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BAMBOO GERMPLASM RESOURCES IN INDIA — DOCUMENTATION AND CONSERVATION

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Around 126 species of bamboos are reported to occur in India. Northeastern India (16 genera, 58 species) shows highest variability followed by Penninsular India (8 genera, 24 species), western 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 occurrence of various bamboo genera

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

Table 2 : Commercially exploited species of bamboo in India

Sr.No.	Species	Occurance
1.	<i>Bambusa arundinacea</i>	Throughout India upto 1250m
2.	<i>B. balcoa</i>	Eastern U.P., Bihar, Bengal, Assam and Arunachal Pradesh with 600m
3.	<i>B. nutans</i>	Sub Himalayan tracts U.P. to Arunachal Pradesh, 600-1500m
4.	<i>B. tulda</i>	Widely cultivated in plains and foot hills of N India, wild in E. India.
5.	<i>Dendrocalamus hamiltonii</i>	West, central and east india in lower hills, upto 900m
6.	<i>D. strictus</i>	Commonly cultivated throughout India in plains & foothills. In deciduous forests all over India except North East and west Coast.
7.	<i>Melocanna baccifera</i> syn. <i>M. bamboosoides</i>	Bengal, Assam, Meghalaya, Tripura, Mizoram and other parts of E. India in plains and lower hills.
8.	<i>Ochlandra ebracteata</i>	Trivandrum, Kerala
9.	<i>O. scriptoria</i>	West coast, Malabar at low elavation.
10.	<i>O. travancorica</i>	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 northeastern 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 northeastern 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/northeastern region whereas a few others like *Ochlandra* and *Oxytenanthera* are localized in their distribution to the Deccan plateau/ southern India. The western 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 (No. of Species)
		Genera	Species	
1.	East and North-East India	16	58	<i>Arundinaria</i> (9), <i>Bambusa</i> (12), <i>Cephalostachyum</i> (5), <i>Chimonobambusa</i> (6), <i>Dendrocalamus</i> (7), <i>Dinorchloa</i> (2), <i>Gigantochloa</i> (2), <i>Melocanna</i> (1), <i>Nohouzeana</i> (2), <i>Oxytenanthera</i> (2), <i>Phyllostachys</i> (2), <i>Pseudostachyum</i> (1), <i>Semiarundinaria</i> (1), <i>Sinobambusa</i> (1), <i>Teinostachyum</i> (1), <i>Thamnocalamus</i> (4).
2.	Westren Himalayas including foothills	5	14	<i>Bambusa</i> (4), <i>Chimonobambusa</i> (2), <i>Dendrocalamus</i> (4), <i>Phyllostachys</i> (2), <i>Thamnocalamus</i> (2).
3.	Indo-gangetic plains	4	8	<i>Bambusa</i> (4), <i>Cephalostachyum</i> (1), <i>Dendrocalamus</i> (2), <i>Oxytenanthera</i> (1).
4.	Penninsular India	8	24	<i>Bambusa</i> (3), <i>Cephalostachyum</i> (1), <i>Chimonobambusa</i> (1), <i>Dendrocalamus</i> (1), <i>Indocalamus</i> (3), <i>Ochlandra</i> (9)
5.	Andaman and Nicobar Island	6	7	<i>Bambusa</i> (2), <i>Cephalostachyum</i> (1), <i>Dendrocalamus</i> (1), <i>Dinorchloa</i> (1), <i>Oxytenanthera</i> (1), <i>Schyzostachyum</i> (1)

Table 4 : Diversity of bamboos available in North East India

Sr. No.	Number of		References
	Genera	Species	
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 Research 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 (Vermah 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 bamboo sets. 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 northeastern states and maintaining a live collection under All India Coordinated Project on Underutilized and Underexploited Plants, which is one of the active collaborators of IN-PGRS, at Arunachal Pradesh Centre, Basar, under ICAR Research Complex for NEH region (Thomas *et al.*, 1990, Rana, 1992). Prevalent diversity of bamboos in the peninsular India was proposed to be conserved at NBPGR Trichur centre. The work was carried out at Basar beginning 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 subsequently added. Representative 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/ northeastern 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 strengthen 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
<i>Arundinaria hirsuta</i>	I	N	Y	N
<i>Arundinaria manii</i>	I	N	Y	N
<i>Bambusa arundinacea</i>	I	Y	Y	T
<i>Bambusa curiculata</i>	I	Y	N	N
<i>Bambusa balcoa</i>	I	Y	Y	Y
<i>Bambusa burmanica</i>	E	Y	N	Y
<i>Bambusa copelandii</i>	E	Y	N	N
<i>Bambusa nana</i>	E	Y	Y	Y
syn. <i>B. glauscens</i>				
<i>Bambusa multiplex</i>	E	Y	Y	Y
syn. <i>B. glauscens</i>				
<i>Bambusa longispiculata</i>	I	Y	N	N
<i>Bambusa nutans</i>	I	Y	Y	Y
<i>Bambusa oliveriana</i>	E	Y	N	N
<i>Bambusa pallida</i>	I	Y	Y	Y
<i>Bambusa polymorpha</i>	I	Y	Y	Y
<i>Bambusa spinosa</i>	I	Y	N	N
<i>Bambusa tulda</i>	I	Y	Y	Y
<i>Bambusa ventricosa</i>	E	Y	N	N
<i>Bambusa vulgaris</i>	E	Y	Y	Y

(Table 5 continues)

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

(Table 5 continues)

1	2	3	4	5
syn. <i>M. bambusoides</i>				
<i>Neohouzeana</i>	I	Y	N	N
syn. <i>Teinostachyum dullooa</i>				
<i>Oxytenanthera albociliata</i>	E	Y	N	Y
<i>Oxytenanthera abyssinica</i>	E	Y	N	Y
<i>Oxytenanthera nigrociliata</i>	I	Y	N	N
<i>Phyllostachys aurea</i>	E	Y	N	N
<i>Phyllostachys assamica</i>	I	N	Y	Y
<i>Phyllostachys manii</i>	I	N	Y	N
<i>Pseudostachyum polymorphum</i>	I	N	Y	N
<i>Teinostachyum helferii</i>	I	N	Y	N
<i>Pseudosassa japonica</i>	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 approach 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
<i>Bambusa burmanica</i>	Myanmar
<i>Bambusa copelandii</i>	Myanmar
<i>Bambusa nana</i>	China/Japan
syn. <i>B. glauscens</i>	
<i>Bambusa multiplex</i>	China/Japan
syn. <i>B. glauscens</i>	
<i>Bambusa oliveriana</i>	Myanmar
<i>Bambusa ventricosa</i>	China/Japan
<i>Bambusa vulgaris</i>	Pantropical (Origin unknown)
<i>Bambusa vulgaris</i> var. <i>stricta</i>	Pantropical
<i>Dendrocalamus brandisii</i>	Myanmar
<i>Dendrocalamus calostachys</i>	Myanmar
<i>Dendrocalamus collettianus</i>	Myanmar
<i>Dendrocalamus giganteus</i>	Malaya and Myanmar
<i>Dendrocalamus membranaceus</i>	Myanmar
<i>Gigantochloa alter</i>	Malaya
<i>Gigantochloa alter</i> (Black mutant)	Malaya
<i>Guada angustifolia</i>	Tropical America
<i>Melocana humilis</i>	Myanmar
<i>Oxytenanthera albociliata</i>	Myanmar
<i>Oxytenanthera abyssinica</i>	Sudan/Africa (parts of)
<i>Phyllostachys aurea</i>	Japan
<i>Phyllostachys bambusoides</i>	China/Japan
<i>Phyllostachys puberula</i>	Japan
<i>Pseudosassa japonica</i>	Japan
syn. <i>Arundinaria japonica</i>	
<i>Schizostachyum brachcladum</i>	Malaya
<i>Thyrsostachys oliverii</i>	Myanmar
<i>Thyrsostachys siamensis</i>	Myanmar

within-species diversity on the pattern of NAC sites of IN-PGRS (NBPGR, 1991). It may be clearly pointed out that such germplasm 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 Forestry Research and Education and Forest Research Institute. The first gene sanctuary 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 sanctuaries made operational in the country, Nokrek (Meghalaya), Manas (Assam), Nilgiri (Karnataka, Kerala and Tamil Nadu) and Great Nicobar (Andaman 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 micropropagation and *in vitro* conservation. The tissue culture technique 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 multiplication 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.

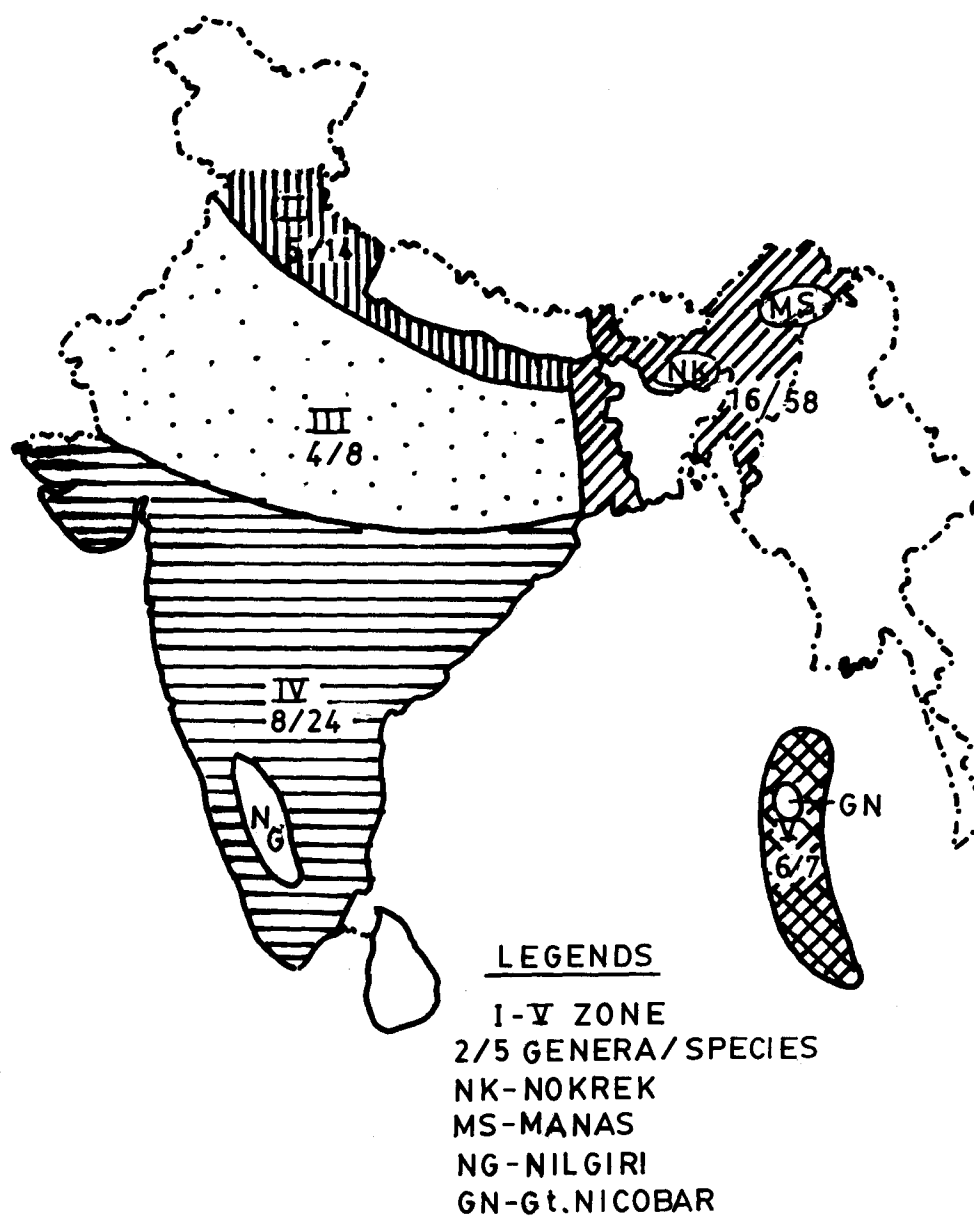


Fig. 1. Bamboo diversity in different agro-ecological zones and proposed gene sancturies

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 levels 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 seedlings. Such observations/ parameters 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. glaucescens*).

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 remote areas where sophisticated laboratory facilities are lacking. However, tissue culture 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 subsequent 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 utility 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.

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COLLECTING COTTON GERMPLASM FROM TRIPURA AND MEGHALAYA

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Seventy six germplasm samples of cotton were collected from tribal areas of Tripura state and west Garo hills in Meghalaya during December, 1993. Sixty one samples (55 white linted and 6 brown linted types) with long, medium and small bolls represented diversity in annual diploid cotton (*Gossypium arboreum* L.) from *Jhums* and exhibited great variability in boll weight, boll length, seed number/loculus/boll, ginning out-turn, seed index and lint index and resistance to biotic and abiotic stresses. Fifteen samples, 8 in kidney cottons (*G. barbadense* var. *brasiliense*) with fused naked seeds and 7 in other type with separate seeds, represented diversity in perennial allotetraploid cotton (*Gossypium barbadense* L.) from valley and plain areas. Some of the accessions having extra long boll (15 cm) with high retentivity, high boll weight (6.0 g), high seed numbers/loculus (20) seeds per boll (59), high ginning out-turn (55%), high lint index and field resistance to jassids and bollworms were found to be most useful genetic resources to be exploited directly and indirectly in cotton improvement programme. The brown linted types are rarely seen.

Key words : Cotton, *Gossypium* sp., variability, diversity

North-eastern hill region in India is considered to be the important centre of *Gossypium* variability wherefrom races *cernuum*, *sinense* and *bengalense* are supposed to have been derived from *Gossypium arboreum* race *burmanicum* (Paranjpe and Panigrahi, 1961). The *cernuum* cottons are highly suitable for upholstery, high absorbant cotton and mixing with wood and have a great export potential. These cottons have also been reported to be good donors for high boll weight, high ginning out-turn, high seed number per loculus and per boll and resistance to jassids and bollworms (Duhoon and Singh, 1980; Duhoon, 1981). Perennial kidney cottons belonging to *G. barbadense* var. *brasiliense* have also been reported to occur in this region. The annual cottons from this region have been utilized in the breeding programme and are conserved in the National Gene Bank. Cotton cultivation in *jhums* is going down due to lack of improved varieties and organized markets, the worst affected being the khaki cottons which are now rarely available. Consequently these valuable genetic resources are diminishing continuously. Therefore, the

present exploration was undertaken to collect and study the local variability in annual diploid cotton (*Gossypium arboreum* L.) and perennial tetraploid cotton *G. barbadense* var. *brasiliense* in parts of Tripura and Meghalaya.

REGIONS SURVEYED AND SAMPLING STRATEGIES

The materials consisted of randomly drawn 76 samples of seed cotton representing annual (*Gossypium arboreum* L.) and perennial (*G. barbadense* L.) cottons. The samples were collected from 69 sites (Fig. 1) in two distinct habitats. Fifty four sites were surveyed in *jhums* on hill slopes and 15 sites in valleys and plains in North Tripura, West Tripura and South Tripura districts of Tripura state and West Garo Hills district of Meghalaya. The explored areas lie between 23° to 26° latitude and 90°5' to 92°5' longitude. The altitude varies from 150 to 2000 m above msl. The population samples of annual cotton were collected from *jhums* on hills and single boll per plant from 20-25 random plants (as per availability) was picked up to represent diversity and to study variability within and between populations. The samples of perennial tree cotton were collected from homesteads/courtyards/backyards in plains and 15-20 bolls from single or 2 trees per site (as per availability) were picked up to represent a sample. The passport data were recorded alongwith specific features of each sample. The observations on useful post harvest traits like boll weight, number of seeds per loculus and per boll, locule length, fibre length, ginning out-turn, seed index and lint index were recorded on each sample.

DIVERSITY PATTERN

North-eastern hill region, comprising states of Assam, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya, is very important for diversity in many crops including cotton. Tripura, and Garo hills in Meghalaya are the specific areas where different races of annual diploid cotton (*Gossypium arboreum*) are supposed to have originated. The species-wise variability for important traits is presented in Table 1.

The *Gossypium arboreum* cottons are grown in *jhums*, a method of shifting cultivation practised by the tribals in NEH region in India, on hill ranges varying in height from 330 to 2000 m above msl. These cottons popularly known as Jhum Kapas are grown as a mixed crop with paddy, sesame, chillies, okra, sunhemp and cucurbits under rainfed conditions, without any plant protection and fertilizer application. Sixty one samples representing white and brown lint types were collected. The white coloured types, represented by 55 samples are more common and known to the trade as Comilla cottons or Garo hill cottons. The Comillas are the only cotton of commercial importance in NEH region and called as dollar earner. Apart from the small quantities utilized for domestic uses in filling and mixing wool, the bulk of the produce

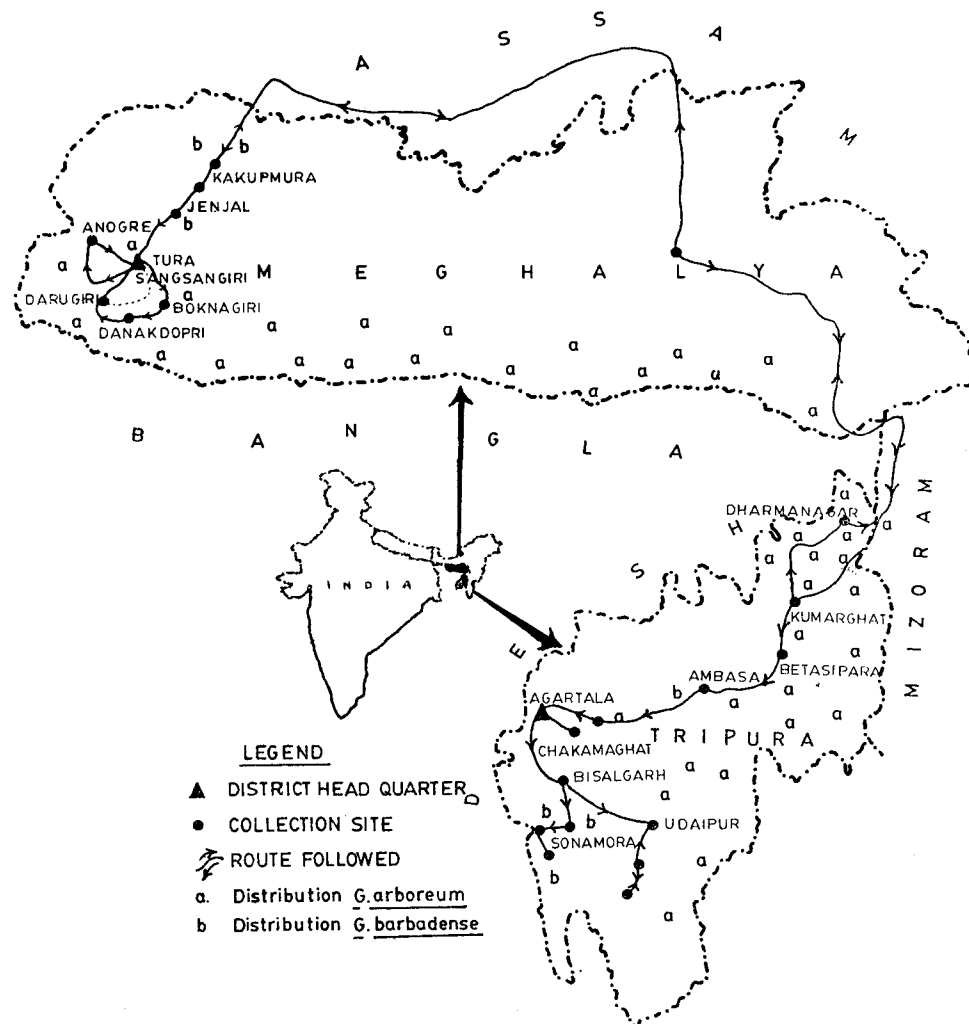


Fig. 1. Route map for cotton germplasm collection in Tripura and Meghalaya

Table 1 : Range of variability for important traits in cotton samples from Tripura and Meghalaya

Characteristics	Species	
	<i>Gossypium arboreum</i> L.	<i>Gossypium barbadense</i> L.
Ploidy	Diploid	Allotetraploid
Popular name	<i>Jhum</i> cotton	Tree cotton
Trade name(s)	(a) Comilla cotton (White coloured) (b) Chittagong cotton (Brown coloured)	
Nature	Annual	Perennial
Crop duration (days)	180-210	350-365
Plant height (cm)	70-145	200-600
Bolls/Plant	2-8	25-1500
Boll weight (g)	3.0-6.0	2.0-3.5
Seeds/locule	12-20	5-7
Seeds/boll	35-69	16-21
Ginning out-turn (%)	38-55	20-25
Fibre length (mm)	13-19	20-25
Seed index (g)	3.5-4.5	6.5-8.0
Lint index	2.8-3.5	—
Loculus length (cm)	5.0-15.0	2.5-3.5

is exported at a price equivalent to superior long staple cottons. Of the 55 white coloured *G. arboreum* samples, 32 represented diversity in long boll types belonging to *G. arboreum* race *cernuum*, 5 in small boll types belonging to race *burmanicum* as suggested by Silov (1944). The remaining 18 intermediates may be introgressed types.

The brown types, represented by six samples are rarely available due to their continuous discrimination by the trade. These cottons, in general, are known as **Manipur Khaki** and to the trade as Chittagong cotton. The cotton populations with narrow lobed leaves and sympodial branching habit exhibited a wide range of variability for plant height (70 to 145 cm), fluffy open bolls

with high retentivity and loculus length (5 to 15 cm), high boll weight (3 to 6 g/boll), number of seeds per loculus (12 to 20), number of seeds per boll (37 to 59), fibre length (13 to 19 mm), small fuzzy seeds with read index from 3.4 to 4.5g, linit index from 2.8 to 3.5, high ginning out-turn from 38 to 55 per cent, lint colour (White, light to dark brown) and fuzz colour (greenish, brownish and grey). The results with similar trends in variability were reported earlier also (Singh *et al.*, 1988).

The perennial allotetraploid cottons (*Gossypium barbadense*) got entry into India in 1790 from Brazil and Peru alongwith another perennial cotton "Bourbon" representing *G. hirsutum* race *punctatum* introduced by East India Company (Singh, 1984). Since then these cottons got established in the analogous climatic conditions in valley and plain areas of north eastern hill region. Normally 1-3 trees are grown in backyard homesteads for domestic consumption. The plants grow upto 5-6 m in height and continue to yield cotton upto 7-8 years. Pruning is done for convenience in harvesting cotton. Fifteen samples of 2 distinct types were collected from backyards in west Tripura around Sonamura. Of these, 7 represented kidney cottons (*Gossypium barbadense* race *brasiliense*) with a characteristic feature of fused seeds forming a typical kidney shaped structure. The fibres are developed only on the other surface of the kidney

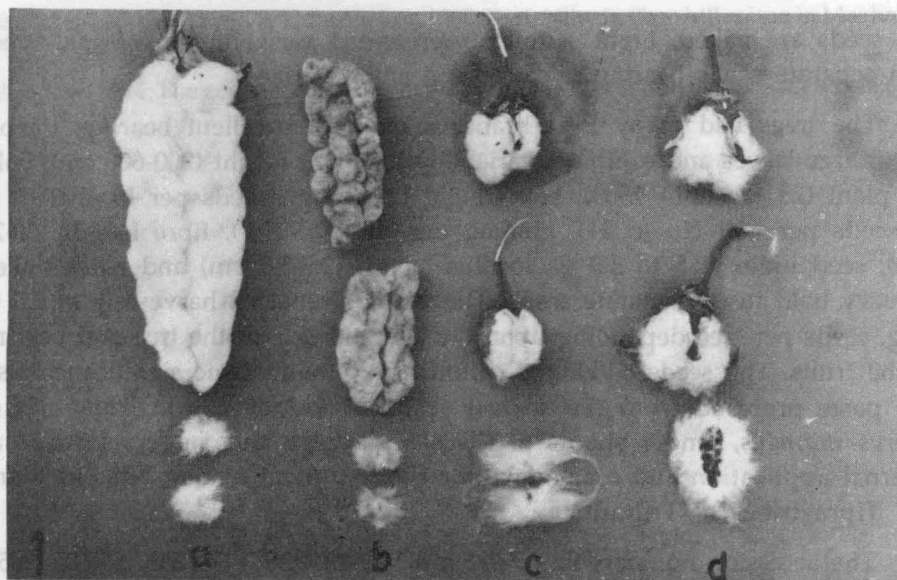


Plate I. Variability in boll size, shape, fibre length and colour in cotton from Tripura and Garo hills

(a) Long boll type Garo Hill Cotton (*G. arboreum* race *cernuum*)

(b) Medium boll brown coloured Khaki cotton (*G. arboreum* L.)

(c) Perennial tree cotton (*G. barbadense*)

(d) Perennial kidney cotton (*G. barbadense* var. *brasiliense*)

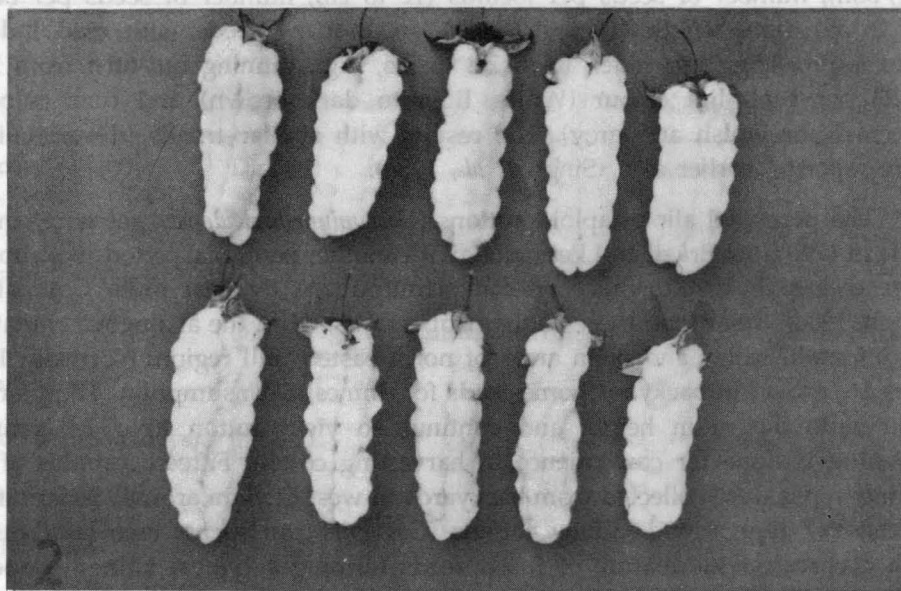


Plate II. Exploitable variability in *Cernuum* cottons from Garo hills

and seeds are naked. Eight samples represented variability in normal types with separate seeds bearing fibres on the entire surface.

The trees had many long branches, poor to excellent bearing, deeply lobed large leaves and exhibited variability for plant height (200-600 cm), bolls per plant (25 to about 1500), boll weight (2.0-3.5 g), seeds per loculus (5 to 7), seeds per boll (16 to 21), ginning out-turn (20-25%), fibre length (20-25 mm), seed index (6.5 to 8.0 g), loculus length (2.5-3.5 cm) and black naked to fuzzy bold fused/separate seeds. The farmers reported harvesting of 0.5 to 6 kg. seeds per tree depending upon the age and size of the tree and bearing of the fruits. The seeds of kidney cotton have ethnobotanic significance also. The paste prepared from the soaked seeds of kidney cotton, rhizomes of *Cyprus rotundus*, tender shoots of *Cynodon dactylon* and jaggery is used as external application and oral intake for the treatment of dog bites in Rieng and Tipra tribes of Tripura.

The accession numbers SD-17-2859, SD-17-2897, SD-17-2856, SD-17-2854, SD-17-2838, SD-17-2846 and SD-17-2849 with white lint and SD-17-2820 and SD-17-2808 with brown lint, belonging to race *cernuum* of *G. arboreum* by virtue of their high seed number per locule 18-20 seed, per boll (57-59), high boll weight (6.0 g), high ginning out-turn (54-55%), high boll retentivity and field resistance to major pests and diseases like jassids, bollworms and black

arm are the most valuable genetic resources having great potential for direct and/or indirect exploitation in cotton improvement programme. The coloured cottons with desired resistance to pests and diseases have the additional advantage of avoiding the use of inorganic dyes.

In addition to the above collected materials, a lot of exploitable variability still exists particularly in the inaccessible remote areas in this region which is the seat of diversification of *G. arboreum*. Therefore, intensive surveys involving the state organizations are required to be conducted to capture this important gene pool for posterity. A part of the collected samples had been deposited in the National Gene Bank at NBPGR for long term storage and another part sent of CICR, Nagpur for characterization, evaluation and utilization.

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COLLECTING GENETIC DIVERSITY OF AONLA (*PHYLLANTHUS EMBLICA* L.) GERMPLASM FROM UTTAR PRADESH

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Thirty three genotypes of aonla, identified during the exploration conducted in eastern part of Uttar Pradesh, exhibited wide range of variability in plant characteristics, morphological and chemical composition of the fruits and yield potentiality. Variability was also observed in fruit colour, juiciness, content of tannin and fibre in pulp. High significant correlation was observed between fruit length and fruit diameter with average fruit weight. Whereas, negative and significant correlation was observed between acidity with fruit length, fruit diameter and average fruit weight which is a desirable characteristic. The most notable genotype selected was a seedling tree in the village Deojani Ka Purwa in Pratapgarh district (MR/RD-89-9) bearing bigger size fruit of attractive colour. In vegetatively propagated elite variety Banarasi, few superior clones (MR/RD-89-9), MR/RD-89-30 and MR/RD-89-32) were identified to be most promising and ideal for adoption directly on the basis of profuse bearing and better fruit quality with colour.

Key words : Aonla, diversity, germplasm, augment, evaluate, promising genotypes

The aonla, known as Indian gooseberry (*Phyllanthus emblica* L.) is said to be indigenous to tropical South East Asia, particularly to central and south India (Firminger, 1947). It is one of the most important minor fruit crops of commercial significance, grown without much care (Bajpai and Shukla, 1985). It is highly nutritious having medicinal value and one of the richest sources of vitamin C. Commercial orcharding exists in Gujarat and Uttar Pradesh (Chundawat, 1990). However, rich diversity occur throughout the country including eastern Uttar Pradesh due to propagation by seed. It has been observed that seedling propagated tree has longer life and also less susceptibility to diseases. Only a few genotypes/landraces viz., 'Banarasi', 'Chakiya' and 'Francis', all seedling selections are popular and are under cultivation (Bajpai and Shukla, 1985; Chundawat, 1990). Several factors including deforestation and natural calamities pose great threat to its survival. Therefore, there is an urgent need to identify the germplasm, augment and to evaluate to select

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suitable types for direct use, donor types for improvement and to conserve for future use.

REGIONS SURVEYED AND SAMPLING STRATEGIES

An exploration was undertaken jointly by NBPGR and NDUAT, Faizabad during December, 1989. The area surveyed included Faizabad, Pratapgarh, Allahabad, Mirzapur and Varanasi district of U.P. lying between 81°0' to 82°5'E longitude and 23°5' - 27°0' N latitude. The exploration was undertaken when fruits were physiologically mature. Random as well as biased sampling (Sinha, 1981) to collect a particular genotype/landrace was followed. The Horticulture department and progressive orchardist were contacted in each district to collect first hand information (Arora, 1981) about the diversity of crop and accordingly route for exploration was followed. Ten fruits were randomly collected and qualitative and quantitative observations were recorded. The vitamin C and acidity were also analysed. Variability parameters were estimated for seven characters and correlation coefficient were computed.

EXTENT OF DIVERSITY

Thirty three genotypes of aonla identified during the exploration, showed wide range of variability in fruit morphological characteristics including vitamin C, tanin and fibre content in the pulp (Table 1 & 2). Among these, 14 genotypes are located in Pratapgarh, 3 in Allahabad, 7 in Mirzapur, 1 in Varanasi and 8 in Faizabad districts of Uttar Pradesh. Aonla cultivation is concentrated in Pratapgarh district, because of its semi-arid climate and deep sandy loam soil, rich in calcium which is suitable for its cultivation. In Allahabad, Varanasi, and Mirzapur districts, less number of orchards were observed. Most of the old plantations are of seedling origin and establish considerable variability as in shape, size, quality of fruits including vitamin C, tanin and fibre content in the pulp. It was also observed that seedling trees were less susceptible to disease and had also longer life. Less necrosis problem was noticed in the orchards having proper spacing and fruits receiving proper sunlight. Dense planting had serious problem of necrosis. Among the widely grown genotypes (**Banarasi**, **Chakiya** and **Francis**), **Chakiya** was observed to be more tolerant to disease and pest and physiological problems. However, **Banarasi** was widely acceptable genotype due to attractive colour, bigger fruit size and its suitability for various preparations including sweets (*Morabba*).

The range, mean and variance of 33 genotypes for 7 characters are presented in Table 2. The range of fruit length varied from 2.31 cm (MR/RD-89-7) to 4.10 cm (MR/RD-89-9); diameter from 2.60 cm (MR/RD-89-28) to 4.85 cm (MR/RD-89-17); number of segment per fruit from 6.0 (number of genotypes) to 8.0 (MR/RD-89-17); percentage of TSS in juice from 10.0 (MR/RD-89-1) to

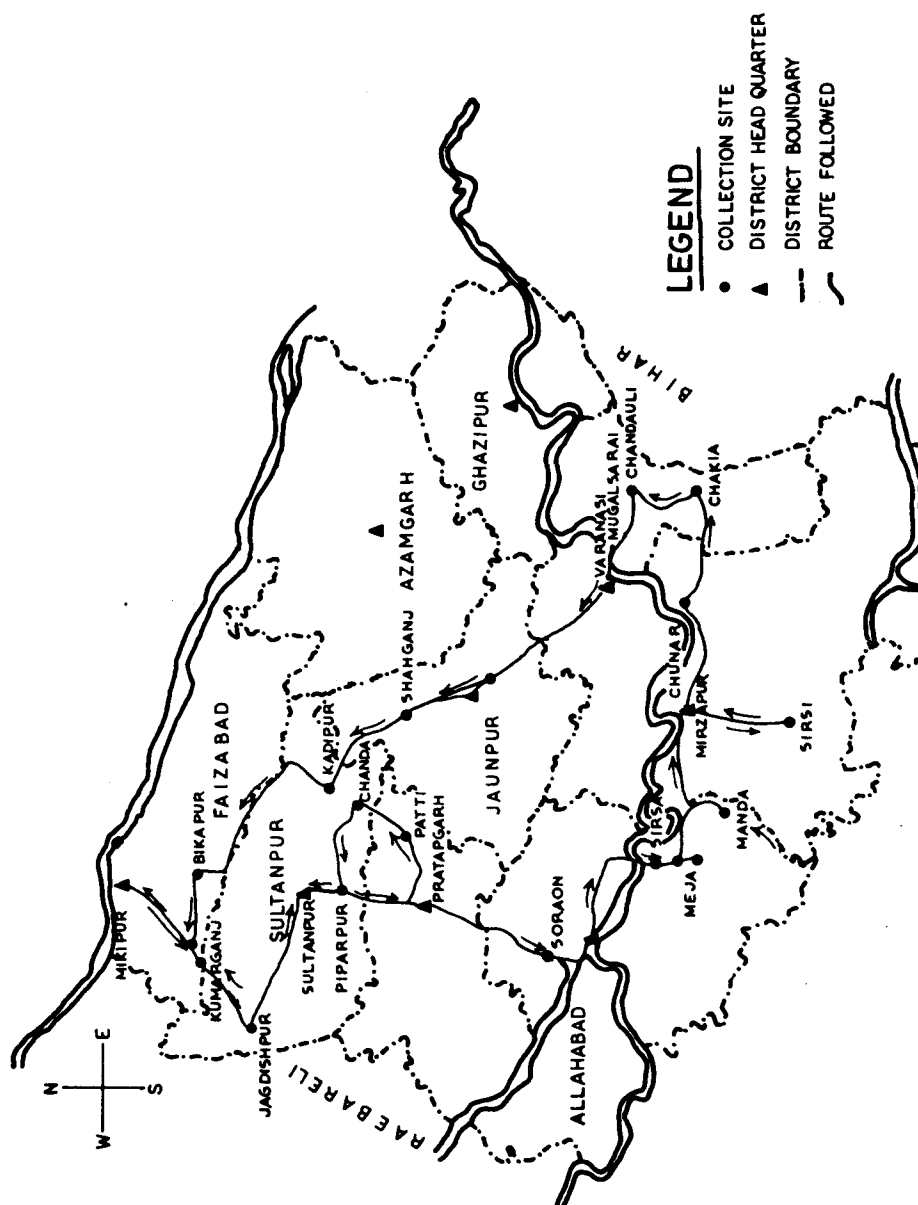


Fig. 1. Exploration and identification of *Phyllanthus emblica* germplasm in eastern Uttar Pradesh

Table 1 : Fruit characteristics of identified aonla germplasm

Collector's No. (MR/RD-89-)	Shape	Colour	Apex	Cavity	Ridges	Fruit stalk	Juiciness	Tanin content	Fibre content
1	R	YG	R	D	P	Thin	M	M	M
2	R	YG	R	D	P	Thin	M	M	M
3	FR	YG	F	VD	P	Thin	H	L	L
4	FR	LG	A	D	LP	Thin	M	M	M
5	R	LG	R	D	LP	Thin	M	M	L
6	R	LG	R	D	HP	Thin	H	M	M
7	R	LG	R	D	LP	Thin	M	H	M
8	R	WG	A	S	P	Thin	L	H	H
9	R	GY	R	S	P	Medium	H	L	L
10	R	YG	D	S	P	Medium	H	M	L
11	FR	Y	A	S	P	Thin	H	L	L
12	FR	YG	R	D	P	Thin	H	M	L
13	R	YG	R	D	P	Thin	H	M	L
14	R	YG	A	S	P	Thin.	H	M	L
15	FR	YG	R	S	LP	Medium	M	M	L
16	O	YGR	A	S	P	Medium	L	H	H
17	FR	YRT	A	S	P	Thick	H	L	L
22	FR	LG	R	S	P	Thin	H	M	L
23	R	WG	R	S	LP	Thin	L	H	H
28	R	YG	R	S	LP	Thick	L	H	H
30	FR	YG	R	D	P	Thick	M	M	M
31	R	LG	R	VD	P	Thick	M	M	M
32	FR	GY	R	VD	P	Medium	H	L	L
33	FR	YG	R	VD	P	Medium	H	L	M
34	FR	YG	R	VD	P	Medium	H	L	M
48	R	YG	A	VD	LP	Thin	H	M	L
49	R	YG	A	VD	LP	Thin	H	M	L
50	R	YG	A	VD	LP	Thin	H	M	L
51	R	YG	A	VD	P	Thin	H	M	L
52	R	YG	R	VD	P	Thin	H	M	L
53	R	YG	R	VD	P	Thin	H	M	L
54	R	YG	R	S	P	Medium	H	M	L
55	R	YG	R	VD	P	Medium	H	L	L

Where : F = flat, A = angular, D = deep, Vd = very deep, S = shallow, P = prominent, LP = less prominent, HP = highly prominent, R = round, FR = flattened round, O = oval, YG = yellowish green, LG = light green, Wg = whitish green, Y = yellow, YRGT = yellowish green with red ting, GY = golden yellow, YRT = yellow with red tings, L = less, M = medium, H = high.

15.50 (MR/RD-89-7); percentage of acidity from 1.30 (MR/RD-89-13) to 1.96 (MR/RD-89-28); content of vitamin C (mg/g) from 3.55 (MR/RD-89-3) to 9.40 (MR/RD-89-32) and average fruit weight from 12.3 g (MR/RD-89-7) to 52.6 g (MR/RD-89-30). Mean values and estimates of phenotypic variances were high for vitamin C content, average fruit weight, and T S S. Variability was also observed in fruit colour (light green, greenish, whitish, yellow, golden yellow, yellow with red tinge), shape (round, oblong, oval, oval with conical apex, round with depressed apex), base cavity (shallow, deep and very deep), ridges on fruit surface (less prominent, prominent and highly prominent), and content of juice, fibre and tanin in pulp (less, medium and high).

Table 2 : Values, range, mean and variances for seven characteristics of aonla germplasm

Collector's No.(MR/RD-89)	Fruit length (Cm)	Fruit diameter (Cm.)	No of segment	TSS (%)	Acidity (%)	Vitamin C (mg/g)	Average fruit weight (g)
1	3.75	4.06	6.0	10.0	1.53	5.80	38.0
2	3.25	3.90	6.0	12.5	1.46	4.70	30.1
3	3.65	4.40	7.2	14.0	1.33	3.55	43.0
4	3.80	4.17	6.0	14.0	1.92	5.30	40.0
5	3.32	3.90	6.0	14.0	1.67	5.20	31.3
6	3.86	4.54	6.0	14.5	1.62	6.25	42.7
7	2.31	2.86	6.0	15.5	1.90	4.80	12.3
8	2.87	3.05	6.0	13.5	1.83	6.00	17.0
9	4.10	4.81	6.0	10.5	1.64	6.55	51.0
10	3.77	3.42	6.0	13.0	1.79	4.35	41.3
11	3.85	4.75	6.6	14.5	1.60	6.80	41.2
12	3.82	4.10	6.0	10.5	1.49	4.90	41.3
13	3.30	3.75	6.0	13.0	1.30	4.70	29.1
14	3.70	4.05	6.0	12.0	1.33	4.80	39.2
15	3.75	4.80	6.0	14.5	1.40	5.10	35.6
16	2.80	3.10	6.0	12.5	1.90	4.90	21.2
17	3.70	4.85	8.0	14.5	1.68	7.14	50.0
22	3.70	4.68	6.0	14.0	1.49	6.10	36.8
23	2.70	2.95	6.0	14.0	1.90	5.90	16.4
28	2.50	2.60	6.0	13.5	1.95	6.10	12.3
30	3.93	4.83	6.0	14.0	1.85	5.83	52.6
31	3.40	3.60	6.6	13.0	1.60	4.50	35.2
32	3.76	4.46	6.0	13.0	1.79	9.40	45.0

(Table 2. *contd.*)

33	3.71	4.40	6.0	14.0	1.40	5.17	41.2
34	3.75	4.40	6.0	14.0	1.35	7.50	40.0
48	3.58	3.90	6.0	14.0	1.46	7.17	31.0
49	3.46	3.75	6.0	12.0	1.45	4.88	26.3
50	3.78	4.06	6.0	12.0	1.70	5.15	31.1
51	3.45	3.98	6.0	11.0	1.60	4.75	31.4
52	3.68	4.50	6.0	11.5	1.45	5.20	41.7
53	3.23	3.80	6.0	13.0	1.60	5.40	24.7
54	3.61	3.76	6.0	13.5	1.60	4.27	28.0
55	3.92	4.62	6.0	14.0	1.40	6.50	44.0
Range	2.31	2.60	6.0	10.0	1.30	3.55	12.3
	4.10	4.85	8.0	15.50	1.95	9.40	52.6
Mean	3.51	4.02	6.15	13.14	1.61	5.51	34.64
SE±	±0.08	±0.11	±0.08	±3.85	±0.04	±2-.45	±2.40
Variance	0.19	0.39	0.19	489.66	0.04	138	03

In character association analysis (Table 3), some of the most important combinations showed positive and significant relationship such as fruit length, fruit diameter with average fruit weight. However, negative and significant correlation was recorded between acidity with fruit length, diameter and average weight which is desirable in the crop. The accessions having such combinations can be utilized directly as well as a donor parent to improve fruit size and its quality. The variability existing in the population can be exploited in selection programme.

Table 3 : Correlation coefficient for 7 characters of aonla germplasm

Characters	Fruit length (Cm)	Fruit diameter (Cm)	No. of Segments/ fruit	TSS Brix (%)	Acidity (%)	Vitamin C Content (mg/g)
Fruit diameter (cm)	0.875**	1.000				
Number of segment/fruit	0.108	0.245	1.000			
TSS (Brix) (%)	-0.226	-0.005	0.239	1.000		
Acidity (%)	-0.472**	-0.489**	-0.069	0.178	1.000	
Vitamin C content (mg/g)	0.092	0.215	0.062	0.327	0.125	1.000
Average fruit weight (g)	0.911**	0.884**	0.306	0.133	0.355*	0.143

**Significant at 1% level

PROMISING SELECTIONS

MR/RD-89-9 : It is a tree located in the village Deojani Ka Purwa in Pratapgarh district. The tree is semi spreading and bears round, attractive golden yellow fruits with fruit length of 4.1 cm, and diameter 4.8 cm and weight 51.0 g. The tree showed field tolerance to necrosis, a serious problem in aonla cultivation. Fruit has round apex, shallow cavity, prominent ridges, contains high amount of juice and less of tanin and fibre.

MR/RD-89-17 : It is a clonal selection from **Banarasi** variety located in Allahabad district. The tree is about 80 years of age and of spreading habit. It bears flattened round fruits having angular apex, shallow cavity, prominent ridges and golden yellow with red tinge on surface. It is highly juicy with less tanin and fibre content. It has 8 segments and average weight of 50 g and contain high vitamin C (7.14 mg/g).

MR/RD-89-30 : The tree has semi spreading and tall growth habit. It has profuse bearing of large sized fruits (52.6g), with fruit length 3.9 cm, diameter 4.8 cm, number of segment 6, and good amount of vitamin C (5.83 mg/g). The fruits are greenish yellow, round apex, deep cavity, prominent ridges and contains high juice and less amount of tanin and fibre.

MR/RD-89-32 : It is a clonal selection from Varanasi variety having profuse bearing. The tree is semi spreading and tall. It bear flattened round, greenish yellow fruits having round apex, very deep cavity, prominent ridges, highly juicy and less amount of tanin and fibre. The fruit is 3.76 cm long, 4.46 cm in diameter, 6 segments, 45.0 g in weight with low acidity (1.79%) and high amount of vitamin C (9.4 mg/g).

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EVALUATION AND CLASSIFICATION OF URID BEAN (*VIGNA MUNGO* L.) GERMPLASM

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The evaluation and characterisation of germplasm gives considerable data to classify the material. The classification as multivariate basis rather than univariate is desirable. An attempt was made to classify 216 accessions of uridbean germplasm by cluster analysis. It gave convenient grouping of 12 clusters with like genotypes within clusters for different traits. The implications of classificatory approach have been discussed.

Key words : *Vigna mungo*, evaluation/characterisation, multivariate analysis

Urid bean (*Vigna mungo* L.) is one of the important pulse crop with its centre of diversity located in India. A thrust on its collection and evaluation is urgently needed to obtain donor parents for genetic restructuring of genotypes towards resistance to diseases, insects and abiotic stresses. Very often, in germplasm collection, many accessions are duplicate and it becomes difficult to exploit germplasm till it is aptly classified. Multivariate classification with the help of ordination methods like principal component analysis is useful tool for clustering of genotypes. The representative types from each cluster thus obtained can be earmarked for different breeding objectives. The present studies on 216 accessions were initiated to classify them through this approach.

MATERIALS AND METHODS

The experimental material for this study comprised 216 germplasm accessions having landraces, primitive cultivars and current cultivated varieties. The experiment was sown in *khari*, 1990 at Pantnagar, in the foothills of Himalayan range, under subtropical climate. All accessions were evaluated in augmented design with three intermittent checks namely Pant U-19, Pant U-30 and Pant U-35, after every 10 rows. Each plot consisted of one row of 4 m length. Various observations on quantitative and visual traits were taken but only quantitative traits were subjected to statistical analysis. The observations on pod length, plant height, 1000 seed weight, number of pods per plant and

yield per plant were analysed to get adjusted means by methods described by Federer and Raghav Rao (1975) and Peterson (1985).

The value of genotypic means were adjusted for block effects on the basis of replicated check plots in every block. The number of blocks were determined by relationship

$$b > \left[\frac{10}{c-1} + 1 \right]$$

so as to get atleast 10 degree of freedom for error expectations. Thus 24 blocks were used having 3 checks and 216 test accessions. The adjustment factors (r_j) were computed as under :

$$r_j = (1/c) (B_j - M)$$

where c = number of checks; B_j = j th Block having checks c ; M = grand mean

Thus, the r_j is equivalent to mean of the j th block subtraction grand mean. By subtracting these adjustment factors from observed mean, the table of adjusted means were obtained. These quantitative variable means were analysed for Principal components in the form of a multivariate matrix (S),

$$\text{where } S = (X_{ij})$$

i.e., a $n \times n$ symmetric semi-definite with some eigen values say r as +ve and $1 - r$ as zero was obtained which gave eigen values and eigen vectors of matrix S . The principal components of this eigen matrix were enumerated by taking the defined new variable as linear combination of x_i variables or a line was found in a space of x on which the projections of the data units were dispersed maximally. The first principal component would be represented by this line with largest variance of any linear combination of variables in the data matrix. Similarly, $r = 5$ number of principal components with orthogonality to previous components were obtained.

These components were utilized for grouping of genotypes as described by Beale (1969) and elaborated by Spark (1973). The basic assumption followed was that the euclidian distances ' D ' separating ' n ' points in a ' p ' dimensional space are proportional to the dissimilarities between the accessions and secondly no object can belong simultaneously to two clusters. F-test was utilized for assigning appropriate number of clusters.

RESULTS AND DISCUSSIONS

The range for various characters showed wide differences in minimum and maximum values which are given in Table 1.

Table 1 : Range and checks mean of various quantitative characters in urid bean germplasm

	Pod length (cm)	Plant height (cm)	1000-seed wt. (g)	Pods per plant (no.)	Yield per plant (g)
Accessions range	3.2-5.9	19.4-33.1	17.37-70.70	3-89	2-26.0
Checks mean : PU-19	4.18	58.23	40.50	29.59	8.03
PU-30	4.30	69.27	43.04	24.84	8.88
PU-35	4.39	69.10	42.58	27.56	8.62
CV (%)	8.53	26.80	15.97	41.69	40.41

The range values indicate occurrence of wide variations for seed weight, pods per plant as well as yields, suggesting an optimistic picture for further improvement in urid bean for these traits. Variability can be incorporated in other characters by wide hybridization among distant accessions.

The classificatory procedures for earmarking distant genotypes have been emphasized by number of scientists (Griffing and Lindstrom, 1954; Moll *et al.*, 1962, Arunachalam, 1981). The D^2 statistics has been used by several workers in different crops including black gram but the limitations of this technique have also been pointed by Arunachalam (1981). The classificatory approaches like principal components and clustering of genotypes to overcome the limitations of D^2 have been advocated by Beal (1969). In the present study, all the variables were converted to single index of similarity in the form of principal component. The eigen vectors, roots and associated variance have been given in Table 2. The maximum variation of 38.15 per cent was explained by first latent vector followed by second vector (25.09%). Thus around 60 per cent variation was explained by first two vectors and rest by other three.

Table 2 : Eigen vectors, eigen roots and associated variance for different components in urid bean germplasm

Characters	Eigen vectors				
	1	2	3	4	5
Pod length (cm)	0.28	0.28	0.61	0.39	0.54
Plant height (cm)	-0.24	0.62	-0.13	0.56	-0.45
1000-seed weight (g)	0.22	-0.67	0.01	0.65	-0.25
Pods per plant	-0.13	-0.003	-0.69	0.30	0.64
Yield per plant	-0.88	-0.25	0.35	0.87	0.14
Eigen roots	1.90	1.25	0.92	0.63	0.28
Variation (%)	38.15	25.09	18.47	12.62	5.64

The cluster analysis grouped 216 accessions into 12 different non-overlapping clusters. The appropriate cluster arrangement as determined by F-test revealed that the 12 clusters were most suited. The average inter and intra cluster distances are presented in Table 3 and depicted in Fig. 1. The cluster 6 and 11 were found at a maximum diverse ends. Cluster 6 with smallest number of genotypes (5) is also exclusive because of the genotypes with high values for number of pods per plant and yield per plant (Fig. 2).

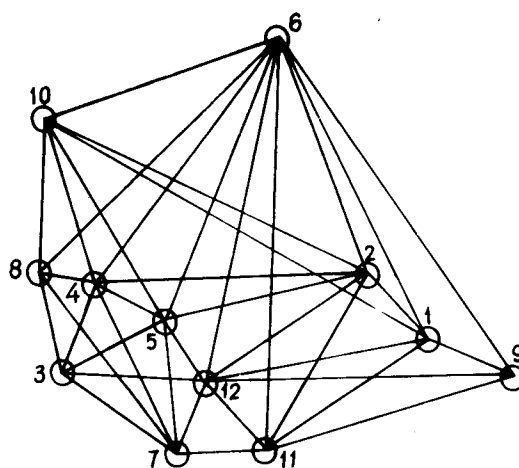


Fig. 1. Cluster diagram showing relative inter cluster distances among germplasm lines

These 12 clusters can be further grouped into four distantly related groups based on their inter- cluster distances. The biggest group consisted of 7 clusters (3, 4, 5, 7, 8, 11, 12), the next bigger group had 3 clusters (1, 2, 9) and the rest had one cluster each. This representation reflects the relative divergence of clusters and allows a convenient selection of group of genotypes with their overall phenotypic similarity for any hybridization programme facilitating better exploitation of germplasm. Although such classificatory studies are not reported in uridbean but similar studies have been done, (Negassa 1986; Ahlawat, 1987; Guo and Zhang, 1989) etc. in various other crops.

The relative superiority of different clusters for various characters is represented in the form of bar diagram (Fig. 2) which would help convenient selection of genotypes from particular clusters. The list of such possible donors has been given in Table 4 which indicate that a number of promising parents can be selected for further improvement work.

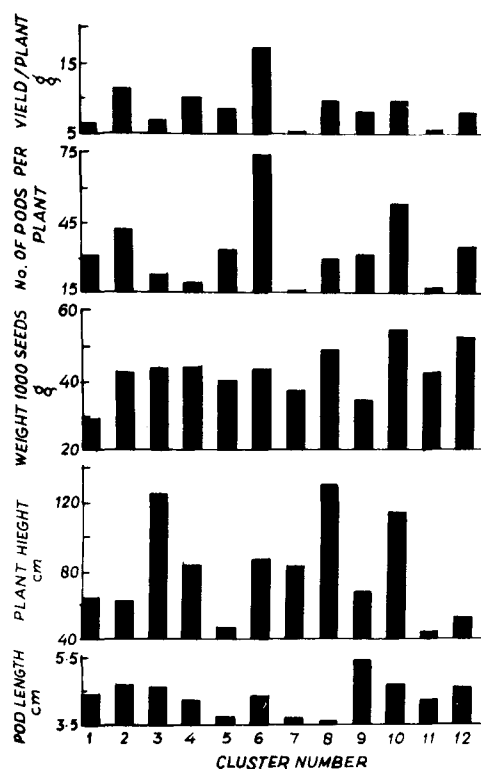


Fig. 2. Cluster mean for different characters

Table 3 : Average inter and intra cluster distances in urid bean germplasm

Clu ster. No.	1	2	3	4	5	6	7	8	9	10	11	12
1.	(1.441)											
2.	2.072	(1.435)										
3.	2.393	2.526	(1.461)									
4.	2.788	1.980	2.201	(1.493)								
5.	2.162	1.986	2.894	2.341	(1.238)							
6.	3.820	2.760	4.361	4.176	3.356	(2.630)						
7.	1.938	2.833	2.151	2.304	1.794	4.465	(1.238)					
8.	3.027	3.012	2.253	2.555	2.368	3.670	1.917	(1.596)				
9.	2.175	2.216	2.631	2.980	3.587	4.517	3.522	4.283	(1.319)			
10.	3.367	2.885	2.528	3.754	3.145	3.378	3.539	2.960	3.795	(1.612)		
11.	2.173	2.221	2.328	1.934	1.785	4.627	1.861	3.093	2.776	3.450	(1.233)	
12.	2.859	2.029	2.449	2.542	2.175	4.038	2.905	3.289	2.992	2.337	1.652	(1.346)

Values in parentheses show intra cluster distances

Table 4 : Potential genetic donors for different characters in urid bean germplasm

Character	Cluster number	Genotype
Grain yield per plant (g)	6	U-14/4, PLU 1064, U-3411, PLU-29, PLU-166
1000-seed weight (g)	10	PLU-573, GPU-74, U-12/12, PLU-517, U-1317, HPU-110, HPU-119
Plant height (cm)	8	PLU-640, U-12/1A, PLU-360, PLU-577 HPU-156, PLU-393, KH-1, IC-24814,
Pod length (cm)	9	PLU-317, PH-32, UPU-107, PLU-764, PLU-129, HPU-192-8, PLU-53, U-10008, IC-15790, PLU-260

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CONSERVATION AND UTILIZATION OF INDIAN MEDICINAL PLANTS*

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The demand for plant-based raw-material, used pre-dominantly in Indian System of Medicine (ISM) has grown enormously in recent years. The over-exploitation by the manufacturing sector of several native medicinal plants are in danger of extinction. The 'Red Data Book of India' has adequately recorded such plants. By citing a few examples, the author has discussed the extent of threat, and the need to conserve variability for current and future use. The variants occurring in protected habitats like 'National Parks' needs to be collected/evaluated and documented.

Key words : Indian medicinal plant, conservation, utilization, extinction/threat

India is known for its rich heritage of medicinal plants. The classical treatise on Ayurvedic medicine of pre-Christian era namely, Charak, Sushruta and Bagbhatta described use of 1100, 1270 and 1150 medicinal plants, respectively in drug formulations. This diversity occurs in diverse habitats. Many of these are endemic exhibiting variability in the form of morphotypes, ecotypes and chemotypes existing amongst the populations. The variability in such economically important species is an insurance for continuing research for productivity upgradation. At present, there is a growing awareness and rising demand for plant-based drugs as their products have milder action over body functions with little or no side effects. It is estimated that about forty species currently provide raw materials for all pharmacopoeia based products in modern medicine and has, in turn, a total sale of 50 million US dollars annually; seventy per cent of these plant-based raw materials come from sub-tropical and tropical parts of the world.

The rising demand in the organised manufacturing sector has ruthlessly exploited wild growing plant populations of species which have bulk demand. Obviously, a number of these plants have become rare, endangered or are on the verge of extinction. In this context, the loss of valuable genetic diversity

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in the species is much greater because the frequency of populations decline continuously in the original habitats of the species. At present, a number of large Drug Houses and multinational companies in the country are making plant based formulations which have rendered several species scarce in distribution (Gupta 1988). To site some examples, Sandoz Laboratories and Unichem Laboratories at Bombay are producing patented drugs under the name "Ashoka Cordial" and "Liquid Menorin", respectively based on wood of *Saraca asoka*. The Bengal Chemicals and Pharmaceutical Works uses a large quantity of *Andrographis paniculata* in their preparation, patented under the name of "Kalmegh compound" and CIPLA Laboratories produce 'Guggal lippids' based on gum resin of *Commiphora wrightii*. None of these companies have captive plantations of any species and hence the entire demand of raw materials is met through collections of wild growing populations affecting in turn, distribution, regeneration and productivity in the forests.

The Indian system of Medicine (ISM) which pre-dominantly utilizes plant-based raw materials has an equally large organized consumer sector. It has 6,000 licensed manufacturing units producing drugs for an estimated value of about Rs. 8 billion annually, and 15 prescribed by about 4,00,000 registered medical practitioners. This demand is not only large but is also growing at a faster rate. Many of these plants in bulk demand have a wider gap between their demand and supply in the absence of cultivation. This situation needs redressal through production management of these raw materials in the forests or their introduction as commercial crops.

PERCEPTION OF THREAT

The literature on medicinal plants in India provides evidence of antiquity and early use, before the settled agriculture commenced, in this part of the world. The ancient Aryans (4,000 B.C.) used "Som plant" to make energising and restorative drink which also possessed property of bestowing endurance and longevity. Little is known about the original composition of this famous drink because the plant species had been extensively exploited during those periods. Similarly, the '*Lakshmana booti*' of Ramayan period is now lost in mystery. There is continuing loss of several valuable plants used in classical formulations where their substitutes are currently used.

Amongst these plants, it may be noted that use of multi- ingredient based classical drugs in trade has increased manifold. This could be judged from the production figures of large number of firms manufacturing products like *Astavarga*, *Dashmool*, *Chyavanprasa*, *Triphala*, *Arogyavardhani*, *Nirdrodya rasa*, *Ajeevada Kantaka rasa*, *Smritisagar rasa* etc. The eight roots which form ingredient of *Astavarga* drug are *Jeevaka* (*Microstylis nucifera*), *Rsabhak* (*Microstylis wallichii*), *Kankoli* (*Roscorea procera*), *Kshira-Kankoli* (*Ros-*

corea alpina), **Meda** (*Polygonatum verticillatum*), **Maha-meda** (*Polygonatum cirricifolium*), **Riddhi**, (*Hebenaria acuminata*) and **Vridhi** (*Hebenaria intermedia*) which are now extremely rare in distribution. The drug manufacturers largely depend on Bagbhatt's direction (c.f. in Astanga Hridayam Samhita) authorising use of alternate source when the original plant prescribed in the text is not available. Thus, **Bidari-Kand** (*Pueraria tuberosa*) is used at present for **Jeevaka**, **Asgandh** (*Withania somnifera*) for **Kankoli**, **Kali musli** (*Curculigo orchoides*) for **Kshira-kankoli** and **Taradi** (*Dioscorea bulbifera*) for **Meda** and **Maha-meda** roots in the **Astavarga** drug. Even some of these substitutes are now in short supply. The same is the case of five tree-based roots (out of ten roots) prescribed as ingredient for manufacture of **Dashmool** drug; the other five belong to annual/perennial herbs and are relatively easily available.

Literature on these plants is adequately dealt with in the Red Data book of India and Threatened plants in Indian flora (Jain and Sastry, 1979; Nayar and Sastry, 1987). Similarly, there are several publications on distribution, utilization, conservation, documentation and their introduction into cultivation (Gupta, 1977; Gupta and Sethi, 1983). Based on these reports and demand analysis, the medicinal plants under excessive pressure in forestry sector are **safed musli** (*Chlorophytum arundinaceum*, *C. borivillianum*), **Chirayata** (*Swertia chirata*), **Ateesa** (*Aconitum heterophyllum*), **Ban-kakri** (*Podophyllum hexandrum*), **Kutaki** (*Gentiana kurroo*, *Picrorhiza kurroo*), **Puskhar mool** (*Inula racemosa*), **Jal-brahmi** (*Bacopa monniera*), **Guggal** (*Commiphora wrightii*), **Gudmar** (*Gymnema sylvestre*), **Bidarikand** (*Puraria tuberosa*), **Salampanja** (*Orchis latifolia*), **Sankhpushpi** (*Convolvulus pleuricaulis*), **Vishnukranta** (*Evolvulus alsinoides*), **Dhoop** (*Jurinia macrocephala*), **Gaozban** (*Anchuria strigosa*), **Resha khatuni** (*Lavatoria kashmeriana*), **Jeevaka** (*Microstylis nucifera*), **Kankoli** (*Roscorea procera*), **Kshira kankoli** (*Lilium polyphyllum*), **Meda** (*Polygonatum verticillatum*), **maha-meda** (*Polygonatum cirricifolium*), **Ridhi** (*Hebenaria acuminata*), **Vridhi** (*Habenaria intermedia*), **Rasna** (*Pluchia lanceolata*), **Vatsanabha** (*Aconitum chasmanthus*), **Sarpangandha** (*Rauvolfia serpentina*), **Discorea** (*D. deltoidea*, *D. prazeri*), **Anantmool** (*Tylophora indica*), **Sariva** (*Hemidesmus indicus*), **Somvalli** (*Ephedra gerardiana*), **Bharangi** (*Clerodendron serratum*), **Jatamansi** (*Nardostachys jatamansi*), **Gajpipali** (*Piper cubeba*) etc. These species demand protection of habitats and support for regeneration, growth, seed production and dispersal to improve their populations in the forest both as a conservation effort as well as to improve productivity of each herb growing there.

UTILIZATION

A large part of variability in medicinal plants is the result of intra-species and inter-species natural crossing between populations growing in different ecological conditions. The broad array of natural genepool thus exists in the

forests with differences in form, structure, composition and chemical content which provide base material to be utilized in agriculture through selection where desired characters are genetically fixed in a cultigen. In nature, the genetic variability also occur at different ploidy levels accompanying genetic separation due to in-built preference of each for growing in different geographical regions. Sweet Flag (*Acorus calamus*) provides an interesting example where diploid. ($2n = 24$), triploid ($2n = 36$) and tetraploid ($2n = 48$) forms occur in different regions in nature. These forms have shown varying composition in oil of root and rhizomes having distinct aroma characteristics and other properties. Thus, the oil of roots of the diploid has a fine odour; it inhabit temperate parts and the oil is used to impart warm and spicy note in liquors, particularly vermouth in Europe. The oil of root of triploid and tetraploid forms have high β -asarone content (9-18%), which have been reported to cause cancer in rats and hence are forbidden for use in food products. It is now found that β -asarone causes sterility in several species of house fly, fruit fly and related other pests and as such have a role in control of crop pests. Similarly, fruits, of *Vicoea indica* found in Tamil Nadu has vicolide-B (a sesquiterpenoid lactone) which has anti- fertility property whereas this compound is absent in plant population found in neighbouring states in the country. Srivastava *et al.* (1990) have reported high percentage of physiologically active terpenic alkaloids in seed oil of *Jyotismati* (*Celastrus paniculatus*) collected from Vindhyan hills; but these constituents are in lower quantity in plants collected from central Himalayan region of Uttar Pradesh, the traditional home of the species in India. The seeds of *Jyotismati* is widely used as a nervine tonic in Ayurvedic medicine.

The utilization of variability in plant genetic resources is best illustrated from recent Indian work on genus *Cymbopogon* and *Ocimum*. The genetic studies on lemon grass (*Cymbopogon flexuosus*) have shown heritability of economically important traits like oil content and citral to be 9.6 and 20.5 per cent, respectively. This oil is used in imparting specific lemon like odour to soap and detergents; its citral is used to produce β -ionone, which in turn is utilized in synthesis of vitamin-A. A selection from germplasm has yielded cv. OD-19 which produces high herbage and oil yields and is grown as a rainfed crop in Kerala. A further selection from germplasm assembly has brought forward OD-448 (red stemmed) and OD 408 (white stemmed) cultures, which gave higher yield of oil over the OD-19, used as control. Its allied species *C. pendulus* is a source of a new variety 'Praman' which produces higher citral content in the oil. A cross between *C. khasianum* $\times$ *C. pendulus* has produced a new variety "CKP-28" which produces still higher citral (82-85%) content in the oil; this culture is recommended for growing over rich fertile irrigated lands in north India. Similarly, in palmarosa grass (*Cymbopogon martini* var. *motia*), a selection IW-31245 has been identified for producing high overall

herbage and oil yield. A second culture 'Trishna' is developed as a synthetic by polycross breeding of four inbred parental lines at Lucknow and is claimed to produce 40 per cent higher oil yield. Further, a cross between *C. nardus* var. *confertiflorus* x *C. jwarancusa* has yielded a new variety "Jam-rosa" which produces high geraniol (80-83%) and geranyl acetate (17-8%) content in the oil. This oil is the starting material for production of geraniol commercially in India.

In basil, the occurrence of euploidy in nature has played a major role in speciation. The oil of different species contain major aroma-compounds like eugenol, linalool, linalyl acetate, methyl chavicol, thymol, camphor etc which have commercial demand in food flavouring industry. In sacred basil (*O. Ocimum sanctum*), a selection from NBPGR produces 55 l/ha of oil in a growing period of 110-120 days under rainfed cultivation; this oil has high eugenol (53%) and caryophyllene (19%) content and is useful in manufacture of medical products for curing cough, throat infection and bronchial irritation. Another variety is 'Clo-Ocimum', developed through a cross between *O. gratissimum* *O. viride* at Jammu, it has 75 to 85 per cent eugenol in the oil. This oil has replaced clove oil as source of eugenol in industry. A yet another culture is now released as a result of selection and purification from West African material of *O. cannum* called "OC-11"; it contains 70-72 per cent linalool in the oil. These new varieties have placed India as a net exporter of the basil oils to the world market.

CONSERVATION

The Indian Forest Act of 1972 and its comprehensive revision provides guidelines on protection and management of medicinal plants in forests which fall under category of 'Minor Forest produce' (M.F.P.). Several states in India have specific M.F.P. Acts which regulates collection and export (to other state) of these raw materials. The Act facilitates notification of medicinal plants which may be allowed commercial collection by specifying forest areas and season of collection under renewable licence to be granted to an individual or a local cooperative society. However, much of this regulatory activities have got diffused at operational stage due to collection rights of local people, low protection of the forest in terms of guards, lack of trained manpower and non-availability of relevant illustrated literature for field staff.

There are forests which still possess large and sustainable populations of many commercially important medicinal plants from where collection is being done. It is proposed that the State Governments may carry out quick survey and identify rich Protected and Reserve Forests (ranges) which holds exploitably large multi-species communities of medicinal plants. These identified

forests should be managed as model resource base as sustainable producer of major medicinal and aromatic plants raw materials in the country. It is necessary to emphasise that conservation and utilization are two inseparable components of forest management. The increased availability of these scarce materials in the market shall act as a deterrent to out-of season collection from protected forests. An efficient system for medicinal plant resource management should be developed as a part of regular work of States Silviculture Research Division which may be supported with the establishment of a small monitoring cell in office of Chief Conservator of Forests of each state. This will enable net working for investment of all those forests placed under management for production of these raw materials in the forestry sector in states and allow taking up developmental schemes by the Ministry of Environment and Forests in these selected forests for raw materials.

India has established a large number of National Parks and Protected forest habitats in all ecological regions in the country. These protected habitats provide excellent opportunities of studying growth, regeneration, ecological preferences, species association, chemical content, composition and bearing behaviour of endangered medicinal plants. This information would eventually be utilized both for *in situ* regeneration of the species as well as for commercial cultivation as part agro-forestry system. This work should receive allocation of resources by Ministry of Environment and Forests, ICAR, DST, CSIR etc. and operated at different Universities to students to choose these as topic of their postgraduate and doctorate dissertation. The Union Ministry of Agriculture (Horticulture Division) has sanctioned funds to establish sixteen Medicinal Plant Gardens in State Agricultural Universities and Research institutes all over the country. These gardens will collect existing plant diversity in about 100 economically important medicinal plants and 35 endangered species in their respective regions and raise it in these Gardens as *ex-situ* conservancies. These Herbal Gardens will serve as agencies to produce and supply sample seed of plant genetic resources on one hand and bring out educational material and hold short-term training programmes for students, foresters and growers.

Department of Biotechnology, Government of India has established three National Gene Banks for Medicinal Plants with long term storage facility (modules) installed at Lucknow, Thiruvananthapuram and Delhi. These Gene banks will provide facility to place all plant genetic resource variability with documented information on important characters. Medicinal plants conservation is a complex process, where utilization of material is due to its unique chemical composition. The material fetches higher price due to desired chemical content of the produce. The Gene bank, therefore, should be supported with a detailed programme of collection, systematic evaluation, documentation and development of retrieval system involving several multi-disciplinary institutions to

enable retrieval and use of these genetic stocks in developing new cultures for growing in farm and plantation industry.

Changing scenario at global level

The pharmaceutical industry is consistently bringing out new and more potent medicinal plants in use. In fact, several old sources of remedies have lost their value in industry but others, hitherto unknown in industry, have emerged in the world market. Thus, *Ephedra gerardiana* and *Artemisia maritima* have gone out from world Pharmacopoeias. *Rauvolfia* roots have lost market in industry because a better source of ajmalicine and reserpine is found in roots of *Catharanthus roseus*. Again, the demand of quinine, quinidine and cephaline have declined drastically due to arrival of synthetics. At present, *Panax ginseng* root is an important medicinal plant raw materials and large quantities are imported in India annually. Related species *P. pseudoginseng* var. *himalaicus* is found in Subansari, Lohit and Kameng districts of Arunachal Pradesh. The root is found at par in quality. Another promising material is *Silybum marianum* where seed contains a hepato-protective drug for use in modern medicine. This species has been located at Baramulla (Kashmir) and Dehra Dun (U.P.). Similarly, etoposide is produced from roots of *Podophyllum pelatum* (Bristol Meyer) in U.S.A. Whereas an Indian ally *P. hexandrum* is found as equally potent for use as a drug. These examples highlight the potential of the germplasm resources in emerging high value drug plants which is likely to dominate the world pharmaceutical industry in near future. An efficient conservation and management of plant genetic resources of these taxa in India will provide material for raising new plantations in the country.

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GENETIC ARCHITECTURE OF NARCOTINE IN OPIUM POPPY (*PAPAVER SOMNIFERUM* L.)

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Genetic studies of narcotine based on additive-dominance model was carried out in opium poppy. A partial dominance to dominance was noticed. Partial dominance was coupled with duplicate epistasis with negative (j) and (i) while dominance was coupled with complementary epistasis and positive (j) and (i). Additive as well as dominance gene effect were both prevalent in the inheritance of narcotine. High heritability coupled with high genetic advance was noticed in both the crosses. Considering gene effects, the intermating among the segregants followed by the recurrent selection is recommended to isolate high narcotine genotypes.

Key words : Opium poppy, narcotine, heritability, genetic advance

Narcotine is one of the major alkaloid of opium poppy (*Papaver somniferum* L.), which is beneficial in allaying cough and headache. It may be useful in asthma, whooping cough and spasms of intestine, bile duct and urethra. For the improvement of narcotine, the knowledge of different gene actions is essential to formulate a proper breeding system. The genetics of narcotine is rarely known. However, Khanna and Shukla (1986) observed that the absence of narcotine was generally governed by dominant gene over its presence. Absence of narcotine (noscapsine) resulted in enhanced content of morphine alkaloids and that can be ascribed to a block in biosynthetic steps (Nyman and Hansoon, 1978). Considering the importance of narcotine, the present investigation was undertaken following additive-dominance model.

MATERIALS AND METHODS

Six generations, P_1 , P_2 , F_1 , F_2 , B_1 and B_2 of two crosses, viz., NBRI-1 $\times$ BR-222 (a) and NBRI-2 $\times$ BR-222 (b) were grown in RBD with three replications at NBRI, Lucknow during 1990-91. The row length was 3 meter with crop geometry 30 $\times$ 10 cm². The data on 5 plants for each parent and F_1 and 10 plants for each backcrosses and F_2 were recorded. The analysis of narcotine was done by HPLC (Khanna and Shukla, 1986). The weighted least square using the reciprocals of the squared errors of each mean as weight were used

for estimating 3 parameter $\hat{m}$, $\hat{d}$ and $\hat{h}$ from the generation means based on F_α matrix. An additive-dominance model ($\hat{m}, \hat{d}, \hat{h}$) non-epistatic and a model including epistatic interactions were applied to data (Hayman, 1958) and tested for goodness of fit using joint scaling test (Cavalli, 1952 Mather and Jinks, 1982). The joint scaling test uses chi-square test for adequacy of the model, by comparing observed and expected mean for adequacy of model at three degrees of freedom.

RESULTS AND DISCUSSION

The analysis of variance for narcotine was significant in both the crosses. The generation means and the estimates of genetic components based on the best fit model are given in Table 1. The mean value of narcotine in F_1 was observed tending towards the mid parental value in both the crosses. In F_2 mean values were lower than in F_1 though it was variable from 5.87 to 9.53, which showed high magnitude of F_2 variances. Similar trend was also noticed in B_1 population (Table 1). The low heterosis observed may have been caused by the absence of genes with dominance effect at most of the loci. Similarly, a low degree of inbreeding depression from F_1 to F_2 was also indicative of absence of loci with dominance effect. A partial dominance coupled with duplicate type of epistasis in cross NBRI-1 $\times$ BR-222 (a) and dominance coupled with complementary epistasis in cross NBRI-2 $\times$ BR-222 (b) were noticed. Duplicate epistasis in addition of negative ($\hat{j}$) and ($\hat{l}$) components make it difficult to select suitable genotypes in cross NBRI-1 $\times$ BR-222 (a) while complementary epistasis in addition of positive ($\hat{j}$) and ($\hat{l}$) indicates the possibility of transgressive segregants and thus makes it possible to select genotypes with high narcotine content in cross NBRI-2 $\times$ BR-222 (b).

Simple scaling test was not significant in both the crosses showing absence of epistatic interaction. This was further confirmed through χ^2 test. Additive gene effect was positively non-significant in both the crosses while dominance effect was negatively significant in NBRI-1 $\times$ BR-222(a) and positively significant in NBRI-1 $\times$ BR-222 (b) in 3 parameter model. Considering digenic interaction additive $\times$ additive ($\hat{i}$) was more prevalent in NBRI-1 $\times$ BR-222 (a) and additive $\times$ additive ($\hat{l}$) followed by dominance $\times$ dominance ($\hat{j}$) in NBRI-1 $\times$ BR-222 (b). The positive dominance effect of six parameter model in NBRI-1 $\times$ BR-222 (a) was, however, nullified by negative additive $\times$ dominance ($\hat{j}$) and dominance $\times$ dominance ($\hat{l}$) digenic interaction and duplicate type of epistasis. While the complementary epistasis with positive dominance ($\hat{l}$) followed by additive $\times$ additive ($\hat{i}$) and dominance $\times$ dominance ($\hat{l}$) interactions showed possibility of better segregants for high narcotine content. From overall genetic studies it was concluded that the narcotine is controlled by additive and dominance effect. Under the situation inter-mating among the segregants,

followed by recurrent selection is recommended to isolate suitable genotypes for high narcotine content. Further high heritability coupled with high genetic advance in both crosses emphasized that by sorting out 5 per cent of top population from segregating generations, desired selection response in desired direction can be obtained.

Table 1 : The generation means, variance and estimates of genetic components of opium poppy (*P. somniferum* L.)

Parameters	NBRI-1 x BR-222 (a)		NBRI-2 x BR-222 (b)	
	Mean $\pm$ S.E.	Variance	Mean $\pm$ S.E.	Variance
P ₁	8.99 $\pm$ 0.19	0.33	8.08 $\pm$ 0.09	0.08
P ₂	8.35 $\pm$ 0.27	0.65	8.87 $\pm$ 0.25	0.59
F ₁	7.60 $\pm$ 0.14	0.19	8.16 $\pm$ 0.14	0.18
F ₂	7.34 $\pm$ 0.34	1.05	7.21 $\pm$ 0.32	0.90
B ₁	7.74 $\pm$ 0.31	0.85	7.47 $\pm$ 0.27	0.68
B ₂	7.77 $\pm$ 0.27	0.67	7.72 $\pm$ 0.20	0.36
Simple Scaling Test				
$\bar{A}$	-1.11 $\pm$ 0.75		-1.30 $\pm$ 1.26	
$\bar{B}$	-0.41 $\pm$ 1.90		-1.59 $\pm$ 1.79	
$\bar{C}$	-3.18 $\pm$ 1.27		-4.43 $\pm$ 2.14	
Six parameter model (Hayman 1958)				
$\hat{m}$	7.34** $\pm$ 0.34		7.21** $\pm$ 0.32	
$\hat{d}$	-0.03 $\pm$ 0.84		-0.25 $\pm$ 0.66	
$\hat{h}$	0.59 $\pm$ 2.15		1.22 $\pm$ 2.17	
$\hat{i}$	1.66* $\pm$ 0.84		1.54* $\pm$ 0.76	
$\hat{j}$	-0.70 $\pm$ 1.99		0.29 $\pm$ 1.56	
$\hat{l}$	-0.14 $\pm$ 3.82		1.35 $\pm$ 3.75	
Type of epistasis	Duplicate		Complementary	
Three parameter model (Mather & Jinks 1982)				
$\hat{m}$	10.35 $\pm$ 0.37		8.29 $\pm$ 0.36	
$\hat{d}$	0.18 $\pm$ 0.30		0.26 $\pm$ 0.33	
$\hat{h}$	-5.47* $\pm$ 0.65		1.53* $\pm$ 0.71	
χ^2 (6-3)	4.69		4.82	
Δh	78.89		80.00	
GA	1.65		1.56	
GA%	20.70		19.70	

*Significance at 5% level; **Significance at 1% level

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EVALUATION OF *SACCHARUM SPONTANEUM* CLONES UNDER RAINFED CONDITIONS OF NORTH-WESTERN ZONE

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Fifteen clones of *S. spontaneum* were evaluated under normal and rainfed conditions to identify suitable genetic stocks. The clones exhibited no clone-environment interactions for stalk diameter, stalk length, juice extraction per cent and juice quality traits. Highest heritability values coupled with higher genetic correlation between two environments and near unity correlated response of stalk diameter and single stalk weight indicated their importance in selection. Three clones, viz., SES-222, SES- 275 and SES-352 showed similar performance in two environments in respect to stalk yield, single stalk weight, stalk diameter and juice extraction percentage and hence identified as the best parents for future utilization in breeding.

Key words : Genetic stocks, polymorphism, heritability, variance, correlation studies

Saccharum spontaneum, a wild form, is a highly polymorphic species growing in tropics and subtropics, 8°S to 40°N (Brandes *et al.* 1939). Plants vary in appearance from short bushy types with no stalk, to large stemmed clones over 5m in height. It survives under a range of temperatures from tropic heat to winter snow and is found from sea level upto 2700 m in the Himalayas (Mukherjee, 1950). In India, sugarcane is grown predominantly under deficient irrigation conditions or under rainfed situations. Hence, crop suffers from moisture stress at one or the other stages of its growth. The resistance to various stresses had been imparted to the present day commercial varieties from *S.spontaneum* clones but its sampling is just limited to a few clones in relation to great diversity available. The present study was undertaken to identify *S.spontaneum* clones suitable for rainfed conditions of north-western zone.

MATERIALS AND METHODS

The experimental material comprised 15 clones of *S.spontaneum* brought from the world germplasm collection maintained at Sugarcane Breeding Institute, Coimbatore. These clones were evaluated during autumn season 1991-92 in

Randomised block design with three replications in two experiments representing normal irrigated (N) and rainfed (RF) conditions. The rainfed experiment was irrigated only once after planting to ensure the germination. Two meter space was left around the rainfed experiment and was protected by bunds to avoid seepage of water. Data on nine characters were recorded at harvest. Standard statistical procedures were adopted to analyse the data. The correlated response (CR) of an attribute was computed as follows:

$$CR = \frac{r_A h_y^2}{h_x^2}$$

where

r_A : genotype correlation between two environments

h_y^2 : heritability in normal environment

h_x^2 : heritability in rainfed environment

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among clones for nine characters studied (Table 1). The differences were also significant between two environments, i.e. normal (N) and rainfed (RF), for all the traits excepting juice extraction percentage. The clones exhibited no clone-environment interactions for stalk diameter, stalk length, juice extraction percentage, sucrose percentage, brix percentage and purity percentage. Thus the reaction of individual clones to the environmental variation did not differ significantly from that of an average of all clones in the experiment. The clone - environment interactions were significant for stalk yield, number of millable stalks (NMS) and single stalk weight indicating differential response of clones in two environments for these three attributes.

Table 1 : Analysis of variance for nine characters in *Saccharum spontaneum*

Source of variance	D.F.	Mean square								
		Stalk yield	NMS	SSW	Stalk dia-meter	Stalk length	Juice extr-acti-on(%)	Sucr-ose (%)	Brix (%)	Purity (%)
Clones (C)	14	1191.2**	3645.0**	0.046**	0.432**	4778.9**	141.6**	4.77**	12.66**	257.9**
Environments (E)	1	11289.6**	14187.8**	0.119**	0.077**	113422.5**	34.5	8.14**	39.22**	1771.5**
C × E	14	407.2**	5100.4**	0.004**	0.011	402.3	22.6	1.17	1.67	60.9
Error	56	30.3	365.2	0.001	0.009	728.4	12.9	0.84	1.46	59.9

**Significant at P = 0.01

Single stalk weight (SSW) followed by stalk yield were the most variable characters (Table 2). The differences in genotypic coefficients of variation were not conspicuous in two environments for most of the characters. This indicated that *S.spontaneum* clones were able to express its genetic differences under both normal and rainfed environments. According to Mukherjee (1950) *S.spontaneum* is highly adaptable, as its clones are found under drought stress in deserts, water-logged conditions in marshes, and saline conditions near the sea.

The heritability values were the maximum for stalk diameter followed by SSW in both environments (Table 2). Heritability values were more under rainfed conditions for stalk yield, NMS, stalk length, sucrose percentage and purity percentage indicating the necessity for evaluating clones under rainfed conditions to select tolerant clones. Further, the efficient environment within which to select can also be judged by correlated response (CR) of various traits in rainfed environment. CR values of stalk yield, NMS, stalk length, sucrose percentage and purity percentage were less than unity, indicating that selection for these traits would be more effective in rainfed environment. Blum (1983) also emphasized the selection for yield and its components under stress environment whereas selection for stalk diameter, SSW, juice extraction percentage and brix percentage, where CR values were near unity, would be equally effective in both environments. Of these, stalk diameter and SSW were least influenced by the environment as indicated by their highest heritability values and hence should be useful as selection criteria.

Table 2 : Genotypic coefficients of variation (GCV), heritability in broad sense (h^2), genotypic correlation coefficients (r_A) and correlated response (CR) of nine characters

Character	GCV		h^2		r_A	CR
	N	RF	N(h^2Y)	RF (h^2x)		
Stalk yield	42.99	31.28	0.74	0.79	0.7976	0.7471
NMS	14.53	18.41	0.68	0.76	0.4815	0.4308
SSW	44.63	44.19	0.82	0.71	0.9574	1.1057
Stalk diameter	26.19	25.09	0.89	0.87	0.9707	0.9930
Stalk length	9.01	15.57	0.57	0.68	0.4998	0.6752
Juice extraction(%)	19.52	23.63	0.66	0.68	0.9378	0.9102
Sucrose(%)	24.88	26.61	0.65	0.69	0.5789	0.5453
Brix(%)	14.37	11.40	0.68	0.66	0.9818	1.0116
Purity (%)	20.57	24.83	0.54	0.60	0.6200	0.5580

N: Normal, RF : Rainfed

Table 3: Performance of *Saccharum spontaneum* clones for various quantitative traits under normal (N) and rainfed (RF) conditions

Clones	Stalk yield (t/ha)		NMS (000' /ha)		Single Stalk weight (kg)		Stalk diameter (cm)		Stalk length (cm)		Juice extraction (%)		Sucrose (%)		Brix (%)		Purity (%)	
	N	RF	N	RF	N	RF	N	RF	N	RF	N	RF	N	RF	N	RF	N	RF
SES-222	19.1	12.5 (65)	189	181 (96)	0.10	0.08 (80)	0.69	0.65 (94)	303*	233 (77)	19.8	19.6 (99)	3.48	2.97 (85)	10.27*	11.80 (115)	33.89*	25.07 (74)
SES-275	30.9	27.2 (88)	291*	247 (85)	0.11	0.09 (82)	0.62	0.63 (102)	308*	252 (82)	15.2	17.7 (116)	5.57*	4.16 (75)	13.97	15.25 (109)	40.30*	27.28 (68)
SES-352	29.4	21.3 (72)	247*	192 (78)	0.06	0.06 (100)	0.58	0.59 (102)	257*	220 (86)	19.3	16.7 (87)	2.40	1.90 (79)	11.50*	13.12 (114)	20.87	14.83 (71)
IND84-412	97.0*	65.1 (67)	284	270 (95)	0.35*	0.26 (74)	1.25	1.30 (104)	287*	228 (79)	26.4	27.7 (105)	4.16*	3.12 (75)	9.64	10.42 (108)	42.54*	29.86 (70)
IND84-409	101.4*	51.2 (50)	267	248 (93)	0.38*	0.25 (66)	1.33*	1.19 (89)	283*	200 (71)	29.9	26.6 (89)	5.89*	4.71 (80)	10.91	12.04 (110)	53.98*	38.80 (72)
SES-235	75.5*	46.0 (61)	342*	265 (77)	0.22*	0.17 (77)	1.11	1.13 (102)	262*	195 (74)	23.8	23.3 (98)	4.79	5.06 (106)	11.51*	12.96 (113)	41.45	42.64 (100)
SES-246	43.6*	32.8 (75)	342*	304 (89)	0.13*	0.08 (62)	0.93*	0.80 (86)	280*	215 (77)	15.8	17.0 (108)	5.45*	2.81 (52)	13.17	12.49 (95)	39.88*	22.28 (56)
SES-286	38.2*	22.3 (58)	328*	265 (81)	0.12	0.09 (75)	0.76	0.74 (97)	263*	187 (71)	22.8	16.7 (73)	3.43	3.20 (93)	12.27	12.23 (99)	27.90	32.96 (118)
IND84-404	87.2*	36.5 (42)	343*	238 (69)	0.26*	0.15 (58)	1.32*	1.19 (90)	220*	152 (69)	25.7	29.0 (113)	3.62	4.62 (128)	11.11	12.46 (112)	32.58	36.89 (113)

(Table 3. continues)

IND84-405	78.4*	38.2 (49)	328*	208 (63)	0.25*	0.19 (76)	1.25	1.21 (97)	240*	180 (75)	32.0	34.6 (108)	4.99*	3.90 (78)	10.04	10.91 (109)	49.70*	35.89 (72)
IND84-462	89.2*	40.9 (46)	243*	181 (74)	0.37*	0.25 (68)	1.29	1.30 (101)	270*	197 (73)	28.1*	22.5 (80)	3.59	2.81 (78)	9.58	10.87 (113)	37.47*	26.03 (69)
IND84-468	101.9*	44.5 (44)	325*	166 (51)	0.31*	0.27 (87)	1.27	1.23 (97)	295*	230 (78)	24.2	27.7 (114)	3.01	2.55 (85)	9.21	9.21 (100)	32.74	27.97 (85)
IND84-479	81.3*	24.7 (30)	331*	175 (53)	0.25*	0.14 (56)	1.18*	1.07 (91)	237*	148 (62)	26.4*	21.2 (80)	4.39	3.72 (85)	10.78*	12.36 (115)	40.78*	30.61 (75)
IND85-503	81.8*	32.6 (40)	277*	248 (89)	0.30*	0.14 (47)	1.19	1.20 (101)	250*	152 (61)	23.5	19.7 (83)	2.86	3.11 (109)	8.94	10.22 (114)	31.57	29.92 (95)
IND85-503	107.8*	43.4 (40)	341*	293 (86)	0.32*	0.16 (50)	1.37	1.29 (94)	262*	162 (62)	23.3	19.8 (85)	3.20	2.78 (87)	9.98*	11.14 (112)	32.06	24.72 (77)
Mean	69.9*	36.9 (53)	298*	262 (88)	0.23*	0.16 (70)	1.08*	1.03 (95)	268*	197 (74)	23.9	22.7 (95)	4.06*	3.43 (85)	10.86*	11.83 (109)	37.18*	29.21 (79)
LSD (5%)																		
Clones	9.16		21.62		0.36		0.107		30.54		4.08		1.037		1.367		8.75	
Environ- ment	3.35		7.90		0.013		0.039		11.15		NS		0.379		0.499		3.20	

NMS = Number of milleable stalks

*Significant differences under normal and rainfed environments at P = 0.05

Figures in parenthesis indicates the percentage of corresponding values under normal environment

The mean performance of clones differed significantly in two environments for all the traits excepting juice extraction percentage (Table 3). Comparing the performances under normal and rainfed conditions for various characters, the maximum reduction (47%) was observed in stalk yield followed by 30 per cent reduction in SSW. The reduction in stalk yield under rainfed was due to decrease in both of its main components, i.e. NMS and SSW. The decrease in SSW was mainly due to reduced stalk length under rainfed conditions. Stalk diameter and juice extraction percentage were varied least in two environments.

Among the quality traits, there was reduction in sucrose percentage and purity percentage in rainfed experiment whereas about 9 per cent improvement was observed in brix percentage. Higher brix at harvest (November) in the rainfed canes of *S.spontaneum* clones as compared with the irrigated ones appeared to result mainly from the delay in maturity of canes under rainfed conditions. Another factor which might have contributed towards higher brix percentage under rainfed conditions is the contribution of immature portion of the cane which had got high concentration of reducing sugars. As length of cane was reduced by 26 per cent, the contribution of immature portion of cane is expected to be relatively increased. However, other factors like changes in anatomy of canes at tissue and cellular level cannot be ruled out.

The clone IND84-412 was the best for stalk yield (65.1 t/ha) followed by IND84-409 (51.2 t/ha) and SES-235 (46 t/ha) under rainfed conditions (Table 3). But performance of all these clones differed significantly in two environments. Reduction in yield in rainfed environment in comparison to normal environment was the maximum in IND84-409 (49%) followed by SES-235 (39%) and IND 84-412 (33%).

Three clones, viz., SES-222, SES-275 and SES-352 showed statistically similar performances under two environments for stalk yield. Among these three clones, SES-275 and SES-352 were superior to SES-222. The performances of SES-275 and SES-352 were similar in both environments in respect to SSW, stalk diameter, juice extraction percentage and brix percentage and showed least reduction in stalk length in rainfed environment. The clone SES- 275 was significantly superior to SES-252 and SES-222 for juice quality attributes. Therefore, considering the synchronisation in flowering with proven parents, these clones may be utilized in future breeding programmes for developing clones suitable for rainfed or restricted irrigated conditions of north-western zone.

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SCREENING OF SUNFLOWER GERMPLASM ACCESSIONS FOR RESISTANCE TO ALTERNARIA LEAF SPOT

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Key words : Sunflower, germplasm, variability, alternaria leaf spot

Leaf spot of sunflower caused by *Alternaria helianthi* (Hansf.) Tubaki & Nishihara is a serious disease in India and under favourable conditions yield losses may go upto 80 per cent (Agrawath *et al.*, 1979; Balasubrahmanyam and Kolte, 1980). Though destructive levels of *Alternaria* leaf spot have been reported in India, no concerted efforts to screen systematically the available germplasm is made to locate field resistance (Morris *et al.*, 1983). However, significant genetic variability for *Alternaria* leaf spot has been reported in sunflower (Agrawath *et al.*, 1979; Nagaraju *et al.*, 1992a, 1992b). It is in this context, that further studies were carried out to screen the available sunflower germplasm and to determine and document the variability existing, if any, against this disease under field conditions.

One hundred and four sunflower germplasm accessions selected from the Germplasm Unit, GKVK, Bangalore were evaluated for *Alternaria* leaf spot under natural epiphytotic conditions in the *kharif* seasons of 1990 and 1991 alongwith the susceptible checks, Morden and L 101. The selected germplasm entries were seeded in third week of July during the tested season of 1990 and 1991 in a randomised complete block design with two replications. Each entry was grown in a single row of 3.0 m length with a spacing of 60 cms between rows and plants spaced 30 cms apart. *Alternaria* leaf spot severity was monitored in the field from germination and the final observations were recorded at 50 per cent grain filling stage of the crop. Disease severity was determined on the basis of visual rating as per cent area affected using 0-9 scale (Nagaraju *et al.*, 1992a and 1992b).

The occurrence of *Alternaria* leaf spot is the highest on sunflower during rainy season (*kharif*) under Bangalore conditions. The selected germplasm lines showed varied levels of resistance and none exhibited either immune or highly resistant reaction to this disease. Similar results were obtained in our earlier studies also (Nagaraju *et al.*, 1992a and 1992b). In the present studies, among the tested genotypes, the leaf spot severity ranged from 4.00 to 37.5 per cent during 1990 and 2.50 to 47.50 per cent in 1991 *kharif* season, whereas it was 32.50 per cent and more than 50.00 per cent on susceptible checks, Morden and L 101, respectively. Hence, keeping this in mind, we concentrated on the best lines among the available germplasm for further resistance development. The lines expressing less than 5.00 per cent leaf spot severity among the tested genotypes. The differential reactions, over years could probably be due to the difference in environmental conditions prevailing around the experimental area during the respective seasons. Most of the genotypes tested fell into moderately resistant to susceptible category. Similar types of results were obtained earlier when another set of 100 genotypes was tested (Nagaraju *et al.*, 1992a) during *kharif* 1988 and 1989.

The results indicated that a wide variability to *Alternaria* leaf spot exists in the germplasm collections and a few lines are highly promising against this disease. The lines showing resistant reaction in both the seasons namely, Accessions 708, 765, 810, 829, 860, 886, 889, 1040, 1050, 1052 and 1053 will be re-tested for further confirmation and subsequent utilization in crop improvement and disease management programmes.

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PLANT GENETIC RESOURCES WITH SPECIAL REFERENCE TO RICE VARIETIES OF MAJULI ISLAND

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Key words : Rice, germplasm, exploration, diversity

Majuli is the biggest freshwater island in the world located in Brahmaputra river in Jorhat District of Assam. It has an area of 1245 sq. kms. and lies between 93° 39' to 94° 50' E longitude and 26°40' to 27°10' N latitude (Fig.1). Out of a total geographical area of 12,4512 ha occupied by this island, 24.38 per cent is cultivable area and 0.2 per cent is under forest cover. The irrigated area is only 4 per cent. The island constitutes vast arable sandy area along the river banks cultivated by small and marginal farmers. A cropping intensity of 189 per cent is maintained and the cultivation of vegetable crops is discouraged due to poor communication with the main land. The present studies reports on the plant genetic resources of the island and its rich diversity in rice.

Exploration and collection of rice germplasm and a general survey of the floral diversity was undertaken in the Majuli island during September, 1991. The soils and crop growing conditions in the island showed much variation. Rice germplasm was collected by taking random population samples of 80-90 panicles per accession. Passport data were recorded at the site. Comprehensive notes were taken on varietal characters including the grain characters and uses. Majuli represents alluvial plain deposits of the Brahmaputra and its tributaries, viz., Kherakatia, Luit Suti and Tuni Suti. The soils of the island are mainly of 3 types, viz., loam, clay loam and loamy sand. These are acidic in nature. Humid and warm weather is characterized by high mean annual rainfall of 2000 mm; maximum temperature of 28° to 36°C during summer and minimum of 10° to 15°C during the winter months. The island receives very less rainfall during the period from November to March.

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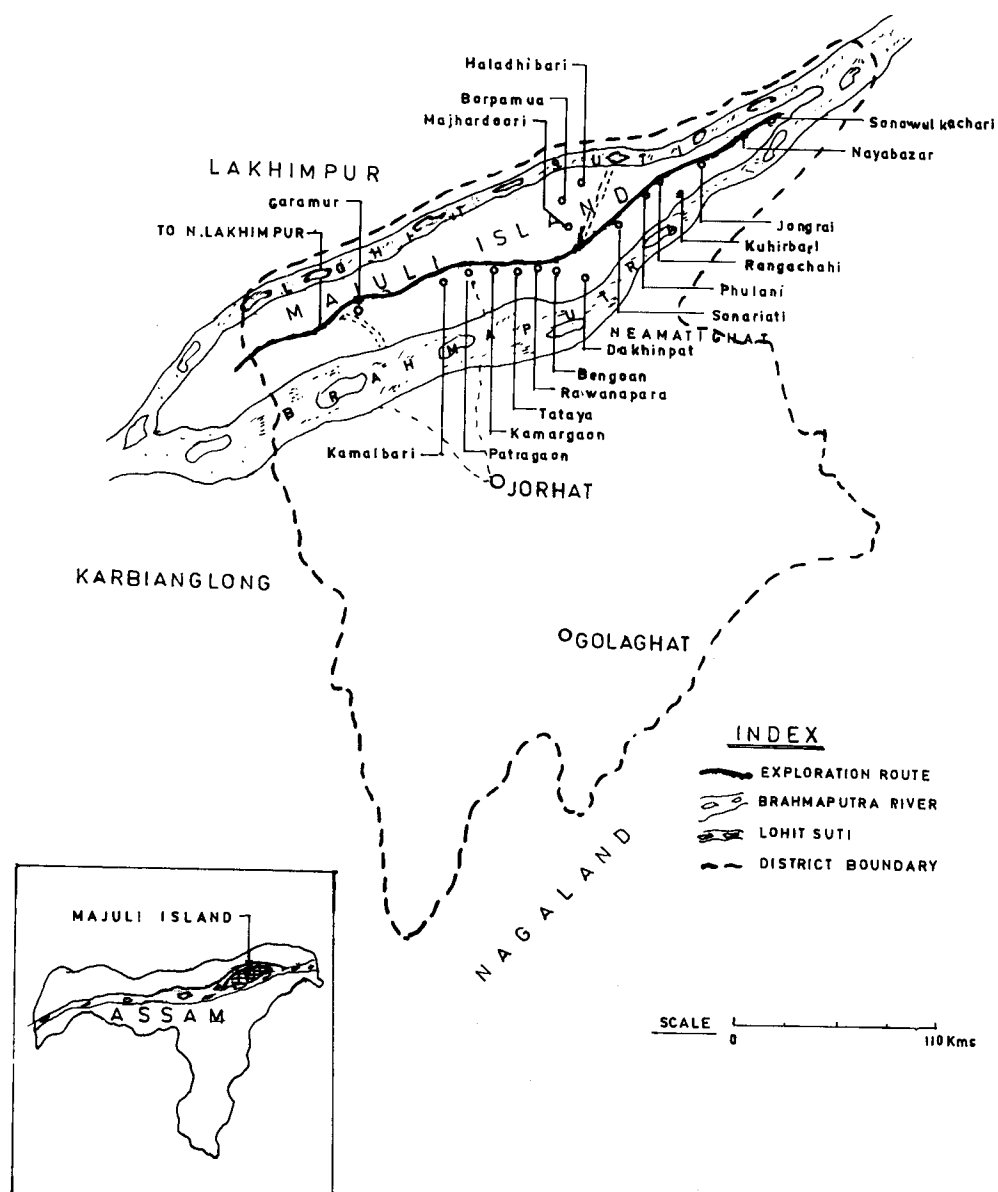


Fig. 1. Map of Majuli island in Assam showing exploration route and collection sites

Floral Diversity Pattern

According to Islam (1990), plants of 139 families, 505 genera and 692 species are found in Majuli. Among these, 76 per cent species belong to dicotyledonous group. It has been observed that the predominant families are Poaceae, Asteraceae, Fabaceae, Euphorbiaceae, Cyperaceae, Solanaceae, Malvaceae, Scrophulariaceae, Acanthaceae and Convolvulaceae. The vegetation consists of evergreen forests, swamp forests, savanna formation and the grasslands. The economically useful plants of Majuli also show wide diversity. Many of these are found in cultivation. Table 1 depicts the genetic resources of various economically useful plant species in terms of number of species which shows the existence of variability for useful plant groups. Some of such plants have even been naturalised over the period. To mention a few of these are *Brassica nigra*, *Hibiscus subdariffa*, *Luffa cylindrica*, *Capsicum annuum*, *Coriandrum sativum*, *Sesamum indicum*, *Perilla frutescens*, *Trichosanthes dioica*.

Table 1 : Number of species of economically useful plants in Majuli

Crop Group	Number of Species
Cereals	3
Corms	6
Root vegetables	4
Stem and leafy vegetables	10
Vegetable fruits	16
Pod and seed vegetables	5
Plantation crops	1
Fruit plants	23
Oil yielding plants	5
Leaf fibre crops	4
Fibre yielding plants	10
(a) Cultivated	
(b) Wild	25
Leaf sheath fibre plants	3
Mesocarp fibre plants	2
Spices and aromatic plants	11
Medicinal plants	43
(a) Cultivated	
(b) Wild	75
Ornamental plants	60
Total	306

Cultivated Crops and their Diversity

The total cultivable area in the Majuli is 30,358 ha, which includes current fallow 1,296 ha, old fallow 332 ha and net sown area 26,356 ha. The total irrigated area is 1204 ha; forest cover 250 ha and the average land holding is only 0.3 ha. Rice is the staple crop grown in 3 seasons viz., *sali*, *boro* and *ahu*. The other important crops include potato, maize, tobacco, wheat, mustard and rapeseed, groundnut, sesame, niger, pea, lentil, blackgram and greengram. The cultivation of deep water or flood tolerant varieties is common in some pockets because the frequency of flood is high. The predominant local varieties are *Hatisalai*, *Salpna* and *Jahinga* which could give a grain yield of 30-40q/ha. *Mahsuri*, an improved HYV also performs well in Majuli (40-50 q/ha). Major disease of rice is leaf blast but among pests, *ufra* in *bao* (deep water) fields, case worm, stem borer, *hispa* and *gandhi* bug cause substantial damage.

Diversity in paddy germplasm

In the small area of over 26,000 ha of cultivated land with a native population of 1,34,000, seventy landraces of paddy have been found in cultivation (Table 2). The reason for occurrence of much large number of varieties / landraces over the small area may be as follows :

Difficult means of communication with the mainland : Paddy is the staple food of the inhabitants and in case of any shortage, miserable conditions are faced for immediate transportation. In order to avoid such situations, germplasm diversity preserved over generations of conscious selection provide insurance against crop failure and also during shortage of food.

Frequent floods : Changing course of river also creates uncertain situations and at times may play havoc with the crop. This has provided suitable ecological selection pressure on the paddy varieties being grown, resulting thereby, flood and drought tolerant types.

Favourable edaphic and ethnic situations : High soil fertility, diverse growing conditions and tendency for self-sufficiency for food are the important factors in favour of high varietal diversity.

Disease and insect pest pressure on the crop : The varietal materials must have been introduced in the island over different periods from the main land without adequate quarantine measures. The continuous high humid conditions and suitable mild hot temperatures conducive to the prevalence and annual recurrence of disease and insect-pests incidences caused severe damages to the crop particularly by *hispa*, *gandhi* bug and stem borer. This has indirectly cautioned farmers to select for resistant materials and diversify their varietal stock.

Table 2 : Paddy varieties grown in Majuli Subdivision of Jorhat District, Assam

Ahu March-April to June-July	Bao (deepwater) March-April to November-December	Sali June- July to October-November
Guni, Ekha joi, Borkula, Ekora guni, Gobarguni, Kaoriguni, Milung, Meghi, Bangah, Bedguti, Lepu, Benganguti, Saraituni, Haitibor, Salpna Ahu and Kalaguni.	Rangoli (Ranga gotha), Amuna, Kakua, Kahijul (Kalijul), Bogajul, Sakibao, Nagheri, Maiman-singia, Deoribao, Indinarayan (Indianayan), Chenga, Maguri, Dubri, Dalbao, Biria Bhanga, Adulia (Hedulia) bao, Rupahi bao and Kholio bao.	i) <i>Lahi</i> (Fine grain) varieties: Salpna, Taraboli, Suhagmoni (Jengoni), Khamati Sali, Kolahali, Malbhog, Ampakhi. ii) <i>Joha</i> (Scented) varieties : Bhabeli joha, Kala joha, Manaki joha. iii) <i>Soft rice</i> (Sweeter, good for Chira, Khoi & Muri) varieties : Komol dhan, Hatidatia, Bor Jahanga, Horu Jahanga and Rangasali. iv) <i>Jalpan</i> (Breakfast) varieties : Ghewan bora, Borbora, Pakhuri (Coru Chakwa bora), Gorunda Pakhi (Necklace bora) and Harubora (Tilbora). v) Local common (cooked rice) varieties : Bor Chakhua, Horu Chakhua, Betu, Nania, Jaldubi, Hati-sali, Sailsali, Chakharu, Nakera, Dalkachu hali, Kala Ampakhi, Neokadam, Henduri hali (Senduri hali), Herai Powa and Mahsuri (Aizons).

The three seasons for paddy growing are **Ahu** (moisture stress period), **bao** (a crop which remains submerged in water) and **sali** (rainy season crop). All the **ahu** season varieties are short duration (110-120 days) and are tolerant to moisture stress. **Sali** season is characterised by the regular precipitation. The **hali** or **sali** varieties are generally of medium maturity duration (130-160 days). The **bao** paddy varieties are well adapted to flood waters and hence are grown in flood prone areas. These varieties are, in general, of very long duration (170-215 days), have very bold grains and mostly bear awns. The

main (or sali) crop constitute the biggest group of 35 paddy varieties. These varieties could be further grouped as **Joha** (scented), **Lahi** (fine grain), soft rice, **Jalpan** (breakfast) and general cooked varieties (Table 2). The varieties showed much variation in grain size, starch and sweetness, husk colour, colour and size of lemma (sterile), awn character (colour and length), plant height, pigmentation on culms and adaptation to various soils (submerged or non-submerged) and planting conditions. For instance, **Ranga Sali** and **Salpna** does well under continuously submerged soils. The **Gorunda** variety had very long (full grain length) sterile lemmas. Among scented varieties **Kala Joha** is considered to be the best variety. For taste, **Khamti** rice is the best and when a sample of it was cooked it was observed that it appeared as if ghee had been added to it. Another variety **Ekha joi** is well adapted to water logged soils and had allelopathic effect on weeds, as these were found to be suppressed. Some varieties have already become obsolete. These were **Sarai Tuni** (good grain quality) and **Haria Duli** (scented ahu).

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GORAKH IMLI (*ADANSONIA DIGITATA* L.) — A LITTLE KNOWN EDIBLE PLANT

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Key words : Gorakh imli, Baobab/Monkey bread, *Adansonia digitata*, economic uses

The introduction of plants from one country to another have played a great role in changing the economy of a nation. Some have deserved the rank of plants of commercial importance due to complete change in eating habits of native people, for example, introduction of oranges from china; chillies, wheat and potato from the New World.

Adansonia digitata L. (Baobab, Cork tree, Monkey bread, Sour gourd tree), a native of Africa is not truly wild in India. The other species *A. gregorii* is from Australia. Both the species are cultivated in many warmer parts of the world including India. Of 10 species, two are cultivated in India and they are age old introductions. *Adansonia digitata* is more important. Its cultivation goes back to introduction by Arab Traders (who called it *habhabu*), probably during Moghal period (Desmond, 1992). The baobab occurs in its natural habitat in Senegal and Abyssinia, also on wet coastal region of Africa, extending to Angola. Villages in West Africa are often have around one or more giant baobab trees. It is an important tree to the Negros. *Adansonia digitata* commonly sold under the name **Gorakh Imli** in North Indian markets (Fig. 1), belongs to family Bombacaceae. It is a tree with a short trunk, very widely spreading branches from a mushroom-shaped head, leaves digitate, pubescent beneath when young, glabrous, deciduous, flowers axillary, solitary, with long peduncle, bark smooth, calyx cup shaped, leathery, 5 cleft, petals 5, exceeding reniform with thick testa, embedded in pink pulp.

It is cultivated in various parts of India. Natural regeneration occurs only under high humid condition. For artificial regeneration, 1-2 year old seedling, grown in a well irrigated nursery, may be transplanted during August-September. The tree is chiefly available in the coastal area around Bombay. The abandoned capital Mandoo near Indore (Madhya Pradesh) is



Fig. 1. Gorakh imli (*Adansonia digitata* L.) fruits

over run with *Adansonia* trees. A few plant population could be seen beyond the coast of Coramandal, Bengal and adjacent areas. In Rajasthan, rare plantations in open forests (Ajmer, Chittorgarh and Pratapgarh) are also available. Types cultivated in different agro-climatic areas need to be thoroughly screened for extending its cultivation in other areas (Uphof, 1968; Wlth India, 1985).

Edible produce and usage

Gorakh imli is an invaluable source of food, fodder, medicines, shades, shelter and utensils such as baskets. Its hollow holes also serves as a storage tank for water, bark as cordage and thread. In Senegal, the Negros use the pounded bark and leaves as condiments. The leaves are cooked with other food to serve as a cooling agent. Fruit pulp tastes like ginger bread having pleasant acidic flavour. Acidic beverages are prepared at the local level. The

fruit having dry and acidic lemon flavour has pleasant taste. The seeds are embedded compactly in pulp. The dried pulp is rich source of Calcium and Vitamin B₁. It is used as food seasoner and an appetiser. A refrigerant drink is prepared from the pulp after boiling in water. The dry pulp with water gives relief from chronic bronchial asthma. In coastal areas of India, dry flowers are used as floats for fishing nets; bark yields a strong fibre used in cordage. Owing to its value as a rich source of vitamins and food, its utility is considered as a substitute for tamarind (Table 1). High variability in fruit size and shape ranging from a foot long to the size of a small lemon, or gourd shaped, is available. In coastal region of Gujarat, the fishermen eat the leaves a leafy vegetable. Dry fruits are very light weight and are used as floats by the fishermen. Hedoriek, 1981. It deserves extended cultivation in India for its exploitation.

Table 1. Chemical analysis of fruits of Gorakh imli (*A. digitata*) and tamarind (*Tamarindus indica*) L. (in % in wet fruit)*

Major constituents	<i>A. digitata</i>	<i>T. indica</i>
Moisture	17.90-33.8	20.9
Protein	1.44-2.15	3.1
Lipids	0.06-0.69	0.1
Calcium	15.60-33.5	17.0
Phosphorus	6.00-36.1	11.0
Vitamin C	3.80-20.1	0.3

* With India, 1985

Some general considerations

The Gorakh Imli has not drawn attention of the user community leading to selection of better types for the Indian region. Uses too are less-known among the general population. Considering its importance and utility in its native land (Africa), cultivation of this plant can be identified for this region. Suitable selections are required to be made out of the cultivated population in India. If required desired types may be introduced from its native region. Gorakh Imli is predominantly cultivated in India for domestic use only to substitute for sour/acidic items. In land of its origin, it is known for its multipurpose uses. Its cultivation on larger scale would enable us to use it as an additional source of food.

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DOMESTICATION OF WILD ORNAMENTALS

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Key words : Wild ornamentals, domestication, floriculture

In India, search for new species and elite clones notably by Botanical Survey of India, forest departments, herbarium and taxonomy divisions of many universities and research institutions was made to bring new and unexplored plant wealth under cultivation. So far, only economic and medical plants were kept under priority and very little attention was given to the ornamental plants. Most of the flowering plants, grown at present, in our gardens are of exotic origin, introduced mainly during the British rule. In recent years the importance of native flora and its use in gardening has been realised.

Recent developments in floriculture have brought in close competition to gain market. Therefore, floriculturists are always in search of new and rare genotypes. Domestication of wild ornamentals may be useful to attain the following objectives :

1. New wild species of potential ornamental/economic importance may be introduced into cultivation after survey and exploitation of wild germplasm.
2. Superior/improved varieties may be developed through hybridization using wild, domesticated germplasm.
3. Domestication will help to provide habitat for endangered and threatened plant species.
4. Useful genotypes may be conserved for future breeding programme.

Certain species viz., *Aeschynanthus tricolor*, *Antennaria dioica*, *Argyreia hirsuta*, *Bidens pilosa*, *Butomus umbellatus*, *Calceolaria mexicana*, *Castilleja coccinea*, *Combretum decandrum*, *Commelina elavata*, *Convolvulus sapium*, *Coronilla varia*,

Cuphea pinetorium, *Cyanotis pilosa*, *Cynoglossum fureatum*, *Desmodium glustinosum*, *D. scalpe*, *Epilobium coloratum*, *Exacum bicolor*, *Gaura bienis*, *Hepatica acutiloba*, *Hypericum mysorensis*, *Linaria vulgaris*, *Linum sulcatum*, *Lochnera rosea*, *Oenothera tetraptera*, *Saponaria officinalis*, *Solanum sisymbriifolium*, *Strobilanthus kunthianus*, *Tephrosia virginiana*, *Tradescantia ohiensis* and *Tulipa tarda* (all herbaceous plants) and *Acacia cultriformis*, *A. podalyriifolia*, *Butea superba*, *Careya herbacea*, *Casearia graveolens*, *Cassia artemisioides*, *Cassia suberosa*, *Colebrookia oppositifolia*, *Cordia sebeslena*, *Erythrina arborescens*, *E. glabrescens*, *Entada scandens*, *Helicteres isora*, *Hovea longiflora*, *Menecylon malabaricum*, *Osbeckia*, *Phyllanthus pulcher*, *Reinwardtia indica*, *Stereospermum chelonoides*, *Woodfordia floribunda*, (perennial plants), growing in the forests have potential as ornamentals. These may be screened for use as new ornamental species.

Domestications made at National Botanical Research Institute

1. *Erythrina resupinata* Roxb. (Leguminosae)

A wild plant of rare beauty and prostrate habit was collected from Tarai forest of U.P. and Bihar and domesticated as a rockery plant. The flowers emerge earlier than the leaves.

2. *Sopubia delphinifolia* G. Don (Scrophulariaceae)

An annual herb growing widely in the central and southern parts of India bears attractive pink flowers during rainy season.

3. *Lantana camara* L. (variegated form) (Verbenaceae)

Lantana camara is an evergreen flowering shrub with red, yellow or white flowers. A variegated form of *L. camara*, having ornamental foliage was collected from Chitrakoot forests of district Banda (U. P.). The plants is propagated by cutting of young shoots.

4. *Nyctanthus arbor tristis* (Oleaceae)

Nyctanthus arbor tristis is an indigenous species and is widely distributed in the forests of Chitrakoot and Madhya Pradesh region. A survey, indicated that much floral polymorphism exists within this species. Five distinct clones of *N. arbor tristis* were collected (Srivastava, 1978). The domesticated clones were seed propagated, but to raise homogenous population, they were propagated by patch budding.

5. *Rumex hastatus* D. Don (Polygonaceae)

Rumex hastatus is well distributed in Kumaon hills. It is a perennial herb or a small shrub and bears a long flowering stalk, with pink flowers and fruits. In view of its potential as a rockery plant in the plains, it was domesticated and has been maintained. The plants flower and fruit well under Lucknow conditions (Srivastava and Dhar, 1978a).

6. *Cassia auriculata* L. (Leguminosae)

Occurs extensively in the central and western peninsular India and some parts of Uttar Pradesh had been introduced at Lucknow (Srivastava and Dhar, 1978b). By proper training, the plant made a very good 'free flowering standard'. It flowers almost throughout the year.

7. *Combretum nanum* Buck-Ham. (Combretaceae)

This species collected from Tarai region of Lakhimpur Kheri District, is a small, decumbent, undershrub having very colourful winged fruits. It is suitable as a rockery plant. Fruits of *C. nanum*, when mature, become very colourful and are suitable for interior decoration.

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MULTIPLE DISEASE RESISTANCE IN ADZUKI BEAN

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Key words : *Vigna angularis*, multiple resistance, *Sphaerotheca fuliginea*,
Cercospora canescens, *C. cruenta*, *Colletotrichum lindemuthianum*

Adzuki bean (*Vigna angularis* (Willd.) Ohwi and Ohashi) is a major grain legume in China, Japan and Russia (Sacks, 1977). In India, cultivation of the crop is limited to hilly regions. In Himachal Pradesh, the crop has shown a great potential due to its high productivity and resistance to leaf spot diseases (Gupta *et al.*, 1980). In the absence of a disease resistant variety of Uridbean, an important pulse crop of hills, adzuki bean can boost and stabilise the production of *kharif* pulses especially in disease epidemic years. This crop is sparsely cultivated in some of the remote areas of hills. However, for increased and sustained production, it is desirable to identify agronomically desirable, disease resistant genotypes. This communication reports disease resistant genotypes among local, exotic, and local x exotic derivative lines of *Vigna angularis*.

In one experiment, the material consisted of 30 local and exotic germplasm lines, raised during *kharif* 1989 in RBD in three replications, having a plot size of 3 rows each with 1.5 m length and row to row distance of 30 cm. Fertilizers @ 20 kg N and 40 kg P₂O₅ per hectare were applied at the time of sowing. In another experiment, thirty eight advanced lines derived from a local x exotic cross A 1 x HPU 51 of adzuki bean alongwith their parents grown in pots were also evaluated for resistance to powdery mildew under screen-house conditions (temperature 25 ± 4° C) during *kharif* 1990.

Natural epidemics of powdery mildew (*Sphaerotheca fuliginea*), *Cercospora* leaf spot (*Cercospora canescens* and *C. cruenta*) and anthracnose (*Colletotrichum lindemuthianum*) appeared in the experimental area. The observations on terminal disease severity of *Cercospora* leaf spots and powdery mildew were recorded on 0-5 scale as recommended by All India Co-ordinated Pulse Improvement Workshop, 1978 for mung and mash crops (Singh, 1980). The data on anthracnose was recorded on 0-9 scale (Mayees and Datar, 1986).

Genotypes showing resistant or moderately resistant reaction to various diseases are given in Table 1. Two genotypes each (EC 15257, EC 89957) and (EC 108080, EC 87896) were resistant to powdery mildew and leaf spot caused by *C. cruenta*. Four genotypes were resistant to anthracnose, whereas all the genotypes except IC 87897 were resistant to leaf spot caused by *C. canescens*. Genotypes IC 24104 and A 1 were resistant or moderately resistant to powdery mildew, *C. canescens* and anthracnose. Line EC 87897

Table 1 : Genotypes of adzuki bean resistant to powdery mildew, *Cercospora* leaf spot and anthracnose

Disease	Reaction of genotypes	
	Resistant	Moderately resistant
Powdery mildew	EC 15267, EC 89957	A-1, BDJ/NKG 457, EC 87897, EC 108080, EC 120460, IC 24104, IC 24107, IC 57899.
<i>Cercospora</i> leaf spot (<i>Cercospora cruenta</i>)	EC 108080, EC 87896	A-1, BDJ/NKG 1433, EC 16767, EC 29957, EC 87897, EC 87995, EC 89951, EC 108077, IC 15256, IC 24102, IC 24104, IC 24523, IC57899, IC 120460.
<i>Cercospora canescens</i>	All except EC 87897	
Anthracnose	EC 87896, EC108080	Assam local, EC 16767, EC 29957, EC 87898, EC 108077, EC 108080, IC 15256, IC 24102, IC 24104, IC 24523.

was resistant or moderately resistant to powdery mildew and anthracnose, whereas EC 57899 was resistant to powdery mildew and anthracnose. Genotypes EC 108080 and EC 87896 were resistant to *C. cruenta*, *C. canescens* and anthracnose. Genotypes EC 108077, IC 24104, EC 87896, IC 16767, EC 29957, IC 24523, IC 24102 and IC 15256 were moderately resistant to *Cercospora* leaf spot and anthracnose. Among the recombinant lines derived from the cross A1 x HPU 51, line HPAB 16 was completely free from powdery mildew, whereas lines HPAB 36, HPAB 21, HPAB 12, HPAB 8, HPAB 30 and HPAB 2 were resistant to powdery mildew.

In the present studies, a large number of genotypes with multiple resistance have been identified which may be utilized in breeding programme for the improvement of the crop. Moreover, desirable disease resistance specifically against leaf spots may be transferred to mung and mash. By the time agronomically desirable leaf spot resistant variety of mash is developed ad-zukibean can be cultivated on commercial scale to boost the production of *kharif* pulses.

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PARKIA ROXBURGHII — A USEFUL TREE OF NORTH-EASTERN INDIA

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Key words : *Parkia roxburghii*, economic uses

The genus *Parkia* is known to have 40 species widely distributed in tropical parts of the world, only 3 species occur in India (Willis, 1982). A member of Leguminosae sub-family Mimosaceae, it is popularly known as tree bean. *Parkia roxburghii* G. Don. commonly grows in backyard of houses, *jhums* and forests in Mizoram, Nagaland, Manipur, Meghalaya as well as in forests of Cachar, North Cachar Hills and Sibsagar of Assam (Kanjilal *et al.*, 1938). It usually grows wild in plains and hills upto 500 m above sea level. It is known as **Khorial** and **Manipur-urohi** in Assam; **Zongta** in Mizoram; **Yongchak** in Manipur; **Aoelgap** in Garo Hills; **Barri-phang** in Cachar and **Unkam-pinching** in Nagaland. In Manipur, nine types of tree bean differing in seed size, seeds per pod, dry matter (%), specific gravity and taste, on the basis of organoleptic test were identified (Meitei and Singh, 1990). These are **Nungsiacharu**, **Kangchup**, **Thangmani**, **Kharum**, **Kangpokpi**, **Taothong**, **Narankonjin**, **Jiri** and **Tamenglong**.

Tree bean grows 20 to 30 m tall with spreading branches, having white to brown or light-grey bark, spotted white. Bipinnate leaves are 20-40 cm long, rachis bearing 12-30 pairs of pinnae with 30-80 pairs of leaflets of size 0.6-1.2 cm × 0.1-0.2 cm. The pear shaped flower heads are borne on 20-30 cm long peduncle. Flowers yellowish white, trimorphous - neutral at the base of club, male in the middle and female at the apex. Pods (3 to 5) remain suspended on 10-12 cm long stalks and are of 20-36 × 3.5-4.2 cm in size, containing 12-20 seeds. Seeds are ovoid, 1.9-2.1 cm × 0.9-1.2 cm, enclosed in hard testa.

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Food value

The strong smelling tender pods are cooked as vegetable. The seeds from mature pods are also eaten as *dal* or *chutney* after roasting. The immature seeds, the young leaves and the fleshy part of the flower stalk may be eaten as vegetable and half ripe pods are occasionally pickled. The chemical analysis of immature pods showed 72.1 per cent water, 1.02 per cent fat, 7.7 per cent fibre, 12.68 per cent protein, 3.5 per cent carbohydrates and 3.0 per cent mineral (ash) content. The vitamin C is 7.38 mg per 100 g of fresh weight basis. The nutritional values of immature pods indicated that these are a good source of protein and vitamin C.

Medicinal value

The seeds as well as tender pods are known to cure stomach disorders and regulate liver function. Pods pounded in water are used in washing the head and the face (Burkill, 1935; Quisumbing, 1951). Bark and leaves are used in making lotions for skin diseases and ulcers. Fomentation of decoction of leaves to the rheumatic affected parts is beneficial.

Fuel value

It is a good fuel wood, burning slowly and completely.

Industrial raw material

It gives soft wood, easy to saw and can be worked to give a good finish. It is used in making boxes, show pieces etc. The bark contains 6-15 per cent tannins and is reported to be useful in tanning industry. The wood can also be used as a source of paper pulp (Wlth India, 1966).

Tree bean in agro-forestry

Tree bean is a fast growing species and has the capacity to fix nitrogen as well. It can produce 10 to 25 cubic meter of biomass in 10-15 years. It had no adverse effects on grain yield of soybean and linseed when grown in combination with them. It is also useful as a shade tree in tea plantations (Dhyani and Chauhan, 1990).

Ornamental value

It is usually grown as an ornamental tree in parks and as avenue tree alongside roads.

The future research thrust should be on reducing fibre content, smell and acrid taste of pods; selection of early and prolific bearing types. The

detailed studies on nutritional aspects of seeds and medicinal properties of leaves, bark, seeds or pods needs to be done. It will also be useful to investigate further its capacity of nitrogen fixation and to estimate the quantity of nitrogen fixed for its better exploitation in agro-forestry.

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GENETIC DIVERGENCE IN SOYBEAN (*GLYCINE MAX. L*) EVALUATED UNDER HIGH ALTITUDE CONDITIONS

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Key words : *Glycine max*, genetic divergence, germplasm, inter and intra-cluster values

In view of the importance of soybean in the hilly areas, the germplasm lines have been collected from various parts of the world for breeding programme. Since no information is available in this crop for high altitude region, an attempt has been made to study the genetic diversity for yield and its contributing characters.

Twenty seven accessions were collected and grown at Defence Agricultural Research Laboratory, Field Station, Auli (Joshimath) during 1990-91. Auli is situated at an altitude of 2700 m above msl in central Himalayas. The germplasm included collections from Myanmar, China, England, Germany, Hungary, India, Italy, Korea, Nepal, Turkey, USA and erstwhile USSR. The field experiment was conducted in a randomized complete block design with 3 replications. Each plot consisted of two rows of 3 m length and spacing between rows was 45 cm. Plant to plant distance was maintained at 10 cm. Five competitive plants were selected from each genotype in each replication to record the observations on days to 50 per cent flowering, maturity days, plant height, number of primary branches, size of leaves, pod length, pods per plant, seeds per pod, 100 seed weight and seed yield per plant. Genetic divergence was assessed using Mahalanobis D^2 statistics (Mahalanobis, 1949) and the material was grouped into clusters according to Tocher's method (Rao, 1952).

Analysis of variance of means revealed significant variation amongst the genotypes for all the characters. The coefficient of variation for yield per plant and number of pods per plant revealed that two traits were highly variable.

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Based on D^2 values the germplasm was classified into 8 clusters, as follows :

- Cluster I : Bragg (USA), Lee (USA), Pickely (USA), Monetta (USA), Hood (USA), PLSO-41 (Himachal Pradesh), PLSO-42 (Himachal Pradesh), IC 9445 (Sikkim), IC 7840 (Himachal Pradesh), UPSM-120 (Dehradun)
- Cluster II : EC 25737 (USSR), EC 36896 (Taiwan), EC 36819 (Taiwan), EC 18126 (Nepal), EC 18596 (Nepal), EC 18533 (Nepal)
- Cluster III : EC 34101 (Hungary), EC 34098 (Hungary), EC 32573 (England)
- Cluster IV : EC 34344 (Germany), EC 34348 (Germany), EC 33776 (Italy)
- Cluster V : PI-172-902 (Turkey)
- Cluster VI : PI-123-440 (Myannar)
- Cluster VII : PI-60273 (China), PI-90481 (China)
- Cluster VIII : PI-60269 (Korea)

The average intercluster distance values ranged from 10.4 to 21.7 (Table 1). The maximum distance ($D = 21.7$) existed between Cluster V and VII. The second largest distance ($D = 20.5$) existed between Cluster V and VI. Intracluster distances were smaller than the intercluster distances as greater similarity existed within the clusters. D^2 values revealed that intracluster divergence was maximum for Cluster I (10.8) which included 10 genotypes and accounted for 37 per cent of total germplasm and 23 per cent of exotic lines.

Table 1 : Inter and intra cluster values in soybean

Clusters	I	II	III	IV	V	VI	VII	VIII
I	10.8	11.2	12.9	14.1	15.8	15.0	14.7	15.7
II		10.7	11.9	13.2	17.1	15.9	15.8	15.6
III			9.7	16.5	18.0	14.0	18.7	15.0
IV				9.5	15.3	10.4	19.3	16.4
V					0	20.5	21.7	16.6
VI						0	15.5	17.8
VII							1	17.7
VIII								0

Cluster means showed appreciable variation among the 8 clusters grouped according to D² analysis (Table 2). The differences among cluster means, though observed for all characters, were more pronounced for plant height, size of leaves, pods per plant, seed weight and seed yield. The Cluster VI showed the highest mean seed weight. The genotypes in Cluster IV had highest number of pods per plant but were in medium long maturity duration.

Table 2 : Cluster mean for different clusters in soybean

Characters	Clusters							
	I	II	III	IV	V	VI	VII	VIII
Days to 50% flowering	61.97	61.87	66.66	58.58	58.00	56.50	63.75	63.50
Maturity (days)	120.45	118.30	124.08	116.41	112.50	121.25	119.87	124.50
Plant height (cm)	75.50	58.68	61.42	55.56	46.50	85.09	110.47	72.05
No. of primary branches	6.62	7.22	8.33	6.96	7.95	8.00	5.97	6.84
Size of leaves (cm ²)	75.32	58.31	74.44	63.30	85.60	74.58	64.64	52.38
Pod length (cm)	4.41	4.49	4.37	4.25	4.50	4.79	4.63	4.40
Pods per plant	60.04	63.08	97.07	105.78	83.84	91.15	51.60	74.50
Seeds per pod	2.07	2.73	2.90	2.65	2.90	2.85	3.55	3.00
100 seed weight (g)	12.99	13.71	12.92	14.66	10.50	15.75	10.38	8.25
Yield per plant (g)	20.20	31.77	22.75	37.04	21.90	45.80	13.88	13.80

The utility of classifying germplasm for selection of diverse parents for hybridization has long been appreciated (Bhatt, 1970). The genotypes grouped in Cluster V and VII followed by IV and VII were widest apart and were of short duration, tall, having broader leaf size, bold seed and high yield. Obviously, the crosses between genotypes of these clusters might be useful for fixing transgressive segregants. However, selection of more than one genotype from large clusters may pose specific problem. Apart from high genetic divergence, the performance of genotypes for characters such as number of pods per plant and seed weight should be considered prior to their inclusion in breeding programme. The genotypes EC 34344, EC 33776, PI 172-902 and PI 60273 appeared to be desirable for further soybean improvement programme. Inclusion of these parents in crossing programme is expected to prove rewarding.

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GENETIC VARIABILITY FOR SOME AGRO-MORPHOLOGICAL TRAITS IN CHICKPEA GERMPLASM

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Key words : Chickpea, genetic variability, heritability, genetic advance, germplasm

Germplasm collection, maintenance and its evaluation for economically important traits is a prerequisite for starting any breeding programme for the genetic improvement of the crop. Chickpea (*Cicer arietinum* L.) occupies unique position in Indian Agriculture by virtue of its high protein content apart from fixing atmospheric nitrogen. Although reports on evaluation of the germplasm of chickpea are quite frequent in literature, yet an attempt has been made in the present study to evaluate the germplasm of different ecogeographic sources and types (Desi and Kabuli) for genetic variability in some agromorphological traits.

Fifty nine genotypes of chickpea (*Desi* and *Kabuli*) from different ecogeographic regions were obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad. These genotypes were grown in a randomized block design with 3 replications at experimental farms of Oilseed Research Station, Kangra of Himachal Pradesh Krishi Vishwa Vidyalaya (HPKVV), Palampur. Origin, type and other characteristics of 59 genotypes are listed in Table 1. Each plot had a single row of 2 m length with row to row and plant to plant spacing of 30 and 10 cm, respectively. Recommended cultural practices were followed to raise the crop. Observations were recorded on 10 randomly selected plants in each accession for 12 agromorphological selected traits, viz., seed yield per plant, pods per plant, seeds per pod, 100-seed weight, specific gravity index, plant height, primary branches per plant, stem diameter, days to flowering, days to maturity and green and anthocyanin pigmentation on plant parts. Specific gravity index was expressed as per cent dipped seeds in the mercuric oxide solution of

**Table 1 : Origin, type and seed colour of 59 genotypes of chickpea
(*Cicer arietinum* L.)**

Genotype	Origin	Type	Seed colour
C 235	India	Desi	Yellow
E 100	Greece	Desi	Yellow-brown
EC 103119-2	India	Desi	Yellow
EC 103400	USSR	Desi	Yellow-brown
EC 103418	Iraq	Desi	Yellow
EC 103422	Afganistan	Desi	Yellow
EC 103438	Iran	Desi	Yellow
EC 103457	Egypt	Kabuli	Salmon-white
EC 250142	Greece	Desi	Yellow-brown
EC 850-3127	Egypt	Kabuli	Salmon-white
F 61	India	Desi	Yellow
Giza	Egypt	Kabuli	Salmon-white
JG 37	India	Desi	Yellow
JG 897	India	Desi	Yellow
JM 466	Ethiopia	Kabuli	Salmon-white
JM 482	Pakistan	Kabuli	Salmon-white
JM 483	Netherland	Desi	Yellow-brown
K 468	India	Desi	Yellow-brown
K 1071	India	Desi	Yellow
Malkan A/2	Pakistan	Desi	Yellow
NEC 10	Jordan	Kabuli	Salmon-white
NEC 18	Jordan	Desi	Yellow-brown
NEC 30	Iraq	Kabuli	Salmon-white
NEC 34	Iraq	Kabuli	Salmon-white
NEC 108	Greece	Kabuli	Salmon-white
NEC 123	Morocco	Desi	Black
NEC 143	Sudan	Kabuli	Salmon-white
NEC 175	Peru	Kabuli	Salmon-white
NEC 197	Pakistan	Kabuli	Salmon-white
NEC 229	India	Desi	Brown
NEC 240	USSR	Desi	Yellow-brown
NEC 249	India	Desi	Yellow
NEC 318	Iran	Desi	Yellow-brown

(Table 1 continues)

NEC 426	Iran	Desi	Dark-brown
NEC 550	Iran	Desi	Yellow-brown
NEC 721	Iran	Desi	Yellow
NEC 989	Iran	Desi	Yellow-brown
NEC 1077	Iran	Desi	Yellow
NEC 1135	Iran	Desi	Brown
NEC 1639	Pakistan	Desi	Yellow
NEC 1646	Algeria	Kabuli	Salmon-white
NEC 2305	USA	Desi	Yellow-brown
NEC 2330	Pakistan	Desi	Yellow-brown
NEC 2368	Ethiopia	Desi	Brown
P 840	Morocco	Desi	Yellow-brown
P 992	Pakistan	Desi	Brown
P 993	Pakistan	Desi	Yellow
P 1081-1	Nigeria	Desi	Cream
P 1528-1	Morocco	Desi	Black
P 2019-1	Iran	Desi	Dark-brown
P 2591	Iran	Kabuli	Salmon-white
P 2994	Iran	Desi	Black
PRR 1	Mexico	Desi	Brown
V 4	Mexico	Desi	Brown
V 165	Mexico	Desi	Yellow-brown
WP 2654-A	Ethiopia	Desi	Brown
WR 315	India	Desi	Brown
12-071-05093	Iran	Desi	Black
12-071-10054	Iran	Desi	Black

specific gravity 1.35. Leaf colouration and anthocyanin pigmentation were scored after 3 and 4 months of sowing, on 1-9 scale representing 1 for high and 9 for the least expression of the respective trait. Data recorded on all above traits were subjected to statistical analysis following Panse and Sukhatme (1985). Different genetic parameters, *viz.*, mean, range, coefficient of variation, heritability and genetic advance were calculated following standard statistical procedures.

Analysis of variance (Table 2) indicated presence of sufficient genetic variability for all the traits in 59 genotypes of chickpea. Seed yield per plant

ranged from 4.33 (JM 466) to 29.67 g per plant (NEC 550) with an average yield of 13.15 g per plant. Pods per plant ranged from 42.07 (12 - 071 - 10054) to 154 (P 2019-1) with an average of 90.74. Germplasm population had 1.73 seeds per pod with a range of 1 (MEC 249) to 2.60 (JM 466). Genotype, P 2994 exhibited minimum 100-seed weight (10.70 g), whereas maximum seed weight (33.53 g) was exhibited by NEC 34. Similarly, specific gravity index ranged from 6.33 (NEC 34) to 95.67 (C 235) with an average of 64.77. Plant height at maturity ranged from 68.33 to 104.20 cm with a mean height of 83.26cm. Germplasm had 7.61 average primary branches per plant which ranged from 3.27 (JM 466) to 10.60 (NEC 550). Stem diameter ranged from 0.56 (NEC 10) to 0.97 cm (NEC 123) with a mean of 0.72 cm. A narrow range was observed for days to first flowering and maturity, i.e. 107 to 137 and 192 to 201, respectively. Genotypes C-235 and JM466 were observed to be early maturing and early flowering type, respectively. Intensity of green leaf colour and anthocyanin ranged from scale 1 to 9 with an average score of 4.43 and 6.03, respectively. Eleven (EC 103418, EC 103422, EC 850 - 3137, F 61, NEC 18, NEC 123, NEC 229, NEC 989, NEC 2305, P1528-1 and P2994) and six (NEC 229, NEC 721, NEC 1135, P 992, P1528-1 and V4) genotypes out of 59 studied, had highest intensity of green and anthocyanin pigmentation (score, = 1). For seed yield per plant, 100-seed weight and specific gravity index, 3 genotypes, viz., NEC 550, NEC 108 and NEC 197 were most notable.

Table 2 : Estimates of genetic parameters of variability for structural, phenological, physiological, yield and yield components in chickpea

Traits	Mean $\pm$ SE	Range	Coefficient of variability			Heritability (%)	Genetic advance (per cent over mean)
			Pheno- typic	Geno- typic	Eviron- mental		
Seed yield/plant (g)	13.15 $\pm$ 8.5	4.33–29.67	42.55	41.00	11.38	92.85	81.44
Pods/plant	90.74 $\pm$ 9.19	42.07–154.00	35.64	31.02	17.54	75.77	55.62
Seeds/pod	1.73 $\pm$ 0.10	1–2.60	20.65	18.49	9.19	80.17	34.43
100-seed weight (g)	16.49 $\pm$ 0.43	10.70–33.53	34.12	33.82	4.51	98.25	68.95
Specific gravity index	64.77 $\pm$ 1.66	6.33–95.67	41.01	40.77	4.43	98.84	83.51
Plant height (cm)	83.26 $\pm$ 1.52	68.33–104.20	9.68	9.08	3.17	89.13	17.67
Primary branches	7.61 $\pm$ 0.4	3.27–10.60	29.62	27.97	9.92	89.23	54.37
Stem diameter (cm)	0.72 $\pm$ 0.00	0.56–0.97	13.38	11.98	5.95	80.21	25.19
Days to first flowering	126 $\pm$ 1.14	107–137	5.15	4.91	1.56	90.82	9.64
Days to maturity	197.82 $\pm$ 0.56	192–201	0.92	0.77	0.49	71.28	1.35
Intensity of leaf colour (Grade)	4.43 $\pm$ 0.00	1–9	61.72	61.72	0.00	100.00	126.90
Intensity of purple pigmentation (Grade)	5.03 $\pm$ 0.00	1–9	53.45	53.45	0.00	100.00	110.08

Seed yield per plant had high coefficient of variation both at phenotypic and genotypic levels, which are more than 3 times the coefficient of variability at environment levels. However, highest coefficient of variability was exhibited by intensity of green and anthocyanin pigmentation with no influence of environment. Specific gravity index, pods per plant, primary branches per plant and 100-seed weight also exhibited high coefficient of variability both at phenotypic and genotypic levels. However, pods per plant appeared to be highly influenced by environment. Therefore, selection based on pods per plant may not be quite profitable as compared to the one based on specific gravity index, 100-seed weight and seed yield per plant itself. In general, high heritability estimates were recorded for all yield and yield components as also reported by Chandra *et al.* (1971), Ramanujam and Gupta (1974) and Asawa *et al.* (1977). All structural, phenological and physiological traits also recorded high heritability. Sandhu and Singh (1970) and Gupta *et al.* (1972) had also reported high heritability for plant height and primary branches per plant. Among yield and its components, high heritability was associated with high genetic advance (GA as % of mean) for specific gravity index, seed yield per plant and 100-seed weight. Thus, these traits can be used to select high yielding genotypes. Among structural, phenological and physiological traits, intensity of green pigmentation, intensity of anthocyanin pigmentation and primary branches per plant also had high heritability alongwith high genetic advance, which supplements their choice as characterization traits. Genetic advance was low inspite of high heritability for pods per plant, plant height, stem diameter, days to flowering and days to maturity which can be ascribed to low genetic variability for these traits.

Therefore, the present study revealed sufficient genetic variability for specific gravity index, pods per plant, 100- seed weight, primary branches per plant, seed yield per plant, and intensity of green and anthocyanin pigmentation which can be exploited for improvement of this crop as also characterization traits during selection. Specific gravity index, 100-seed weight and seed yield per plant seem to be most reliable selection parameters. NEC 550, NEC 108 and NEC 197 are elite lines for yield and its components, and can be used in breeding programmes.

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SURVEY AND COLLECTION OF WILD CRUCIFERS FROM CENTRAL HIMALAYAS

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Wild species of plants, through prolonged interaction with pathogens, pests and abiotic stresses, have developed many traits which are important for their survival. On this basis, the wild species of crucifers are likely to be valuable sources of genes important in *Brassica* crop improvement. Studies on wild crucifers have shown that they possess high degree of resistance to some diseases which menace the oil-yielding crucifers. Some wild crucifers also possess traits such as short life-cycle, fruit shattering resistance, pest resistance, frost resistance, drought resistance and some important chemical characteristics. Although some studies have been initiated in this direction, the wild crucifers have so far remained unutilized for improvement of disease resistance and other traits in oil-yielding crucifers. At the same time, genes from alien plants have already been used for improvement of crops such as wheat, sugarcane, sunflower, beans, potato and some others.

Only a few places in the world have authentic and readily available supply of germplasm of wild crucifers. These sources, however, carry germplasm only of a relatively small number of usually local crucifers. Germplasm of crucifers from most geographic regions of the world, for example India and Canada, is nowhere to be found. One of the authors (J.P. Tewari) has been engaged in the study of wild crucifers from many parts of the world for the past several years. Recently, a study was undertaken on wild crucifers from Spain, which is part of centre of diversity of the progenitors of certain *Brassicas*. This communication reports on collaborative survey and collection of wild crucifers from central Himalayas in Uttar Pradesh which was undertaken from August 20-26, 1992.

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A total of 13 species of crucifers belonging to 10 genera were collected from different locations ranging from 500-3800 msl (Table 1). Voucher specimens of the crucifers are kept at the NBPGR Regional Station, Bhowali. Seeds of those crucifers which were in the fruiting stage were also collected. Most of the seed samples are small and will have to be multiplied before any further study. Once this is done, testing of various species for resistance to various biotic and abiotic stresses will be initiated. Subsequently, the identified resistant species will be utilised in *Brassica* improvement programme.

Table 1 : Wild crucifers collected from central Himalayas (Uttar Pradesh)

Name	Locality
* <i>Arabis pterosperma</i> Edgew.	Tapovan and Saldhar
* <i>Barbarea vulgaris</i> R. Br. (Winter cress)	Gopeshwar
* <i>Capsella bursa-pastoris</i> (L.) Moench. (<i>Botyla</i> , Shepherd's purse)	Malari
<i>Cardamine impatiens</i> L. (Chamsuru)	Gairsain
* <i>Crambe cordifolia</i> Steven ssp. <i>Kotschyana</i> (bloss) Jafri (pung)	Somna
<i>Erysimum hieracifolium</i> L.	Tapovan
* <i>Lepidium apetalum</i> Willd. (Pirwa)	Niglat, Chopta, Gopeshwar and Tapovan
* <i>L. capitatum</i> A.K. & T.	Tapovan and Malari
<i>L. sativum</i> L. (Haling, Chamsoor , Garden Cress)	Leeti
<i>Megacarpaea polyandra</i> Benth (Barmoola, Rooki)	Tungnath
<i>Rorripa nasturtium-aguanticum</i> (L.)-Hayek (Gaddri , Water cress)	Devaldhar
* <i>Sisymbrium orientale</i> L.	Char Km and Somna
* <i>S. sophia</i> L.	Char Km

Localities: Niglat, Distt. Nainital; Leeti, Distt. Almora; Remaining localities, Distt. Chomoli (India)

*Seed collected

Another interesting fact of the study of wild crucifers is to elucidate the mechanism of resistance to various stresses. Work on *Camelina sativa* and *Capsella bursa-pastoris* at the University of Alberta has revealed some new sulphur containing, dynamically elicited defence chemicals (Phytoalexins) against certain pathogens. Such naturally occurring chemicals may, therefore, provide clues for the chemistry of novel fungicides. Collection of the germplasm of wild plants from a certain area has to be a continuing process as only

some species are found in the fruiting stage at a particular time of the year. Also, survival of certain wild crucifers and landraces of cultivated crucifers is threatened as result of human activities. Therefore, preservation of biodiversity in this group of plants should be undertaken on an urgent basis so that this valuable resource is not lost.

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