1983).

**Cardiotonic drugs**

*Rauvolfia (Rauvolfia serpentina Benth.)*

This is a small evergreen, hardy, perennial bushy plant and has a wide distribution in India and neighbouring countries. The root contains 55 alkaloids, of which reserpine, ajmalicine and serpentine are used in treatment of hypertension, insomnia and certain forms of insanity. This is a drought enduring crop and grows well over rich sandy-loam to clay-loam soils with high N and K content. The seed germination is low (15 to 40%). At NBPGR centre, Delhi, a large number of accessions were collected from Assam, Karnataka and Goa and analysed for root yield and total alkaloids. The total alkaloid content varied from 0.67 to 2.14% with reserpine varying from 0.08 to 0.21 per cent. *R. vomitoria* an introduction from West Africa exhibited 2 to 3 per cent total alkaloid in the roots with 0.3% reserpine. This is a small tree which remains in field for 4 to 6 years. Successful raising of intercrop of onion (*kharif*) and garlic (*rabi*) during the first year proved to be profitable. The user industry desires short duration, high root producing genotypes containing high combined reserpine and ajmalicine content in the total alkaloids to compete with periwinkle roots in trade.

*Periwinkle (Catharanthus roseus D. Don).*

It is a small hardy perennial bushy herb native of West Indies and naturalised as ornamental herb in many tropical countries of S.E. Asia and East Africa. The herb contains over 100 alkaloids of which VLB (vincristine and vinblastine) alkaloids are more (0.0004 to 0.003%) in leaves and ajmalicine plus serpentine content is high (0.2 to 0.3%) in root at maturity. This is mainly grown for root crop which is largely exported. Based on evaluation of limited genetic stocks assembled at NBPG, Delhi and IIHR, Bangalore, promising lines with high root yield (IC 49577, IC 49583), high ajmalicine/serpentine content (EC 11575) and high vindoline content (EC 120837) were identified. Detopping by 2 cm at 50 per cent flowering improved root yield, total root alkaloids, ajmalicine and serpentine contents beside inducing higher uptake of N-fertilizer. Rapid methods for analysing ajmalicine, serpentine, vindoline and catharanthine have been developed at the Bureau. Genetic stocks rich in ajmalicine-serpentine from east African coastal region and West Indies are required to be introduced.
Foxglove (*Digitalis lanata* Ehrh.)

This is a biennial temperate herb, native of Central Europe which produces large number of long radical leaves in the rosette stage and a long inflorescence over which bell-shaped decorative flowers are borne in the second year. This species has long been introduced in the Himalayan mountain tracts. The foliage contains glycosides like digoxin and lanatosides used in treatment of cardiac diseases. Germplasm from South European countries was evaluated and EC 115996 possessing high foliage yield and total glycoside of 0.3 to 0.65% was identified as promising. Trial cultivation made at Kodaikanal (T.N.) showed possibility of obtaining high foliage yield which allows 4 to 5 coppicing of plants in a period of 18 months. This cultivar also showed good performance at Munnar (Kerala). The performance of hybrids developed at species level (with *D. purpurea*) are under study at Solan (H.P.). However, it is necessary to introduce and evaluate commercial varieties grown in several European countries.

Squill (*Urgenia indica* Kunth.)

It is a small perennial bulbous herb with long fleshy linear leaves and produces terminal recemes in the second year. The bulbs are ovoid to tunicate in shape, varying in size with different shade of white, light cream to pink coloured outer skin. The bulbs contain glycoside (schilarin-A, B and proschilarin) used as cardiac stimulant in place of digoxin in medicine. This species is distributed over poor sandy to clayed soils in foothills of Western Himalyas, all over the coastal tract in Peninsular India, Aravali and Vindhyan ranges in central India. The germplasm collected from several places is being evaluated at NBPGR, New Delhi.

Gum-Guggal (*Commiphora wightii* (Arn.) Bhandari)

This is a branched spinescent shrub spread over poor sandy to rocky soils in extreme dry and desert conditions in Western Rajasthan, Kutch (Gujarat) and Khandesh. The bark, on incision, yields a bitter aromatic pale-yellow gum resin during cold season which is used to reduce cholesterol content in blood and in treatment of rheumatoid arthritis and several other diseases. Collections of wild plants made from Gujarat have been planted at Anand. Similarly, collections made from Jodhpur Sikar, Churu, Udaipur and Ajmer districts of Rajasthan have been raised at Jobner (Jaipur) for identifying fast growing genotypes which may give higher yield of gum-resin at maturity. Studies for estimation of sterol content are in progress.
Steroid bearing plants

*Dioscorea* (*Dioscorea deltoidea* Wall. and *D. floribunda* Mart. and Gal.)

The steroid yielding *Dioscorea* spp. are perennial dioecious vines found both in temperate hills of Himalaya in India (*D. deltoidea* and *D. prazeri*) and tropical regions of central America and Mexico (*D. floribunda*). Their fleshy large tubers contain saponins producing between 2 to 5 per cent diosgenin. The world demand for diosgenin is very high because of its use as a starting raw material for production of sex-hormones (testosterone, pregnenes, hydrocortisone). The Indian Institute of Horticultural Research, Bangalore has done pioneering research work on this crop which has been able to develop two varieties, namely, ‘FB(C)B-I’ and ‘Arka Pukar’ for commercial cultivation. The Arka Pukar is vigorously growing vine, producing broad, dark green leaves and uniform growth of tubers spreading evenly on all sides. It yields 60 tonnes tuber/ha containing between 3 to 3.5 per cent diosgenin at 2 years age. Several plantations have come up in Karnataka, Goa, Tamil Nadu and Assam. Studies for domestication of *Dioscorea deltoidea* are in progress in Kashmir and Himachal Pradesh. This species produces tubers of high diosgenin content but remains in field for longer period of 5 to 6 years.

*Khasi-Kateri* (*Solanum khasianum* Clarke)

This perennial stout hardy spinescent bushy shrub is found in most parts of north-eastern hills and in Nilgiris in India ascending up to 1600m from mean sea level. The mature berries contain solasodine (1 to 3 per cent) in the pulp and its rind part which is used as a substitute of diosgenin in producing corticosteroids and sex-hormones. In the last over one and half decade, intensive studies on the genetics and crop improvement of this species has been carried out at a number of Research Institutes in India resulting in evolving several nearly spineless cultivars, producing high berry yield with upto 3% solasodine content. These cultivars are now brought under commercial cultivation in M.P. and Maharashtra. Tetraploids and aneuploids developed at Bangalore showed no improvement in solasodine content. Since this crop can be grown over marginal lands with low irrigation and low input cost, it has enormous possibility of cultivation in the country. The user industry in India calls for new varieties containing over 3 per cent solasodine in the berries. *Solanum laciniatum* Ait. recently introduced at Solan is a native of temperate parts of New Zealand and Australia. All aerial parts including berries contain solasodine; the berries are very rich with 5 to 5.5% solasodine. Its cultivation practices have been standardised and it can now be taken up for commercial cultivation into sub-temperate hills.
Anti-malarial drug plant

*Cinchona* (*Cinchona ledgeriana* Moens.)

The Cinchona belongs to high rainfall receiving slopes of Andes mountains in South America. Amongst the 65 species recorded to contain 30 different alkaloids in their hard thick bark, four (*C. ledgeriana, C. officinalis, C. succirubra* and *C. robusta*) possess high quinine and quinidine alkaloids, used in treatment of malaria and cardiac diseases respectively. These species are highly cross pollinated, giving rise to numerous hybrids; a few of these are in cultivation. These are small handsome 6–20 m tall trees, growing between 400 to 2600 m elevation over large areas (4,000 ha) in Darjeeling district (West Bengal) and Nilgiris district (Tamil Nadu) in India. These species prefer rich loam to clay-loam, well drained acidic (pH 4.5 to 6) soils; prefer humid conditions but are susceptible to frost and die under water-logged conditions. High quinine and quinidine containing clones are vegetatively propagated. A number of fast growing natural hybrids have been identified for cultivation. Similarly, *C. robusta* is used as a root-stock for *C. ledgeriana* to produce better growth of stout root system. The best Indian crop (from *C. ledgeriana*) possesses 5, 4 and 19 per cent quinine in barks of root, stem and trunk respectively, while clonally propagated trees in Indonesia contain between 4 to 7.5% quinine.

The major limitation in upgrading of bark yield and quality is the lack of diverse genepool in the country. The introduction of high quinine and quinidine producing clones from Indonesia is desired. A systematic long-term programme of hybridisation and selection from progeny stock need to be initiated on this crop.

Expectorant and Ematiane bearing plants

*Liquorice* (*Glycyrrhiza glabra* Linn.)

This is a hardy perennial bushy herb which inhabit poor sandy-loam riverine lands to deep silty/rocky soils (pH 5.5 to 8.0) in warm sub-temperate tracts of west Asia and westwards up to eastern parts of Hungary. These habitats have dry summer season with low annual rainfall, varying from 10 to 29 cm. In particular, west China and south USSR have large concentration of *Glycyrrhiza* spp. and a few alien are used as substitute of the commercial source of drug. The root and total root extract has expectorant, demulcent, fabrifuge, anti-tussive and anti-inflammatory properties for which it finds important place in all galenicals and cough syrups used in treatment of bronchial and respiratory diseases. A collection of 14 accessions which includes 3 species is being maintained. Performance studies on this crop under the project
at Anand and Indore centres has identified EC 114304 (ex. USSR) to produce healthy growth in central and western India and produce high rhizome yield with 5 to 8 per cent glycyrrhizin content. The Russian selection grows 10 to 30 cm deep and then runs parallel to the ground, combing the entire underground space. Waterlogging kills the growing plants and shade affects its growth. The underground parts contain high glycyrrhizin content in autumn season when it could be harvested. The liquorice plants are shy in flowering and do not produce viable seed under Indian conditions. In 10 years period, flowering was observed in 1982 at Anand, Indore, Hisar and Delhi. A collection of *G. foetidissima* (EC 114048) is very slow growing but is found to produce up to 14 per cent glycyrrhizin content. This species is not responsive to fertilizer use; maximum yield response was recorded at 40 kg./ha at Indore. A modified calorimetric and polarographic method has been developed at Delhi to make rapid and accurate estimation of its active content. At Anand, the technique of rapid multiplication of plantlets from axillary buds through tissue culture has been perfected and 4,780 such plantlets have been distributed for growing in Gujarat.

This crop is found highly susceptible to root-rot disease (*Fusarium oxysporium*); it occurred in epidemic form in 1985 such that it ruined all our experimental trials at Indore and Anand. However, this enabled us to screen our genetic stock which showed two of the accessions to provide the moderate resistance to the disease.

*Ipecac (Cephaelis ipecacunha* (Brot.) A. Rich.)*

This is a perennial herb, native of wet evergreen forests in foothills of Brazil and Nicaragua in South America. The root is the economic part which grows between 10 to 30 cm long annulated, corky texture and contains high emetine and cephaeline content used as expectorant and anti-vomiting drug besides its high demand in treatment of amoebic dysentery. The plant requires shady sheltered location, well drained acidic moist soils high in organic matter, seasonal variation in temperature limited between 60 to 84°F and high humidity during growing period. This crop is grown mainly in Darjeeling district (300-900 m) and these plantations have made India as the main exporter of emetine salts to world market. Despite trade benefits, the germplasm is confined to a single composite line obtained in 1866 from Royal Botanical Gardens in Great Britain. The crop is susceptible to several fungal diseases which cause heavy loss in a plantation. A 3-years' old plantation gives from 600 to 1,000 kg of dry roots, containing an average of 2.5% total alkaloids of which between 1.3 to 1.4% is emetine. Efforts are needed to introduce more material from areas of diversity.
The Alma Ata declaration of WHO under "Health for All by 2,000 A.D." will have a meaning if these life support species in the field of medicinal plants are assigned such priority as to draw multi-national co-operation in research and development through international funding. In the last ten years, there has been a growing awareness for conservation of genetic resources of medicinal plants. In fact, the role of these species in the health care programmes is much appreciated in most south and south-Asian countries which led to establishment of national research institutes in several countries to work on cultivation, chemistry and clinical screening of traditional medicinal plants. In this context, the IBPGR sponsored seminar on Plant Genetic Resources held at Delhi in 1978 assigned 'priority-one' to medicinal crops for south Asian countries. Later, the joint FAO/UNEP/IBPGR supported Fourth International Conference on Crop Genetic Resources at Rome (1981) included medicinal plants and a need for institutionalised support of plant genetic resources work on these species in several regions. It was indicated that IBPGR/FAO could do little in the field as these crops fall outside their mandatory crops. The conference, however, recommended that “genetic resources programme should be encouraged to take responsibility for species of particular significance such as traditional and medicinal plants and programmes with regional responsibility should endeavour to become centres of excellence for them”. Similarly, WHO Research study group on Traditional Medicine held at Delhi (1978) emphasised need for developing a "code of practices for the growing, harvesting, collecting, curing, handling, packaging, and storing the plant materials (used in traditional medicine) for primary health care of south and south–east Asian region". Further, it suggested that efforts be made to promote local cultivation of medicinal plants. A report on Second Consultation on the Pharmaceutical Industry under UNIDO at its meeting held at Budapest (1983) recommended to “convene an expert group meeting to advise UNIDO to outline the steps to be taken in future programmes with regards to the transfer of technology for the genetic improvement of medicinal plants and their processing”. As a follow up action in 1985 the UNIDO has listed 68 medicinal plants for establishment of a data bank in the field of medicinal plants. Concerted efforts are needed to link these initiatives and hasten research efforts at international and national level.

At International level

There is a need for international co-operation in this field covering all those medicinal plants which have large world demand in Drugs and
Pharmaceutical industry. This co-operation should work out modalities for initiating multi-national plant exploration missions for important medicinal species in the region of their maximum diversity. In Indian context, bilateral explorations may be planned for spyllium in Iran and Iraq, senna in Arabian peninsula and Egypt, Cinchona and ipecac in Andes mountains and liquorice in West Asia and south USSR. Regional curators may be identified for maintaining inventories for international sharing including long term storage of genepools for posterity. Descriptors and descriptor-lists should be finalised for all important species. To begin with, crop catalogues should be brought out by research institutes holding materials of such crops as Mints, Foxglove, Belladonna, Pyrethrum, Opium poppy, etc. to enable wider use of genetic stocks in crop improvement whereever desired. Plant Introduction is the back bone of modern agriculture and will do immense benefit to the programme if commercial varieties of all these crops grown in different countries are documented to enable free exchange of nucleus seed for trials in alien new habitats. A limited programme of international nurseries in a few priority species could be considered to hasten generation of new useful materials which are in larger demand to operate the programme of primary health care of the WHO. International training may also be useful in handling of these specialised crops. Establishment of a International Research Centre on Medicinal Plants for Asia and the Pacific region is desired to carry out these functions.

At National level

At national level, plant exploration for the priority species should be conducted and evaluation carried out at several locations. An ICAR Working Group on Course Development in Horticultural Crops has identified medicinal and aromatic plants as new field for teaching at graduate and post graduate level. It has developed the content of this course work for teaching. In this respect, it is noteworthy that five Agricultural Universities are presently running such teaching at graduate level. The Agricultural Council may consider providing bulk grant for building up facilities and staff in initial years. This will encourage students to carry out basic studies on these crops so that more information would be generated on cytogenetics, genetics, breeding behaviour, gene action, physiology of synthesis of secondary metabolites, effect of stress environments, identity and control of pest and disease and several related fields. All this will have a multifold effect in developing superior varieties and better cultivation practices for these life support species whose harnessing through cultivation, processing and end-utility is sure to improve quality of life in Asia and the Pacific region and outside as well.
REFERENCES


