Chapter 11

Biodiversity of North-East India and its Conservation

Pramod Tandon and Suman Kumaria
Plant Biotechnology Laboratory, Department of Botany, North-Eastern Hill University, Shillong - 793 022, Meghalaya

Plant genetic resources are the basis of human survival and economic well-being, as they provide food, clothing, shelter, medicines, biomass energy and industrial raw materials, besides offering a potential for providing many more, yet unknown, benefits to the future generations. The Indian region having diverse geoclimatic conditions, boasts of a rich diversity of plants, animals and microorganisms. Indian flora accounts for 10.78% of the global flora. The endemism of Indian biodiversity is about 33% of the country's recorded flora, which is mainly concentrated in the North-East, the Western Ghats, North-West Himalayas, and the Andaman and Nicobar Islands. North-East India represents a distinct biogeographic zone, rich in bioresources, ethnic cultures and folklore traditions. The plant resources of NE India are enormous and represent about 80% (ca. 8000 spp.) of the floristic wealth of India. The forests are very rich in timber-yielding trees. The region contains floristic elements, some of which are not found anywhere else (endemic species), while some others are reported from regions of India, which are geographically separated from other countries by great distances. The plant genetic resources are getting depleted at an alarming rate. One quarter of the plant species are estimated to be at risk of extinction within the next generation. The conservation of plant genetic resources has for long been realised as an integral part of plant genetic improvement programmes. Conservation may be *in situ* or *ex situ*, either in the natural or semi-natural habitats, or in some purposely-built environment.

INTRODUCTION

Biological diversity or biodiversity, the study of all organisms, species, populations and the genetic variations among these, includes the complex assemblage of communities and ecosystems. It refers to the interrelatedness of genes, species, and ecosystems and their interactions with the environment. Three

levels of biodiversity, namely genetic, species and ecosystem diversity exist. Biodiversity provides the basic essentialities, namely, food, fodder, shelter, biomass, etc. for the survival of mankind. As one of the resource–ecosystems of the environment, it provides the basic raw materials, which are the primary infrastructure and the basic requirements for any economic or other income generating activities. It executes the job of recycling, filtering and absorbing, besides detecting and indicating hazard levels within the environment. Biodiversity helps to maintain the biophysical systems, chemical balance of the earth and climate stabilisation. It is above all, a life supporting system. Biodiversity deserves to be conserved in its total form and its complete existence within the environment is essential.

Over millions of years, new biological species have evolved. The ever-changing new ecological conditions have caused many species to disappear. The changes in the climatic conditions of a particular habitat have led to changes in the inhabitants' population due to their ability or inability to adapt to the changes. Those that can adapt, continue to grow and prosper, while others dwindle and die out in course of time. Habitat loss and destruction, usually as a direct result of human activity and population growth, is a major force in the loss of species, populations, and ecosystems. Alterations in the ecosystem composition, such as the loss or decline of a species, can lead to a loss of biodiversity. Technological interventions and human activities have not only changed the set up and status of evolution, but have also accelerated the depletion, steep decline and deep extinction of biodiversity reserves. The ever-expanding population of humans on earth has created havoc on earth and on its species. The changing ecosystems, soils, waters and atmosphere have led to a crisis in biodiversity. Although, extinction being a rare and an obscure event, is a natural part of evolution and accounts for the extinction of 1-10 species a year. In face, scientists have estimated that the rates of extinction have drastically increased in this century i.e., about 1000 species per year.

The knowledge of biodiversity, which has increased in recent years, is due to the importance of biodiversity with its utilitarian values (medicine and agriculture), ecosystem services (continued production of atmospheric oxygen), and moral, ethical and aesthetic values (Eldredge, 1998). Plant biodiversity is the single greatest resource that humankind has treasured from nature. Scientists have described more than 2,50,000 species of mosses, ferns, conifers, and flowering plants, and have estimated that there may be more than 50,000 plant species yet to be documented, primarily in the tropical forests of the world (Tuxill, 2000).

According to Udvardy (1975), the Indian region falls in two biogeogaphical realms, viz., Palaearctic (which includes the whole Europe, Northern China, Japan, Soviet Russia, North Africa, Persia, etc.) and Indo-Malayan (includes the Malayan peninsula and islands of the Malayan Archipelago). The wide variety in physical features and climatic situations have resulted in a diversity of ecological habitats, like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustain the immense

biodiversity. With only 2.4% of the total land area of the world, the known biological diversity of India contributes 8% to the known global biological diversity. According to the latest assessment, India is placed as 10th among the plant rich nations of the world and 4th among the Asian countries. Some habitats, particularly among terrestrial systems, possess a greater number of species than others. Indian flora accounts for 10.78% of the global flora. The endemism of Indian biodiversity is about 33% of the country's recorded flora, which is mainly concentrated in the North-East, Western Ghats, North-West Himalayas, and the Andaman and Nicobar Islands. According to the Red List of Threatened Species (IUCN, 2000), 44 plant species are critically endangered, 113 are endangered and 143 are vulnerable (Table 11.1). The floral species found in India have been categories into different divisions (Table 11.2).

Table 11.1: Threatened Plants of India by Status Category

Ex	*EW*	*CR*	*EN*	*VU*	*LR/cd*	*LR/nt*	*DD*
7	2	44	113	87	1	72	14

Ex-Extinct; EW-Extinct in the Wild; CR-Critically Endangered; VU-Vulnerable; LR/cd-Lower Risk conservation dependent; LR/nT-Lower Risk near threatened; DD-Data Deficient
Source: IUCN, 2000

Table 11.2: Floral species found in India

Division	*No. of species*
Bacteria	850
Viruses	Unknown
Algae	6500
Fungi	14500
Lichens	2000
Bryophytes	2850
Pteridophytes	1100
Gymnosperms	64
Angiosperms	17500

Source: MoEF 1999

With around 48,000 plant species and 81,000 animal species, India is one of the world's 12 mega-biodiversity centres. The flowering plants of India comprise about 17,500 species, which represent 6% of the world's known flowering plants. About 315 families and 2250 genera of flowering plants are known to exist in India in different ecosystems (Nayar, 1997). However, although the ethos of conservation is ingrained in India's cultural heritage, development activity is increasingly threatening this rich biodiversity.

BIODIVERSITY OF NORTH-EAST INDIA

North-East India and the whole of the Eastern Himalayas are one of the hotspots of the globe (Myers *et al.*, 2000). The plant resources of NE India are enormous and they represent the rich floristic wealth of India. The lower groups of plants like liverworts, lichens, ferns, etc. have not been explored to a great extent. The information on these groups of plants is based only on a few randomly collected species. There are many more species belonging to both flowering and non-flowering plants, that need to be discovered in the whole North-Eastern region. NE India represents a distinct biogeographic zone, rich in biodiversity, ethnic cultures and folklore traditions. About half of the total geographical area of the North-Eastern region is covered by forests.

The vegetation of NE India has been broadly classified into 3 major types viz., (i) the tropical, (ii) the temperate and (iii) the alpine vegetation (Murti and Joseph, 1984). The tropical forests comprise moist and dry deciduous, evergreen and semi-evergreen forests and savannah type of vegetation. The tropical evergreen forests are found in the Assam valley, the foot-hills of the Eastern Himalayas, the lower parts of the Naga Hills and Manipur and the lower elevations of the Khasi Hills. Tropical moist deciduous and dry deciduous forests are found in Tripura, Goalpara, Kamrup, Nowgong and Darrang in Assam, and parts of Meghalaya. Tropical grasslands in the riparian flats are distinct from those at higher altitudes of the Meghalaya Plateau and the lower parts of North Cachar and Mikir Hills. Subtropical mixed forests occur in Western Kameng and the inner valleys of Sing, Tirap and Lohit districts in Arunachal Pradesh. Subtropical pine forests occur within the areas of Khasi and Jaintia hills of Meghalaya and in Rupa valley of Kameng district in Arunachal Pradesh. The temperate forests are confined to elevations from 1700 to 3000m. Based on different elevations, these can be further categorised into lauraceous, high level oak-hemlock, coniferous and birch-rhododendron forests. The alpine and sub-alpine type of vegetation is found in the higher ranges at an elevation of 3000 to 4500 m. This vegetation occurs in the Aka hills of Kameng district of Arunachal Pradesh, Naga Hills and in Manipur.

The occurrence of many primitive plants such as *Altinglia, Euptelea, Tetracentron, Pycnarrhena, Haematocarpus, Aspidocarya, Magnolia griffithii, M. pealiana, M. gustavii, Stanntonia, Paryatia, Exbucklandia, Decaisnea, Holboellia, Distyllum, Houttuynia, Myrica esculenta, Alnus* and *Betula* have rendered North-East India as the 'cradle of flowering plants'. In spite of the rich vegetation, the flora of this region remains largely unexplored, which hinders the full utilisation of the plant resources.

The plant resources of NE India have been grouped under two major categories viz. agricultural and forest plant resources. The agricultural resources are confined mostly to Assam, where they contribute significantly to the state income. Important crops are rice, tea and jute, maize, cotton, jute, potato, pine-apples, oranges, banana, ginger and betel leaves etc. The various forest resources of the region are shown in Table 11.3.

Table 11.3: Forest resources of North-East India

Sl. No.	*Forest Resources*	*Plant Species*
1.	**Timber**	*Shorea robusta, Tectona grandis, Michelia champaka, Bombax ceiba, Shorea assamica, Dipterocarpus macrocarpus, Terminalia myriocarpa, Albizzia leebek, Cinnamomum glanduliferum, Alseodaphne dumicola, Phoeba attenuata, P. goalparensis, Litsaea cebifera, Juglans regia, Engelhardtia specata, Podocarpus neriifolia, Taxus baccata, Pinus insularis, P. wallichiana, P. excelsa, Cedrus deodara, Engelhardtia acerifolia, Quercus semicarpifolia, Q. griffithii, Q. semiserrata, Q. lanceaefolia, Castanopsis hysterix*, etc.
2.	**Bamboos**	*Bambusa tulda, B. pallida, B. vulgaris, Dendrocalamus strictus, D. hamiltonii, Melocanna bambusoides, Chimenobambusa khasiana, Arundinaria calloea, Phyllostachya mannii, Dendrocalamus gigenteus, Bambusa khasiana, B. balcooa, Arundinaria hirsuta, A. suberecta, Chimenobambusa polystachya, Bambusa elegans.*
3.	**Orchids**	*Aerides fieldingii, A. multiflorum, A. odoratum, Anoectochilus sikkimensis* (Jewel Orchid), *Arundina graminifolia* (Bamboo Orchid), *Calanthe mosuca, Cirrhopetalum ornatissimum, Coelogyne spp., Cryptochilus sanguinea, Cymbidium spp., Dendrobium spp., Paphiopedilum* spp., *Phaius tankervilliae* (Nun Orchid), *Pholidota articulata, P. imbricata, Pleione praecox, P. humilis, P. maculata, Renanthera imoschotiana, Rhynchostylis retusa, Thunia alba, T. marshalliana, Trias pusilla, Vanda coerulea, V. teres* etc.
4.	**Medicinal plants**	*Ageratum conyzoides, Aristolochia saccata, Buettneria platyphylla, Blumea balsamifera, Centella asiatica, Clerodendron colebrookianum, Lucas linifolia, Mahonia nepalensis, Nepenthes khasiana, Naravelia zeylanica, Nicotiana tabacum, Oxalis corniculata, Piper betele, P. diffusum, Dioscorea prazeri* etc.
5.	**Essential oils, gums dyes, resins and tannins**	*Cymbopogon martini, Acacia arabica, Pinus wallichiana, Indigofera tinctoria, Rubia cordifolia, Lawsonia alba, Terminalia catappa, T. citrine, T. tomentosa, Canarium benghalensis, C. sikkimensis, Acacthopanax trifoliatus, Aporusa diocia, Baccaurea sapida, Indigofera dosua, Smilax acreata, Turpinia nepalensis,* etc.
6.	**Paper and Match Industry**	*Albizzia lebbek, Alstonis scholaria, Bombax ceiba.*

DEPLETION OF THE PLANT RESOURCES

Forests are a part of the primeval environment and have a very important role in preserving environmental values. As long as the essential structure of forests is maintained, they can be manipulated or 'managed' in such a way so as to optimise their environmental benefits.

It is very unfortunate that plant resources are getting depleted at an alarming

rate. A great number of plant species, including several unique and irreplaceable varieties, are becoming extinct and many more are awaiting a similar fate. Extinction of plant species means loss of opportunity to discover more useful forms. This genetic erosion has alarmingly reduced the diversity and variation within the species. It is a known truth that plant genetic resources have limitations regarding their rates of growth, reproduction and adaptation. As such, additional loss of plant genetic resources, on account of the destructive activities of man, will greatly affect the welfare of future generations. The rate at which extinction of plant resources is occurring, needs immediate concerted efforts because, in the face of accelerating losses, our greatest enemy is time.

The loss of biodiversity may be natural or man made. The natural factors responsible for posing a threat to plant species include changes in the biotic parameters in the environment, such as cyclones, long unfavourable weather spells, earthquakes, etc., and biotic parameters, such as natural competition and biological imparities of the species. The prominent man-made causes, are loss or fragmentation of habitat due to clearance of forests for various developmental activities, expansion of agriculture and aquaculture in prime forest lands and natural wetlands, over-exploitation of forest resources beyond their carrying capacity, without any consideration for their its sustainability, and the introduction of alien-species. The exponential growth, in both human as well as cattle population over the last century, has resulted in an increasing gap in the demand and supply of natural resources. Human population in India has grown over four times during the period 1901-2001, and today it represents about 17 per cent of the world's population. Similarly, the cattle population in India today constitutes about 18 per cent of that of the world. The resulting demand on the forest resources has lead to almost 80 per cent loss in the natural habitats (Mackinnon and Mackinnon, 1986; UNEP, 1995), including the degradation of water bodies. Apart from that, the advent of the green revolution in the early 1960's, relying on a handful of crop varieties, also led to an enormous loss in agro-biodiversity.

Shifting agriculture is the characteristic feature of the North-Eastern region. This land use system involves slashing the vegetation, burning the dried slash, raising a mixture of crops on a temporarily nutrient enriched soil for a year or two, fallowing the plot for the re-growth of natural vegetation, and eventual return to the same plot for another cropping phase after a few years (Ramakrishnan, 1992). Due to shifting cultivation and large-scale deforestation, there has been a continuous degradation of the land, leading to ecological imbalance including soil and water loss, which has ultimately led to problems in agricultural production (Verma and Bhatt, 2001). There are also a large number of problems in the management of agricultural production, which mainly includes gap in extension, poor motivation and awareness, inadequate training and lack of viable improved technology for *Jhum* cultivation. It used to be an appropriate and sustainable land use practice in diverse socio-economic set-ups where the dependent human population was within the carrying capacity of a 10-15 year *Jhum* cycle. However, in recent times, shifting cultivation is regarded as

environmentally destructive as it has a very low input-output ratio. Shifting cultivation has become unsustainable, primarily due to the increase in population that has led to an increase in food demand. In order to meet the growing food demand, the *Jhum* cycle (the intervening period between two successive slashes) has shortened, leading to an overall decrease of crop yield (Anonymous, 1997). As a result, more virgin forest areas have been covered under shifting cultivation. Thus, the vicious cycle continued and more forest areas were converted to wastelands as a result of repeated *Jhum* having very short (often 2-3 years) cycles. Table 11.4 shows the areas covered by shifting cultivation in North-East India.

Table 11.4: Areas affected by shifting cultivation in NE India

State	*Geographical area (sq km)*	*Cumulative area of shifting cultivation (1987-1997) (million ha)*
Arunachal Pradesh	83,743	0.23
Manipur	22,327	0.36
Meghalaya	22,429	0.18
Mizoram	21,081	0.38
Nagaland	16,579	0.39
Tripura	10,486	0.06
Total		1.60

(Source: Anonymous, 1999)

CONSERVATION OF PLANT BIODIVERSITY

Loss of plant species is occurring at a rapid rate. There is an urgent need for sustaining biodiversity due to the following reasons:

- Forests render the climate more equable, prevent soil erosion and landslides and help in flood controlling floods.
- Most of today's food crops have been domesticated from wild tropical plants.
- About 80% of the world's population relies on plants or plant extracts for medicines.
- Pollination and seed dispersal by birds, insects and animals is essential to increase the diversity of genetic recombinations.
- Food security and the development of new crop strains for tomorrow.
- Survival of humans and other species is dependent on the producer.
- Wildlife serves as a gene library; premature extinction of species leads to irreversible loss of genetic information that influences the future evolution of life on earth.
- Aesthetic value.

Conservation of plant genetic resources is the only way to guarantee food supplies for the future. The conservation and subsequent use of such resources are complicated by cultural, economical, technical and political issues. Conservation may be *in situ* or *ex situ*, either in the natural or semi-natural habitat, or in some purposely-built environment. The choice of one or the other technique, or a combination of both, will depend on the particular case. *In situ* conservation involves the protection of genetic resources in the natural environment through the protection of the environment itself. It is an ideal and dynamic approach that allows plants to interact and co-evolve with other components of the ecosystem, including insects, animals and microbes. *In situ* conservation is costly to maintain and is highly susceptible to natural calamities like forest fires, extreme weather conditions, and damage by diseases and animals. The dominant approach of conserving plant genetic resources is by removing them from their natural habitats and protecting them at specialised institutions, such as botanical gardens, nurseries and gene banks. During the last few years, there has been an increase in the number of plant collections and in accessions in *ex situ* storage. Botanical Gardens have played an important role in *ex situ* conservation programmes, particularly in acclimatisation, rehabilitation, multiplication and judicious exploitation of plant resources. These gardens must have coordinated efforts through an international conservation network which would ensure that the rarest plants receive priority for propagation and ultimately, reintroduction. Gene banks focus exclusively on storing seeds of crop varieties and their immediate wild relatives. It is considered essential that all wild related species and varieties of an economic plant should be collected and grown at one place so that they can be easily assessed and utilised in crop improvement and hybridisation.

Biotechnology can play an important role in plant conservation programmes. It represents an interface of basic and applied sciences, involving gradual transformation of science into technology. Many plant species of agricultural, forestry and medicinal importance are vegetatively propagated and maintained in germplasm collections. The use of plant tissue culture technology for the conservation of germplasm through *in vitro* propagation and re-establishment has great potential in micropropagation and embryo rescue of plants (Tandon *et al.*, 1990; Tandon and Rathore, 1992, 1994; Kumaria and Tandon, 1994; Prance, 1997; Seeni and Sabu, 1997; Szendark *et al.*, 1997; Feijoo and Iglesias, 1998; Lynch, 1999; Nobre *et al.*, 2000; Mohammud *et al.*, 2002). The molecular marker technology and molecular diagnostics, *in vitro* technologies and cryopreservation techniques have also been applied for germplasm conservation (Tandon and Kumaria, 1998; Tandon, 2000).

There is a need for conservation strategies to be developed for the protection of species and ecosystems, involving a mixture of both *in situ* and *ex situ* strategies. A few important areas for such a strategy should include the following:

1. Population surveys and the creation of databases, based on adequate data available on the diversity of species and changes over time, so that a proper strategy for conservation could be designed.

2. For facilitating biodiversity conservation, it is important to generate maps of the protected areas, showing their continuity with the existing reserve and protected forests.
3. Improved protection efforts and a landscape approach to conservation, where protected and non-protected areas should be integrated through significant protection measures, initiated at both the state and community levels.
4. *In situ* conservation through management of the populations distantly related in the wild which would be essential for their survival.
5. Computer models which would provide estimates for the survival of the regular population in the face of newly identified threats, population status and other relevant research, for the next 100 years, should be generated. These models should also include different steps needed for improvement in the overall conservation status of the species.
6. The preservation plots and the protected areas in a number of states are the important means for conserving and protecting important plant species. These should be properly demarcated and actively maintained.
7. Since a large proportion of biodiversity occurs outside the network of protected areas, conservation programmes outside protected areas must become an integral part of forest management.

REFERENCES

Anonymous (1997). Agenda notes for the meeting on WDPCA Project. Ministry of Agriculture (SWC Wing) New Delhi.

Anonymous (1999). State of Forest Report. Forest Survey of India. Ministry of Environment and Forests, Govt of India p 113.

Eldredge N. (1998). Life in the Balance: Humanity and the Biodiversity Crisis. Princeton: Nevraumont Publishing Co.

Feijoo M.C. and Iglesias I. (1998). Multiplication of an endangered plant: *Gentiana lutea* L subsp *aurantiaca* Lainz using *in vitro* culture. Plant Tissue Culture and Biotechnology 4: 87-94.

IUCN (2000). Red list of threatened species. Gland, Switzerland: The World Conservation Union.

Kumaria S. and Tandon P. (1994). Clonal propagation and establishment of *Dendrobium fimbriatum* var. *oculatum* Hk f. In: Advances in Plant Tissue Culture in India (Tandon P ed), Pragati Prakashan, India, pp 218-231.

Lynch P.T. (1999). Tissue culture techniques in *in vitro* plant conservation. In: Plant Conservation Biotechnology (Bensen EE ed), Taylor and Francis, London p 41-62.

Mackinnon J. and Mackinnon K. (1986). Review of protected areas system in the Indo-Malaysian realm. IUCN, Gland.

MoEF (1999). National policy and macrolevel action strategy on biodiversity. Ministry of Environment and Forests, Government of India, New Delhi p 74.

Mohammud N. Amin., Nahar K., Ahmed F. and Ahmad S. (2002). Micropropagation of *Annona squamosa* Linn using explants (shoot tip and node) of field grown mature plants. Pakistan Journal of Biological Sciences 5(4): 394-397.

Murti S.K. and Joseph J. (1984). Plant resources of Northeast India. Meghalaya Science Society, Shillong Vol. II: 28-39.

Myers N., Mittermeier R.A., Mittermeier C.G., da Fonseca G.A.B. and Kent J. (2000). Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Nayar M.P. (1997). Changing pattern of Indian flora. Bull Bot Surv India 19: 145-154.

Nobre J., Santos C. and Romano A. (2000). Micropropagation of the Mediterranean species *Viburnum tinus.* Plant Cell Tiss Org Cult 60(1): 75-78.

Prance G.T. (1997). The conservation of botanic diversity. In: Plant Genetic Conservation (Maxted N, Ford-Lloyd BV and Hawkes JG eds), Chapman and Hall, London.

Ramakrishnan P.S. (1992). Ecology of shifting cultivation and ecosystem restoration. In: Ecosystem Rehabilitation, Vol 2, Ecosystem Analysis and Synthesis (Wali MK ed), SPB Academic Publishing Bv, The Netherlands, pp 19-35.

Seeni S. and Sabu K.K. (1997). Conservation and economic utilisation of plant resources through biotechnological means. In: Conservation and Economic Evaluation of Biodiversity Vol. 1. (Pushpangadan P, Ravi K and Santosh V eds), Oxford IBH Publishing Co, New Delhi, p 239-249.

Szendark E., Read P.E. and Miller V.I. (1997). *In vitro* culture initiation and multiplication of the hybrids of the once-dominant Eastern forest tree, the American chestnut (*Castanea* spp). In – Vitro 33(3): Pt 2, 51A.

Tandon P. (2000). Role of Biotechnology in the Conservation of Plant Genetic Reources in the 21st century - An Indian Perspective. Platinum Jubilee Lecture delivered at the 87th session of Indian Science Congress, Pune, January 4, 2000.

Tandon P. and Rathore T.S. (1992). Regeneration of plantlets from hypocotyle derived callus of *Coptis teeta*. Plant Cell Tissue and Organ Culture 28: 115-117.

Tandon P. and Rathore T.S. (1994). Mass clonal multiplication of the threatened Indian insectivorous plant (*Nepenthes khasiana* Hk F) through shoot bud culture. In: Advances in Plant Tissue Culture in India (Tandon P ed), Pragati Prakashan, India p 185-192.

Tandon P. and Kumaria S. (1998). Threats to plant diversity in high altitude areas of North-East India and conservation of rare and endangered plants using biotechnological approaches. In: Science at High Altitude, Proceedings of the National Symposium (Saha S, Ray PK and Sinha B eds), Allied Publishers Ltd, India p 140-147.

Tandon P., Rathore T.S. and Dang J.C. (1990). Mass multiplication and conservation of some threatened plant species of Northeast India through tissue culture. In: Abstracts VIIth International Congress on Plant Tissue and Culture, IAPTC, Amsterdam, Netherlands p 136.

Tuxill J (2000). The biodiversity that people made—and are now losing. World Watch 13 (3): 24-35.

Udvarday MDF (1975). A Classification of the Biogeographical Provinces of the World. IUCN occasional paper 18, Morges, Switzerland.

UNEP (1995). Global Biodiversity Assessment. Cambridge University Press, Cambridge.

Verma, N.D. and Bhatt B.P. (2001). (eds) Steps towards modernisation of agriculture in the NEH region. ICAR Research Complex for NEH Region, Umiam, Meghalaya, India p 536.