Indian J. Pl. Genet Resources 6(2): 93-107, 1993

BAMBOO GERMPLASM RESOURCES IN INDIA — DOCUMENTATION AND CONSERVATION

S. Kochhar and R.S. Rana

National Bureau of Plant Genetic Resources
Pusa Campus, New Delhi 110 012

Around 126 species of bamboos are reported to occur in India. Northeastren India (16 genera, 58 species) shows highest variability followed by Penninsular India (8 genera, 24 species), westren Himalayas (5 genera, 14 species), Andaman and Nicobar islands (6 genera, 7 species) and the Indo- gangetic plains (4 genera, 8 species). Status of live-conserved bamboo species germplasm in the country and a list of the naturalized non-native species is presented. Survey, collection and maintenance work carried out by Indian Council of Agricultural Research (ICAR) Basar centre is highlighted. Their respective herbaria are maintained at National Herbarium of Cultivated Plants (NHCP) at National Bureau of Plant Genetic Resources and Forest Research Institute (FRI). Related aspects on *in situ* conservation, taxonomy, classification and documentation of bamboo germplasm are discussed.

Key words : Germplasm resources, *ex situ* conservation, *in situ* conservation, documentation, descriptors

Bamboo is one of those providential developments in Nature which, like the horse, the cow, the wheat and the cotton, have been indirectly responsible for man's own evolution (Porterfield, 1933). Bamboos are worldwide in distribution unlike cereals and other grasses, which are restricted to narrow habitats and growing conditions, representing in each case a single species or a group of closely related species. These occur from tropical lowlands to the high mountains and number over 60 genera and perhaps as many as 1500 species (Soderstrom and Calderon, 1979). India is rich in bamboo resources having over 126 species representing 19 genera. This diversity is distributed all across from coastal areas in the south to around 10,000 feet above average sea level in the Himalayan highlands. Nine genera are native or naturalized (Table 1) and around 10 species are commercially exploited (Table 2). The rest are frequent to rare and used for local needs of rural folk. A brief resume of the status of bamboo germplasm resources and further scope in India is given below.

Table 1 : Species diversity and occurance of various bamboo genera

Genus	No. of species	Occurance	Remarks
Arundinaria Michix.	150	Warm tropical	-
Bambusa Sieb.	70	Tropical & subtropical Asia, Africa and America	Type genus of bamboos
Cephalostachyum Munro	12	Indomalaya, Madagaskar	-
Dendrocalamus Nees	20	Indo-Malayasia, China	Represents largest known bamboo (*D. giganteus*)
Dinochloa Buese syn. *Melocalamus* Benth.	20	S.E.Asia, Indo-Malaya	-
Gigantochloa Kurz.	20	Java	Giant bamboo stout & durable
Melocanna Trin.	2	Indo-Malaya	Bears berries
Neohouzeana (Camus) Gamble	4	S-East Asia	-
Oxytenanthera Munro	20	Tropical Africa E-Asia, Indomalaya	-
Chimonobambusa Makino	14	India to Japan	-
Phyllostachys Sieb. et Zucc.	40	Himalaya (India) to Japan	-
Pleioblastus (carriere) Nak	1*	China, Japan	*First report from India
Semiarundinaria Makino ex Nak	20	E-Asia	-
Sinobambusa Makino	8	E-Asia	-
Thamnocalamus Munro	5	E-Asia	-

Table 2 : Commercially exploited species of bamboo in India

Sr.No.	Species	Occurance
1.	*Bambusa arundinacea*	Throughout India upto 1250m
2.	*B. balcoa*	Eastern U.P., Bihar, Bengal, Assam and Arunachal Pradesh with 600m
3.	*B. nutans*	Sub Himalayan tracts U.P. to Arunachal Pradesh, 600-1500m
4.	*B. tulda*	Widely cultivated in plains and foot hills of N India, wild in E. India.
5.	*Dendrocalamus hamiltonii*	West,central and east india in lower hills, upto 900m
6.	*D. strictus*	Commonly cultivated throughout India in plains & foothills. In deciduous forests all over India execpt North East and west Coast.
7.	*Melocanna baccifera* syn. *M. bamboosoides*	Bengal, Assam, Meghalaya, Tripura, Mizoram and other parts of E. India in plains and lower hills.
8.	*Ochlandra ebracteata*	Trivandrum, Kerala
9.	*O. scriptoria*	West coast, Malabar at low elavation.
10.	*O. travancorica*	Plains and hills of south India upto 1550m

DISTRIBUTION

A detailed account of 113 species of bamboos found in India alongwith their distribution has been given by Varmah and Bahadur (1980). Further additions were made to the list from new reports thereby increasing the number of available species to around 126. Distribution of various genera and species over 5 different zones in the country (Table 3) shows the availability of maximum diversity of 16 genera and 58 species, in the northeastren Indian states including Bengal which is further summarized in Table 4 to have gone up to 63 (Kochhar *et al.*, 1990). Penninsular India houses 8 genera and 24 species and is ranked next to the northeastren region in terms of available diversity. The floristic distribution in the above two regions is differential; a few genera like *Phyllostachys* and *Pseudostachyum* are restricted to the Himalayan/ northeastren region whereas a few others like *Ochlandra* and *Oxytenanthera* are localized in their distribution to the Deccan plateau/ southren India. The westren Himalayas, including foot hills, rank next to Penninsular India in terms of distribution of number of species (14) but the generic diversity is more available in Andaman and Nicobar Islands (6). One genus, *Schizostachyum* is represented in the off-shore Andaman and Nicobar Islands alone. The Indo-gangetic plains are poorest in terms of available diversity of 4 genera and 8 species of bamboos.

Table 3 : Distribution of bamboo generic / species diversity in different agroecological zones in India

Sr. No.	Zone	Number of Genera	Number of Species	Genera (No. of Species)
1.	East and North-East India	16	58	*Arundinaria* (9), *Bambusa* (12), *Cephalostachyum* (5), *Chimonobambusa* (6), *Dendrocalamus* (7), *Dinochloa* (2), *Gigantochloa* (2), *Melocanna* (1), *Nohouzeana* (2), *Oxytenathera* (2), *Phyllostachys* (2), *Pseudostachyum* (1), *Semiarundinaria* (1), *Sinobambusa* (1), *Teinostachyum* (1), *Thamnocalamus* (4).
2.	Westren Himalayas including foothills	5	14	*Bambusa* (4), *Chimonobambusa* (2), *Dendrocalamus* (4), *Phyllostachys* (2), *Thamnocalamus* (2).
3.	Indo-gangetic plains	4	8	*Bambusa* (4), *Cephalostachyum* (1), *Dendrocalamus* (2), *Oxytenanthera* (1).
4.	Penninsular India	8	24	*Bambusa* (3), *Cephalostachyum* (1), *Chimonobambusa* (1), *Dendrocalamus* (1), *Indocalamus* (3), *Ochlandra* (9)
5.	Andaman and Nicobar Island	6	7	*Bambusa* (2), *Cephalostachyun* (1), *Dendrocalamus* (1), *Dinochloa* (1), *Oxytenanthera* (1), *Schyzostachyum* (1)

Table 4 : Diversity of bamboos available in North East India

Sr. No.	Number of Genera	Number of Species	References
1.	10	48	Gamble (1896)
2.	16	58	Varmah & Bahadur (1980)
3.	15	54	Shukla (1986)
4.	13	48	Haridasan et al. (1986)
5.	1	1	Naithani & Bahadur (1988)
Total	16	63	

CONSERVATION OF GENETIC RESOURCES

Ex situ CONSERVATION

The bamboo germplasm conservation, evaluation and identification work is carried out at the Systematic Botany Branch, Forest Kesearch Institute (FRI), Dehradun, as the pioneer organisation and the lead centre alongwith some other forestry training centres in the country. However, FRI holds a limited variability of 35 species of bamboos in terms of live conservation, in the clonal repository of the bamboo garden (Varmah and Bahadur, 1980; pers comm.). Further, State Forest Departments, Research and Training Centres, Botanical Gardens and a few other organizations, Institutes and universities also maintain live collections of a few species of bamboos in their respective bambooseta. These live-conserved materials mostly represent endemic, semi-cultivated or naturalized species, which are easier to propagate, and the wild species/ types, some of which are low in frequency, rare or endangered ones are poorly represented in different live-collections all over the country.

NBPGR, as the nodal organization of Indian Plant Genetic Resources System (IN-PGRS) plans, conducts and promotes research and information base on various plant genetic resources activities in the country. Collection, conservation and documentation studies on bamboos were proposed in 1982 for conducting survey and collection work in the northeastren states and maintaining a live collection under All India Coordinated Project on Under utilized and Underexploited Plants, which is one of the active collaboators of IN-PGRS, at Arunachal Pradesh Centre, Basar, under ICAR Reseach Complex for NEH region (Thomas *et al.*, 1990, Rana, 1992). Prevalent diversity of bamboos in the penninsular India was proposed to be conserved at NBPGR Trichur centre. The work was carried out at Basar begining from August, 1984 and during the period 1984-1990 above 100 variant samples of bamboos were collected. These collections represented 44 taxonomically classified species, a few distinct types with local names but unconfirmed botanical status, and probable duplicates. Out of these, 30 species established well at the AP centre's live-conservation garden till 1990 and a few more species were subsquently added. Represetative herbaria of the live collections, including culm sheath, leaf and part of a branch and node in each case, of the species being maintained at Basar centre, are kept at National Herbarium, NBPGR and a duplicate herbarium set is maintained at Systematic Botany Branch, FRI.

Kochhar *et al.* (1990, 1992) documented the existing live collection of bamboos at AP centre, alongwith distribution and status of related genera in Arunachal Pradesh/ northeastren India. The live collections at AP Centre include a higher proportion of indigenous species of bamboos, many of which were not available at other live bamboo gardens. Further, Vermah and Bahadur

(1980) documented the live-conserved species at FRI, alongwith other prevalent ones in the country. Status of some live-conserved bamboo germplasm with regards to their availability at FRI, AP Centre, Basar and Van Vigyan Kendra, Chessa has been presented in Table 5 and a list of the exotic species of bamboos naturalized in India is presented in Table 6. There is a need to well-knit the existing live conservation units throughout the country, and establish a few more in the unrepresented zone, for systematic evaluation, using common descriptors and their descriptor states, in order to strenghthen the documentation and database.

Table 5 : Status of some live-conserved bamboo species germplasm in india

Genus/species/synonym	Origin	Availability at		
		FRI	Basar	Chessa
Arundinaria hirsuta	I	N	Y	N
Arundinaria manii	I	N	Y	N
Bambusa arundinacea	I	Y	Y	T
Bambusa curiculata	I	Y	N	N
Bambusa balcoa	I	Y	Y	Y
Bambusa burmanica	E	Y	N	Y
Bambusa copelandii	E	Y	N	N
Bambusa nana	E	Y	Y	Y
syn. *B. glauscens*				
Bambusa multiplex	E	Y	Y	Y
syn. *B. glauscens*				
Bambusa longispiculata	I	Y	N	N
Bambusa nutans	I	Y	Y	Y
Bambusa oliveriana	E	Y	N	N
Bambusa pallida	I	Y	Y	Y
Bambusa polymorpha	I	Y	Y	Y
Bambusa spinosa	I	Y	N	N
Bambusa tulda	I	Y	Y	Y
Bambusa ventricosa	E	Y	N	N
Bambusa vulgaris	E	Y	Y	Y

(*Table 5 continues*)

1	2	3	4	5
Bambusa vulgaris var. stricta	E	Y	N	N
Bambusa cacharensis	I	N	Y	N
Bambusa variegata	I	N	Y	N
Bambusa khasiana	I	N	Y	N
Bambusa sp.	I	N	N	Y
Cephalostachyum fuschianum	I	N	Y	N
Cephalostachyum	I	N	Y	N
Cephalostachyum pergracile	I	N	Y	N
Chimonobambusa griffithiana syn. *Arundinaria griffithiana*	I	N	Y	N
Chimonobambusa callosa syn. *Arundinaria callosa*	I	N	Y	N
Chimonobambusa armata syn. *Arundinaria armata*	I	N	Y	N
Dendrocalamus brandisii	E	Y	N	N
Dendrocalamus calostachys	E	Y	N	N
Dendrocalamus giganteus	E	Y	Y	Y
Dendrocalamus hamiltonii	I	Y	Y	Y
Dendrocalamus longispathus	I	Y	Y	N
Dendrocalamus membranaceus	E	Y	N	N
Dendrocalamus strictus	I	Y	N	Y
Dendrocalamus maclellandrii	I	Y	N	N
Dendrocalamus hookerii	I	N	Y	N
Dendrocalamus sikkimensis	I	N	Y	Y
Dendrocalamus sahnii	I	N	Y	N
Gigantochloa alter (Black mutant)	E	Y	N	N
Guada angustifolia	E	Y	N	N
Melocana baccifera	I	Y	N	N

(*Table 5 continues*)

1	2	3	4	5
syn. *M. bambusoides*				
Neohouzeana	I	Y	N	N
syn. *Teinostachyum dullooa*				
Oxytenanthera albociliata	E	Y	N	Y
Oxytenanthera abyssinica	E	Y	N	Y
Oxytenanthera nigrociliata	I	Y	N	N
Phyllostachys aurea	E	Y	N	N
Phyllostachys assamica	I	N	Y	Y
Phyllostachys manii	I	N	Y	N
Pseudostachyum polymorphum	I	N	Y	N
Teinostachyum helferii	I	N	Y	N
Pseudosassa japonica	E	N	N	Y

I = Indigenous Y = Available

E = Exotic N = Not available

A need to conserve within-species diversity in bamboos is strongly felt. So far, the aproach for collection of bamboo germplasm during various surveys revolves round species level of the taxa. Within-species diversity finds little reference in literature which is ascribed mostly to the edapho-climatic or management factors rather than genetic differences. However, there are ample evidences for the availability of differant biotypes, morphotypes and location-specific adapted types within the same species. At AP Centre, the live collections include two distinct biotypes of *Bambusa pallida* viz. Eso (Adi Gallong) and Murali Bah (Karbi Anglong, North Cachar District, Assam) which exhibit varied phenotypes particularly for culm characteristics (Annon, 1990). Kochhar *et al.* (1990) described population effect of the phenological behaviour in *Bambusa tulda, B. pallida* and *Dendrocalamus hamiltonii*, over two diverse ecological conditions, midhills and valley land, in the West Siang and North Lakhimpur districts of Arunachal Pradesh and Assam, respectively. Little interspecific and more intraspecific variation was observed over two locations for 5 culm morphological and 7 clump management traits in the base population. *Inter se* associations among these traits showed possibility of improvement through selection. Singh (1986) also earmarked plus-bamboos in seven commoner species in Assam to initiate improvement studies through selection. Therefore, the National Active conservation sites should intensify their efforts for maintaining

Table 6 : List of naturalized exotic species of bamboo in India

Genus Species	Country of origin
Bambusa burmanica	Myanmar
Bambusa copelandii	Myanmar
Bambusa nana	China/Japan
syn. *B. glauscens*	
Bambusa multiplex	China/Japan
syn. *B. glauscens*	
Bambusa oliveriana	Myanmar
Bambusa ventricosa	China/Japan
Bambusa vulgaris	Pantropical (Origin unknown)
Bambusa vulgaris var. *stricta*	Pantropical
Dendrocalamus brandisii	Myanmar
Dendrocalamus calostachys	Myanmar
Dendrocalamus collettianus	Myanmar
Dendrocalamus giganteus	Malaya and Myanmar
Dendrocalamus membranaceus	Myanmar
Gigantochloa alter	Malaya
Gigantochloa alter (Black mutant)	Malaya
Guada angustifolia	Tropical America
Melocana humilis	Myanmar
Oxytenanthera albociliata	Myanmar
Oxytenanthera abyssinica	Sudan/Africa (parts of)
Phyllostachys aurea	Japan
Phyllostachys bambusoides	China/Japan
Phyllostachys puberula	Japan
Pseudosassa japonica	Japan
syn. *Arundinaria japonica*	
Schizostachyum brachcladum	Malaya
Thyrsostachys oliverii	Myanmar
Thyrsostachys siamensis	Myanmar

within-species diversity on the pattern of NAC sites of IN-PGRS (NBPGR, 1991). It may be clearly pointed out that such germplsm collection and conservation efforts would carry wider scope for social forestry, agriculture and allied as compared to the existing information centres or Forest Departments' networks on bamboos, which mainly revolve round the commercial exploitation of these species in forestry.

In situ CONSERVATION

There is an ample scope for *in situ* conservation of endemic bamboos of the respective zones in the country. NBPGR, as the nodal organization of IN-PGRS, has active collaboration with the Department of Environment and Forestry, Indian Council of Foresty Research and Education and Forest Research Institute. The first gene sanctury is being established in Meghalaya, focussing on *Citrus* genetic resources, through the joint efforts of the above agency, respective State Government and the NBPGR (ICAR) (Rana, 1992). Of the seven gene sancturies made operational in the country, Nokrek (Meghalaya), Manas (Assam), Nilgiri (Karanataka, Kerala and Tamil Nadu) and Great Nicobar (Andeman and Nicobar Islands) fall in the high prevalence zones for different species of bamboos (Fig. 1). These species should, therefore, be conserved *in situ* in the corresponding gene sanctuaries.

Other related studies

Thomas *et al.* (1990) have reviewed the strategies for conservation of bamboos which gave due emphasis on micropropogation and *in vitro* conservation. The tissue culture techinique would also be helpful in i) maintenance of rare species of bamboos collected from difficult tracts where seed samples are not found during surveys; ii) mass multipication of plus-bamboos of species having long flowering cycle and iii) generation of variants for germplasm improvement.

At NBPGR Research Farm, Issapur, 40 clumps of bamboos representing 3 species, *Bambusa arundinacea, B. tulda* and *Dendrocalamus strictus* were successfully established from tissue culture raised seedlings provided by Botany Department, Delhi University. The observations recorded have shown differential response of seedling age to the status of establishment and clump vigour. The seedling age of 1 year or above was found superior in terms of corresponding plant vigour of the fully grown clumps (4 years age) as compared with the seedling age 6 months or below.

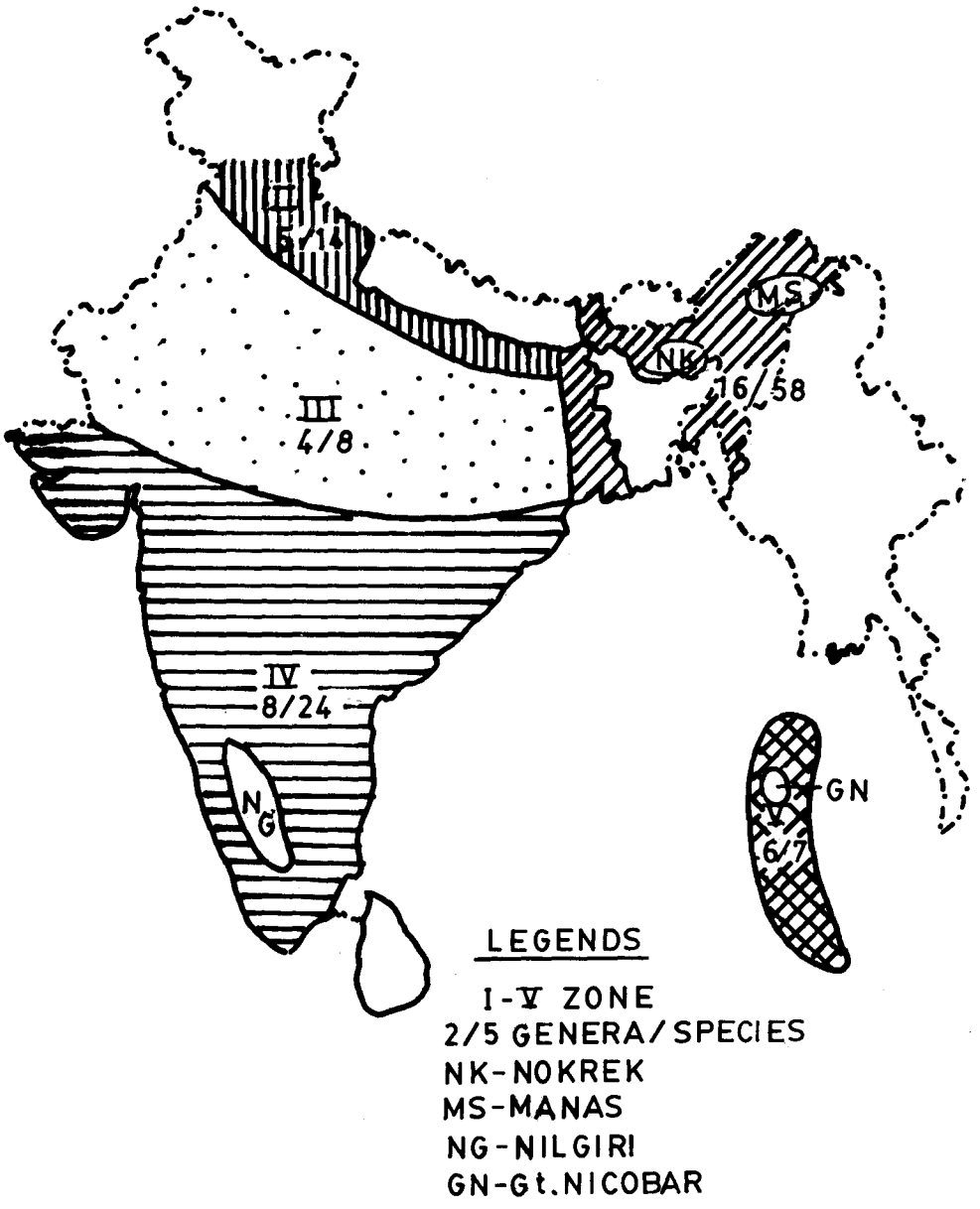

Fig. 1. Bamboo diversity in different agro-ecological zones and proposed gene sancturies

Studies on effect of temperature, humidity and seed moisture regimes for conservation of bamboo seed in the gene bank were not encountered. However, the interrelated effects of temperature and moisture regimes have been studied for medium term storage and seed germination. Ramyarangsi (1990) reported that reduction of initial moisture content upto 5.9 per cent and storage temperatures (2-4°C and –5°C) maintained high percentage of viability for upto 27 months in *Thyrsostachys siamensis*. The optimum lavels for proper germination in case of *Dendrocalamus strictus* were 25-35°C temperature, with the best response at 30°C temperature, and 50-75 per cent relative humidity (Gupta and Kumar, 1977). Both higher and lower regimes were unfavourable.

NBPGR introduced one accession of *Phyllostachys pubescens* (EC-332318 from Germany) in 1990. The country of origin for this material was China and the seeds were collected in 1988 flowering year. The seed was supplied in tightly sealed parchment bag at reduced moisture level. Germination and growth of seedlings was observed upto 2-3 leaves stage, on agar medium supplemented with nutrients, after about 2 years from harvest, which is a fairly long gap in bamboos. However, the seedlings did not survive beyond that stage. Other exploratory observation on bamboos include hastening of flowering cycle in tissue culture raised seedligs. Such observations/ parmeters are directly coverable under the evaluation data, in terms of germplasm handling, which are built once in a long while, on flowering and availability of seed. Yet these are useful for further resource conservation strategy.

GERMPLASM EXCHANGE

The recommendations of the third International bamboo workshop held in India (Ramanuja Rao *et al.*, 1990) on the conservation of bamboo resource and its improvement emphasized collection of genepools and the germplasm exchange. The FRI's list includes 25 exotic species of bamboos, introduced in the past from Myanmar, China, Japan, Malayasia and Thailand (Vermah and Bahadur, 1981) which are now well adapted to the Indian conditions. Some of the naturalized, non-native species successfully established at AP centre are *Bambusa vulgaris, B. nana, B. multiplex* (syn. *B. glauscens*).

One of the bottlenecks for active exchange of bamboo germplasm is the remote availability of seed due to long flowering cycles and the vulnerability of bulky rhizomes to damage during transportation. Three packing systems were devised at Basar for short, medium and long distance transportation (Annon, 1990). FRI has also improvised their own system of packing of bamboo rhizomes for transportation during planting. Further, raising of mass propagules using cheaper and surer methods is helpful in active exchange/ supply of bamboo germplasm. Raising of nodal seedlings by cavity filling of 2 nodal

culm cuttings with 200 ppm boric acid or 100 ppm boric acid + 100 ppm IAA has been found successful in many species (Surendran *et al.*, 1983; Prasad and Kochhar, 1986; Sharma, 1986). This is a simpler and cheaper technique for carrying mass propagules directly from ramote areas where sophisticated laboratory facilites are lacking. However, tissue cultlure is a surer technique for raising low volume propagation materials fit for long distance transportation. The use of plant tissue culture methods to facilitate bamboo germplasm exchange was also emphasized in the recommendations of III International bamboo workshop.

TAXONOMY AND CLASSIFICATION OF BAMBOOS

Colonel Munro's excellent descriptions, notes and system of classification, published in 1868, has been the basis of subsequennt taxonomical studies on bamboos of the old world. Gamble (1896) gave a comprehensive monograph on bamboos from India, Burma and Malaya which provides the storehouse for taxonomical information on Indian bamboos. Additional treatments of bamboos from north-east India were given by Bor (1938, 1940). The first reports on new species, not found to occur earlier, are invariably covered in the 'Indian Forester'. Bahadur (1979) gave a ready-reference account of taxonomy of bamboos based on culm sheath morphology to help in botanically classifying those collections which are not found in flowering stage during an exploration and collection trip.

Nevertheless, in terms of germplasm documentation, it would be desirable to work out simpler classificatory systems based on stable morphological characters, in the absence of readily available flowering branch, due to long flowering cycle in most bamboo species. At the collection site, the passport data would have to be recorded for botanical, morphological and phenological traits irrespective of the confirmation of taxonomic status. It, therefore, becomes pertinent to define suitable descriptors and their descriptor states for classification and documentation of bamboos.

PGR DOCUMENTATION

Little information is available in literature in terms of inventorizing, indexing or documenting genetic resources of bamboos, except for taxonomical accounts of species, taxa and new reports. The inventory of bamboo genetic resources has got own peculiarities as compared to tree or timber inventory on one side (Tomar, 1974) and inventory of germplasm resources which deals with the status of introduced germplasm of different crop species at NBPGR (NBPGR, 1991), on the other. The inventory of bamboos was proposed and followed by foresters taking into consideration the commercial aspects of the bamboo crop. including : i) classification of bamboo area for condition class,

density of plantation, height of clumps, geography/ topography of the site and quality/ cost class, ii) classification of bamboo clumps for maturity, soundness and clump size etc., iii) classification of culms for age, length, diameter, weight, quality etc., and iv) mapping of bamboo areas. Thus it did not emphasize on the species component. Nevertheless, with an increased awareness about the necessity for conservation of genetic resources of different crop species and their relatives, it would be appropriate to characterize and evaluate, document and maintain the existing live-conserved accessions in the country, under a suitable network.

The documentation of bamboos may be done by retrieval of database and indexing. The data should be suitably recorded under the heads : Source data, Planting data, Phenological data including periodical growth of the clump, Morphological characteristics including clump, rhizome, culm, branching, culm sheath, and leaf morphological traits, Floral characteristics, Histological parameters, Wood and Pulp quality traits and Cutting management related parameters. Precise descriptors and their descriptor states have been defined (Kochhar, Unpublished) on the pattern of IBPGR descriptors by extending the abovementioned datasheet (Anon, 1990).

The evaluation data, it is suggested, may be recorded in three steps : Characterization, which may include better hints for morphological identification of the variant; Evaluation, which should include most clump morphological, phenological and culm cutting traits; and Further Evaluation, which may finally help to screen a particular accession with regards to its utilitiy and management traits. In response to any change/s in a particular taxon of bamboos, records of additional notes, under the main head Morphological characteristics (Anon, 1990) would be further helpful to establish botanical reclassification and even regrouping, if required.

ACKNOWLEDGMENTS

Sincere acknowlegments are recorded to the Directors, FRI and ICAR Research complex for NEH region and Chief Conservator of Forests, Arunachal Pradesh for a frequent reference to their live bamboo gerdens at Dehradun, Basar and Chessa, respectively.

REFERENCES

Anonymous. 1990. Annual Progress Report. AICRP on Under utilized and under exploited plants - Bamboos. ICAR Research Complex for NEH Region, AP Centre, Basar. 28 p.

Bahadur, K. N. 1979. Taxonomy of Bamboos. *Ind. J. For.* **2**(3): 221- 241

Bor, N. L. 1938. A list of grasses of Assam. *Indian Forest Rec.* (n. s. Bot) **1** (3): 47-102

Bor, N. L. 1940. The Flora of Assam. Vol. 5. Gramineae - Bambusae. Prabasi Press, Calcutta. p. 4-57

Gamble, J. S. 1896. The Bambusae of British India. *Ann. R. Bot. Gdn., Calcutta.* **7**: 1-133. (lates 1-119)

Gupta, B. N. and Adarsh Kumar. 1977. Interrelated effects of temperature and moisture on seed germination of *Dendrocalamus strictus* nees. *Indian For.* **103** (4): 212-19

Haridasan, K., B. S. Beniwal and M. L. Deory. 1986. Bamboos in Arunachal Pradesh - Distribution and Utilization : A Preliminary appraisal. NEC Seminar on Bamboos and Canes, Shillong. Nov. 27- 28. 7 p.

Kochhar, S., Bhag Mal and R. G. Chaudhary. 1990. Population aspect of the phenological behaviour of bamboo germplasm. *In* : Proc. Intl. Bamboo workshop, Cochin, India. Ramanuja Rao *et al.*(Eds.) Nov.14-18, 1988. KFRI, Peechi and IDRC. pp.51-58

Kochhar, S., R. N. Prasad, Bhag Mal, R. G. Chaudhary, M. Rai and B. D. Sharma. 1990. Bamboo germplasm - diversity and conservation in North East India. *Indian J. Pl. Genet. Resources* **3** (2): 21-26

Munro,W. 1868. A monograph of the Bambusaceae, including descriptors of all the species. *Trans. Linn. Soc. Lond.* **26** : 1-157

NBPGR. 1991. Current holdings of National Active Germplasm Sites. *NBPGR Newsletter.* **7**(1): 10-11

Porterfield, W. M. 1933. Bamboo, the universal provider. *Scient. Mon., N.Y. Feb.*: 176-83

Prasad, R. N. and S. Kochhar. 1986. Standardization of technology for bamboo preservation and cultivation in NEH Region. NEC Seminar on bamboos and canes. Nov. 27-28. 13p.

Ramanuja Rao, I. V., R. Gnanharan and C. B. Shastry (Eds.). 1990. Bamboos : Current Research. Proc. Intl. workshop on bamboos. Cochin, India. Nov. 14 - 18, 1988. KFRI, Peechi and IDRC. 382 p.

Ramyarangsi, S. 1990. Techniques for seed storge of *Thyrsostachys siamensis* In : Proc. Intl. Bamboo workshop, Cochin, India. Nov. 14-18, 1988. Ramanuja Rao *et al.*, (Eds.) KFRI, Peechi and IDRC. pp. 133-35.

Rana, R. S. 1992. Indian National Plant Genetic Resources System. In : Plant Genetic Resources Documentation and Information Management. Rana *et al.* (Eds.) NBPGR, New Delhi. p. 1-16

Sharma, O. P. 1986. Mass propagation of Dendrocalamus hamiltionii Munro - A critical evaluation. *Indian For.* **112** : 517-23

Singh, N.B. 1986. Genetic improvement of economic species of bamboos in Arunachal Pradesh : Selection of plus bamboos and establishment of gene bank. NEC seminar on bamboos and canes, Shillong. Nov. 27-28. 9 p.

Soderstrom,Thomas, R. and C.E. Calderon.1979. A commentary on the bamboos (Poaceae:Bambusoideae). *Biotropica* **11** (3): 161-72.

Surendran, T., C. S. Venkatesh and K. K. Seethalaxmi. 1983. Vegetative propagation of thorny bamboo Bambusa arundinacea (Retz.) willd. using some growth regulators. *J. Tree sci.* **2** (1 & 2) : 10-15.

Thomas, T. A., R. K. Arora and Ranbir Singh. 1990. Genetic wealth of bamboos in India and their conservation strategies. In : Proc. Intl. workshop on Bamboos. Cochin, India, Nov. 14-18, 1988. Ramanuja Rao *et al.*(Eds.) KFRI, Peechi and IDRC. p. 29-31.

Tomar, M. S. 1974. Some aspects of Bamboo Inventory. *Indian For.* **100** (9) : 552-558

Vermah, J. C. and K. N. Bahadur. 1980. Conutry report and status of bamboo research in India. *Ind. Forest. Rec.* (New series. Bot.) **6** (1) : 1-28+vii