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COLLECTION OF CHICKPEA GERMPLASM IN MADHYA PRADESH, INDIA AND THEIR AGRONOMIC EVALUATION

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Three-hundred-and-fifty-one seed samples of local chickpeas (Cicer arietinum L.) were collected in Madhya Pradesh, India, during 1986 and 1987 for the world germplasm collection maintained at ICRISAT Centre. These missions were joint efforts of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, and the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Vast variability was noticed for several morphoagronomic traits of chickpea during these missions. The collected samples were sorted out into relatively homogenous samples and later grouped into five homogenous sets for easy evaluation. These sets were evaluated for eight agronomic traits at ICRISAT Centre (18°N) and Gwalior (26°N). The performance of accessions for seeds per pod and 100-seed mass were almost similar at both locations whereas other agronomic characters varied with locations. The accessions with superior performance in five sets and two locations were identified.

Chickpea, *Cicer arietinum* L., is the most important pulse crop in Madhya Pradesh (M.P.) state of India occupying about 10 per cent of the total cultivated land (India, 1989). During 1988, 2.24 million ha of chickpea was grown in M.P., representing about 26 per cent of world hectareage under the crop (India, 1989; FAO, 1988). However, in the world chickpea collection maintained at the ICRISAT gene bank, there was inadequate representation from M.P., and further, most of the accessions were lacking precise data on their origin. The state is large, has varied agroecological conditions, and many diverse types of chickpeas are known to exist. A mission was therefore organized to collect germplasm samples, and information on cultivation practices, diversity of chickpea, and problems and prospects of this crop in the region. These collections were evaluated

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for morphoagronomic traits to enhance their documentation and utilization. The collected samples were conserved in the ICRISAT gene bank for present and future use.

MATERIAL AND METHODS

The germplasm collection work has accomplished in two missions, 5-20 March 1986 and 6-21 March 1987. The missions were jointly conducted by ICRISAT, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, and the National Bureau of Plant Genetic Resources (NBPGR), New Delhi (Pundir *et al.*, 1989). The route followed is shown in Figure 1. At the majority of the collection sites, seed samples were obtained from crops in the fields. From each site samples were hand-picked from each of about 100 random plants (Pundir and Mengesha-in press). The random samples of the collections were enriched with the addition of selected samples of rare phenotypic variants, as suggested by Bennet (1970).

The two missions resulted in the collection of 351 seed samples which were heterogeneous populations. To facilitate their effective utilization and for easy evaluation, they were sub-divided into relatively homogenous samples and the entire material was grouped into five sets: 1. twin-podded accessions; 2. Kabuli and large-seeded desi; 3. tuberculated seed types; 4. short-duration typical desi, and 5. medium-duration typical desi. Sets 1 to 4 were evaluated and ICRISAT Centre as Trials 1-4 and sets 2 and 5 as trials 5 and 6 at ICRISAT Cooperative Research Station at Gwalior.

ICRISAT Centre, Patancheru (18°N) represents a characteristic short-season site for the chickpea crop. Experiments were conducted during the 1988-89 and 1989-90 seasons, in Vertisol fields. Sowings were done in first week of November, in augmented randomized block design with three replications. Each plot had 4 rows of 4 m length, with 30 cm spacing between rows and 10 cm between the plants. A basal application of 20 kg N and 60 kg P were applied and protective irrigation and insecticide sprays were also given.

Gwalior (26°N) represents a medium-season site for the chickpea crop. The sowing time and other particulars of the experiments were similar to those carried out at ICRISAT Centre.

Observations were recorded on seven characters, namely days to flowering, duration, plant height, number of pods, number of seeds, seed mass, and yield (Table 1). These are some of the important agronomic traits of chickpeas and have often shown significant correlations with seed yield (Pundir *et al.*, 1988; Raju *et al.*, 1978). From each plot, 10 representative plants were harvested and agronomic records obtained. Plot yield was recorded from all the four rows. The plot observations were statistically analysed if the crop growth was normal with acceptable plant stand (number of plants greater than 60% of the optimal number).

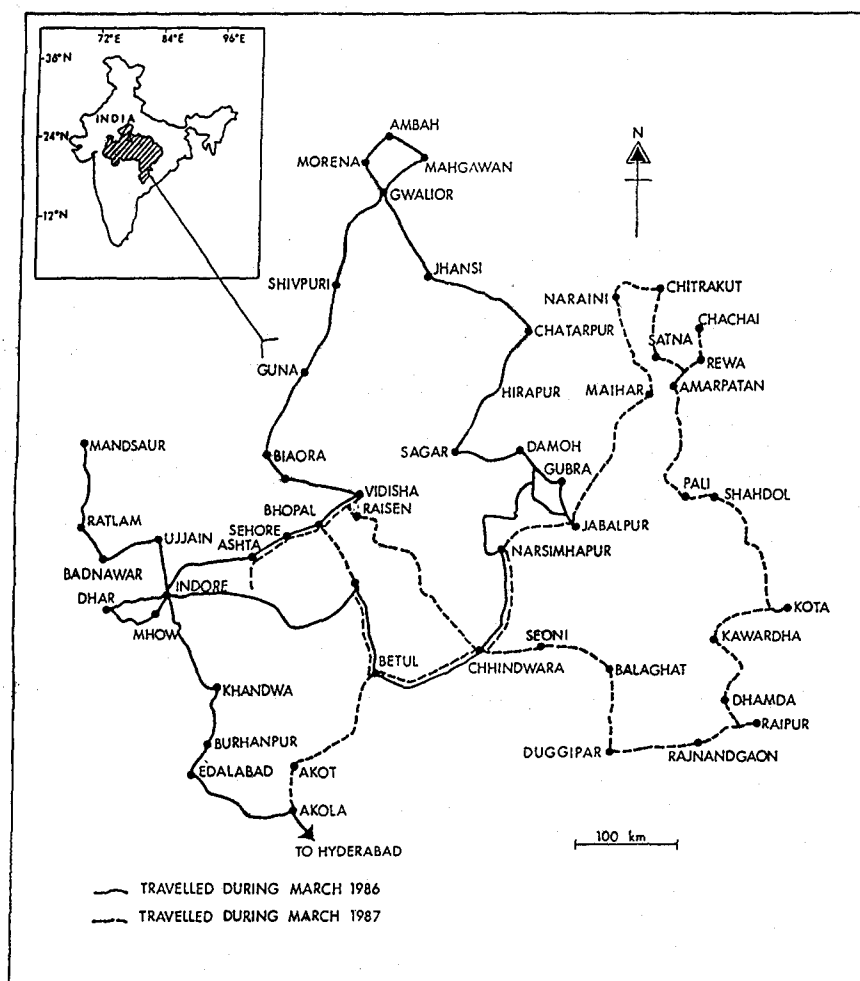


Fig. 1. Map showing route followed during the chickpea germplasm collection in Madhya Pradesh India, during 1986 and 1987

Table 1. Summary results of replicated evaluations of chickpea germplasm originating from Madhya Pradesh, India tested at ICRISAT Centre, Patancheru and Gwalior, 1988-89

AT ICRISAT CENTRE										Top five accessions	
		Days to 50 % flowering	Flowering duration (days)	Plant height (cm)	Pods per plant	Seeds per pod	100-seed mass (g)	Seed yield (kg ha ⁻¹)	Accession No.	Seed yield (kg ha ⁻¹)	
Trial-1											
Twin-podded	Range	46-64	22-33	23.0-27.8	26-47	1.0-1.2	13.6-16.4	839-1211	ICC 14614	1211	
accessions	Mean	50.7	28.7	24.9	35.4	1.1	15.5	1044	JG 62	1200	
Entries: 16	SE	±1.18	±1.02	±0.09	±4.14	±0.08	±0.21	±92.5	ICC 14772	1145	
									ICC 15160	1120	
									ICC 15158	1083	
JG 62 (check)		49	29	25.3	34	1.2	15.7	1200			
Trial-2											
Kabuli and	Range	44-70	25-34	-	18-41	1.0-1.3	13.7-34.0	910-1360	ICC 4953	1360	
large-seeded	Mean	52.0	30.0	-	28.6	1.0	28.0	1160	ICC 14627	1330	
desi accessions	SE	±1.35	±1.20	-	3.57	±0.0	±0.97	±114.4	ICC 15070	1280	
Entries: 24									ICC 14628	1280	
L 550 (check)		62	27	-	29	1.1	19.2	1070	ICC 14637	1260	
Trial-3											
Short duration	Range	46-71	21-31	21.6-31.7	20-42	1.0-1.6	9.9-27.8	870-1817	ICC 15129	1817	
type accessions	Mean	57.6	24.3	25.2	28.2	1.2	13.9	1414	ICC 14750	1796	
Entries: 157	SE	±0.93	±0.74	±0.87	±2.71	±0.07	±0.29	±126.3	ICC 14743	1784	
									ICC 14670	1783	
									ICC 15128	1763	
Annigeri (check)		49	29	24.2	30	1.2	17.9	1317			

Contd....

Table 1. Contd...

Top five accessions									
	Days to 50 % flowering	Flowering duration (days)	Plant height (cm)	Pods per plant	Seeds per pod	100-seed mass (g)	Seed yield (kg ha ⁻¹)	Accession No.	Seed yield (kg ha ⁻¹)
Trial-4									
Tuberculated seed type	Range 39-53 Mean 41.8 SE ± 0.52	32-42 37.8 ± 1.20	21.0-40.8 30.8 ± 1.19	22-56 33.9 ± 3.31	1.0-1.5 1.1 ± 0.07	1.0-27.4 16.6 ± 0.26	854-2448 1966 ± 159.5	ICC 14860 ICC 14780 ICC 15196 ICC 15168 ICC 14849	2448 2435 2370 2345 2338
Entries : 112									
JG 74 (check)	44	37	29.9	30	1.0	16.6	1702		
				AT GWALIOR					
Trial-5									
Kabuli and large-seeded <i>desi</i> accessions	Range 51-89 Mean 69.7 SE ± 4.34	31-64 47.7 ± 4.23	70.5-87.3 76.7 ± 3.84	22-56 38.7 ± 5.22	1.0-1.5 1.1 ± 0.08	16.7-36.3 29.5 ± 0.78	1991-3097 2474.0 ± 246.4	ICC 15115 ICC 14639 ICC 14696 L 550 ICC 14648	3097 3084 2901 2888 2872
Entries : 21									
L 550 (check)	76	42	70.9	43	1.2	23.4	2888		
Trial-6									
Medium and long- duration type accessions	Range 74-90 Mean 83.0 SE ± 1.33	24-38 31.6 ± 2.15	48.5-68.2 57.1 ± 1.68	43-85 60.8 ± 6.22	1.1-1.8 1.4 ± 0.11	12.4-28.3 15.1 ± 0.41	2155-3411 2791.1 ± 172.3	ICC 14817 ICC 14802 ICC 14791 IC 14811 ICC 14798	3411 3355 3344 3315 3224
Entries : 99									
JG 315 (check)	74	38	57.6	63	1.1	14.7	2674		

RESULTS AND DISCUSSION

Germplasm Collection

During both missions, the travel period appropriately coincided with the maturity of chickpea crop and majority of the samples were collected from the farmers' fields. The seeds were shared among the three collaborating institutes.

Often chickpea was sown as a sole crop, though in some cases it was mixed with linseed; "sarson" (*Brassica campestris*, *B. juncea*) or wheat. Seed was generally broadcast in the field with moderate level of land preparation. The crop was sown from September to November depending on optimal soil moisture and harvested from February to April, i.e., in about 110-140 days in different regions. Wherever feasible, the crop was irrigated and large-seeded desi and kabuli types were grown. In general, we noticed good agronomic performance of the crop. Pod-borer damage was minimal and diseases were also not serious. However, sometimes the damage caused by collar rot, Fusarium wilt, and Alternaria blight, were seen. Occasionally, excessive vegetative growth which would lead to low seed yield, was also seen (Pundir *et al.*, 1989).

The chickpea fields that we encountered showed a wide range of variability. Variations of leaf size, plant height, and growth habit were observed. All possible seed types namely typical desi, pink seeded (desi-kabuli intermediate), tuberculated (small projections on seed coat), large-seeded desi and kabuli types were cultivated. In the collected samples, variation in 100-seed mass ranged from 7.0 to 39.1 g with a mean of 15.9 g. However, the majority of samples were between 13 and 17 g per 100 seeds. Twin-podded chickpeas in contrast to single-podded types (common type), were seen in many fields. The crop duration was relatively short (about 110 days) in the southern part of the state and medium (about 140 days) in the northern part. The extent of chickpea diversity in M.P. is comparable with that of Ethiopia (Pundir and Mengesha, 1982), whereas in other Indian states or in other countries, the diversity is much less.

Agronomic Evaluation

A summary of observations on seven agronomic characters from six trials are given in Table 1. In general, all the accessions took fewer number of days to flowering and maturity at ICRISAT Centre than at Gwalior. This comparison is particularly relevant between trial numbers 3 and 6, which consisted of the same set of accessions at both the locations. The number of days to flowering was about 20 per cent longer at Gwalior, than at ICRISAT Centre and the difference was greater for flowering duration, which is a clear indication of prolonged conducive season for chickpea at Gwalior. This resulted in increased number of pods and seed yield. The accessions which produced highest seed yields at ICRISAT Centre did not do so at Gwalior. However, the values of seeds per pod and 100-seed mass were almost similar at both the locations.

The performance of many characters varies according to the environmental conditions and therefore, selection and utilization of the accessions for these characters will be location specific. Undisputedly, however, the researchers across the locations will be interested in the increased manifestation of the three traits: pods per plant, seeds per pod and seed mass, provided that these traits are not inversely related with seed yield. For the benefit of users, we are listing accessions that performed best for these yield traits in the six trials at two locations (Table 2). Though the results are based on replicated trials in different environments, they must still be used as preliminary observations. The seeds are available for research use on request from the Genetic Resources Unit, ICRISAT.

Table 2. Chickpea accessions scoring highest for some yield traits in either of the six trials and in two locations (ICRISAT Centre, Gwalior), 1988-89

Yield trait	Accession numbers			
Number of pods per plant	ICC 14637	ICC 14696	ICC 14718	ICC 14784
	ICC 14818	ICC 14825	ICC 15103	ICC 15122
	ICC 15152	ICC 15154	ICC 15195	ICC 15468
Number of seeds per pod	ICC 4951	ICC 14680	ICC 14684	ICC 14696
	ICC 14704	ICC 14722	ICC 14778	ICC 15115
	ICC 15152	ICC 15155	ICC 15203	ICC 15233
100-seed mass (g)	ICC 4953	ICC 5003	ICC 14648	ICC 14694
	ICC 14713	ICC 14808	ICC 15115	ICC 15160
	ICC 15183	ICC 15201	ICC 15227	ICC 14362

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MAGNETIC STIMULUS: A NOVEL TOOL TO PROMOTE PAPAYA POLLEN GERMINATION

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*Electromagnetic flux produced linear increase 'in vitro' germination and reduced the incubation period of 'mounts' of quiescent papaya (Carica papaya L. cv. 'Washington') pollen. The linear trend for germination began at 18 oersted and continued progressively upto 108 oersted (when the percent increase over control was calculated). At 18 oersteds the per cent increase over control was 6.1 and at 108 oersteds it was 81.8. The best operating strengths were 72 (46.2**), 90 (79.4**) and 108 (81.8**) oersteds. Also, the incubation period of pollen mounts for both germination and tube growth was halved, with germination being more responsive to the treatment than tube growth. Moreover, tube growth did not follow a linear pattern. In tube growth significant increase over control was produced at 90 oersteds (41.9**) and at 108 oersteds (45.2**). At present, possible errors in handling techniques of 'in vitro' viability tests result in valuable and viable germplasm being discarded. This method of magnetic stimulation could be used to break the quiescence of pollen in order to successfully evaluate inherent genetic potential of pollen.*

Sustained substantive success of *in vitro* pollen viability test depends upon many factors; whether pollen be newly collected or conserved (short, medium and long term). Among many interdependent components, genetic potential, nutrient medium, technical manipulation of 'pollen mount', and prevailing conditions of incubation play major roles. If the contributive parameters are not properly controlled a genetically potential germplasm may likely be discarded and lost forever. This is due to the fact that most of the pollen cryobanks base their decision to discard or conserve material, on the basis of viability test.

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**Per cent increase over control

Exposure to magnetic fields has been shown to influence germination of quiescent seeds of sporophytes (Pittman and Ormord 1970). Recently Alexander and Ganeshan (1990) have extended these results to gametophytes. Quiescence of *Carica papaya* L. cv 'Washington' pollen was broken by applying magnetic stimulus, enabling it to express the inherent genetic potential. The experiments on magnetic stimulation of papaya pollen were continued and this report deals with application of magnetic flux varying from 18 to 108 oersteds in order to fix the optimum strength for boosting germination and tube length.

MATERIALS AND METHODS

Two identical bar electromagnets were used as the source of the magnetic pulsing. The magnetic set-up and the electrical and electronic hook-ups used in this experiment were similar as used earlier (Alexander and Ganeshan, 1990). In this experiment one variation was introduced. The alternation consisted in varying the strength from 0 to 108 oersteds, with an 18 oersted increment keeping the exposure time 10 minutes in all treatments.

It was not possible to use other intermediate values due to arrangements of tappings in the step-down transformer. The experimental material was papaya pollen (*Carica papaya* L. cv. 'Washington'). Experimental methods were similar to those followed by Alexander and Ganeshan (1990). In the statistical analysis treatments were compared based on analysis of variance technique using L.S.D. ($P = 0.05$) and per cent change in germination and tube length over control was also calculated.

RESULTS AND DISCUSSION

Table 1 shows the percentage pollen germination and tube length in different treatments. The treatment at 18 and 36 oersteds was at par with the control (zero oersted, ignoring earth's magnetic strength). Maximum germination and tube length were recorded at 108 oersteds. A linear trend with increase in magnetic field strength was evident, which was broken at 72 giving a 'staircase pattern'.

Alexander and Ganeshan (1990) energised papaya pollen at 96 oersted and obtained increased germination and tube length for a 2 hour incubation period. The pollen germination and tube length recorded in the present study for a corresponding magnetic flux are in close agreement with the previous results.

The influence of the magnetic stimulus on pollen tube growth is more critical requiring precise operative methodology more familiar to biophysicists than agro-biologists. *In vitro* germination is a useful tool for pollen viability assessment. The stimulus operates over a wide range of strength for

Table 1. Effects of varying electromagnetic field on *in vitro* germination and tube length of *Carica papaya* L. cv. 'Washington' pollen

Magnetic flux (in oersteds)	Mean ger- mination (%)	Per cent increase over control	Mean tube length (μ)	Per cent increase over control
0 (Control)	27.75 a	—	237.89 a	—
19	29.43 a	6.1	233.50 a	- 1.8
36	31.86 a	14.8	277.00 a	+ 16.4
54	45.00 bc	62.2	318.50 bc	+ 33.9
72	40.58 b	46.2	308.00 b	+ 29.5
90	49.77 c	79.4	337.50 c	+ 41.9
108	50.46 c	81.8	345.50 c	+ 45.2
SE _d	14.42		3.21	

Treatments followed by same alphabets are not significantly different with respect to mean % values of germination and tube length.

germination. So it could be adopted in viability evaluations. Application of magnetic stimulus in bioscience is only three decades old. Scientific interests in this filed started late in the 1950s and continued till 1970.

Magnetic stimulus is responsive to magnetically receptive materials. Biological systems are paramagnetic, hence the response is not clearly understood. Pittman and Anstey (1967), Pittman and Ormrod (1970) and Commoner *et al.*, (1957) explained the action of the stimulus on biological systems. Commoner *et al.*, (1957) attributed influence of magnetism on reaction rate of enzymes to paramagnetic molecules and free radicals in the system. He concluded that for a given magnetic stimulus the processes that normally occur before DNA duplication are influenced.

Stimulation of pollen under magnetic field is suggested as a new tool for *in vitro* pollen germination. This stimulation is useful in expressing the inherent genetic potential of germplasm in terms of *in vitro* viability. In addition to this the incubation period is halved (papaya takes 4 hrs to register 51.5% germination; Ganeshan, 1985). Thus more samples could be evaluated.

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GENETIC DIVERGENCE IN SAFFLOWER (*CARTHAMUS TINCTORIUS* L.)

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Genetic divergence analysis revealed that twenty eight genotypes were grouped in 12 clusters. Cluster II comprised five genotypes one each from Australia, GDR, Pakistan, Japan and USSR whereas clusters VIII to XII were represented by single genotype from Iran, Greece, Syria and India respectively. The common evolutionary trends were obvious, since the genotypes spaced apart were grouped together. It was also revealed from grouping pattern that the nature of selection forces operating under domestic conditions seems to be unidirectional for accumulating similar gene pool across the geographical barriers since genotypes from countries far apart got grouped together. The present study helped in isolating genotypes with high cluster means which are useful for breeding programme. However, geographical diversity was observed to be not strictly related to genetic diversity. This analysis also helped in identifying genotypes which are genetically divergent.

Variability in the population, especially for characters where improvement is sought for, is an indispensable pre-requisite for successful crop improvement programme. A broad spectrum of variability in segregating generation can be generated by crossing genetically diverse parents. The D^2 technique (Mahalanobis, 1936) has been found to be a powerful tool to estimate genetic divergence among populations of different yield components to total diversity. To identify the genotypes of distinct characteristics to be utilized as donor parents, the present investigation was planned to evaluate 28 promising safflower germplasm lines originating from twenty six countries.

MATERIALS AND METHODS

Twenty eight promising safflower lines were chosen from large number of collections maintained at the NBPGR, Regional Station, Akola and Oilseed Research Station (Mahatma Phule Krishi Vidyapeeth), Jalgaon. One culture from each country source along with 3 lines from India namely 'Tara'; IC 1394 and CTS 7218 were selected on the basis of its yield performance. The trial of 28 varieties was conducted in randomized block design replicated thrice. The plot size being 2 rows of 3 metres long and 75

cm apart, number of plants/row being 20. The sowing was done on 12th Nov., 1980. The crop was raised under irrigated conditions with standard cultural practices.

The observations on fifteen quantitative characters viz. days to 50 per cent flowering, plant height, height up to 1st primary branch, number of primary branches, angle of 1st primary branch, days to 50 per cent maturity, number of capitula per plant, capitulum length, capitulum diameter, size of outer involucre bracts (OIB), number of seeds per capitulum, 100 seed weight, seed yield per plant, oil content and oil yield per plant were recorded on five random plants. For estimation of genetic divergence, D^2 statistics (Mahalanobis, 1936) was used. The cluster formation was done by Tocher's method (Rao, 1952).

RESULTS AND DISCUSSION

Based on D^2 values, the twenty eight genotypes of safflower could be grouped in 12 clusters. The cluster means for each group for 15 characters are given in Table-1. The grouping pattern of 28 varieties of safflower in different clusters is presented in Table 2. Cluster-I consisting of four genotypes representing Afghanistan, Egypt, Kenya and Spain. Cluster-II was the largest having five varieties from Australia, GDR, Pakistan, Japan and USSR. Cluster-III was formed by varieties from Algeria, Sudan and USA and Cluster-IV with four genotypes from Mexico, Morocco, Philippines and India. The Cluster-V and VI both comprised two cultures each from Ethiopia and Jordan (Cluster-V) and France and Israel (Cluster-VI). In Cluster-VII, three genotypes were from Portugal, Turkey and Rumania. Cluster-VIII to XII were represented by single genotype originating from Iran, Greece, Syria and India respectively. The clusters with single genotype were characterized distinctly. Genotype JL-1329 from Iran (Cluster-VIII) is very late in flowering, tall growing, low seed and oil yielding and JL-1462, ex-Greece, falling in Cluster-IX was the dwarfest, early with appressed branching habit and very small seeds. JL-1439 in Cluster-X, JL-1394 in Cluster-XI and CTS-7218 in Cluster-XII were also characterized by maximum oil content and seed yield; bold seeds, widest angle and bold capitulum, with maximum seeds per capitulum respectively.

Marked differences between different clusters in respect of all the characters under study were observed (Table 1). The variability range observed for days to 50 per cent flowering (92–113 days), plant height (80–147 cm), height up to 1st primary branch (21–77 cm), number of primary branches (5.3 – 9.9), angle of 1st primary branch (27–44°), days to 50 per cent maturity (124–138 days), number of capitula per plant (20–33),

Table 1. Cluster means for 28 varieties of safflower for genetic divergence

Cluster group	Varieties/ cluster	Source country	Days to 50 % flowering	Plant height (cm)	Height up to 1st branch (cm)	No. of primary branches	Days to 50 % maturity
I	1,6,11,20	Afghanistan, Egypt, Kenya and Spain	106.25	123.62	50.37	7.63	135.47
II	2,4,19,22,24	Australia, GDR, Pakistan, Japan and USSR.	98.20	98.25	27.69	8.31	127.19
III	9,17,25	Algeria, Sudan and U.S.A.	100.60	95.80	32.22	9.13	133.09
IV	12,13,21,26	Mexico, Morocco, Philippines, India	97.91	95.60	21.03	9.89	127.83
V	3,10	Ethiopia and Jordan	106.80	127.03	42.73	7.57	133.00
VI	7,23	France and Israel	101.36	121.23	51.23	7.12	127.87
VII	14,16,18	Portugal, Turkey and Rumania	99.44	108.89	42.87	7.40	130.70
VIII	5	Iran	112.13	146.40	76.87	8.07	137.57
IX	8	Greece	99.50	79.87	34.13	5.33	126.73
X	15	Syria	108.20	128.53	51.00	7.80	138.27
XI	27	India	92.07	89.13	33.27	9.13	124.07
XII	28	India	98.93	100.73	36.00	8.13	132.00

Contd...

Table 1. Cont'd...

Cluster group	Varieties/ cluster	Source Country	Angle of 1st primary branch	No. of capitula per plant	Capitulum length (mm)	Capitulum diameter (mm)	Size of involucre bract (sq. mm)
I	1,6,11,20	Afghanistan, Egypt, Kenya and Spain	31.43	24.92	22.05	18.89	16.33
II	2,4,19,22,24	Australia, GDR, Pakistan Japan and USSR	35.95	24.87	21.69	18.10	18.21
III	9,17,25	Algeria, Sudan and U.S.A.	36.49	23.36	20.20	16.93	16.29
IV	12,13,21,26	Mexico, Morocco, Philippines, India	43.08	32.68	20.35	16.48	15.10
V	3,10	Ethiopia and Jordan	32.20	21.48	19.03	15.33	15.58
VI	7,23	France and Israel	36.13	22.98	19.53	15.97	15.10
VII	14,16,18	Portugal, Turkey and Romania	35.56	23.78	21.64	18.49	11.79
VIII	5	Iran	38.67	22.00	18.93	16.13	15.17
IX	8	Greece	26.40	22.13	19.80	17.00	13.33
X	15	Syria	38.55	30.80	21.60	18.00	13.13
XI	27	India	43.67	27.40	21.60	18.07	19.03
XII	28	India	38.33	20.00	24.73	20.53	19.0

Contd...

Table 1 Contd...

Cluster group	Varieties/ Cluster	Source country	No. of seeds per capitulum	100-seed weight (g)	seed yield per plant (g)	Oil content (%)	Oil yield per plant (g)
I	1,6,11,20	Afghanistan, Egypt, Kenya and Spain	48.52	3.37	35.08	37.10	12.88
II	2,4,19,22,24	Australia, GDR, Pakistan, Japan and USSR.	37.73	3.50	30.99	37.19	11.49
III	9,17,25	Algeria, Sudan and U.S.A.	37.33	2.88	24.21	38.79	9.19
IV	12,13,21,26	Mexico, Morocco, Philippines and India	32.93	3.74	34.77	37.74	13.23
V	3,10	Ethiopia and Jordan	39.17	2.70	22.08	41.08	9.05
VI	7,23	France and Israel	39.10	4.93	36.79	42.40	15.73
VII	14,16,18	Portugal, Turkey and Romania	36.39	3.87	31.19	37.14	11.61
VIII	5	Iran	26.60	2.23	12.61	39.40	5.19
IX	8	Greece	34.13	1.73	19.81	38.43	4.97
X	15	Syria	48.33	4.29	61.60	36.70	22.56
XI	27	India	31.20	5.93	45.80	35.73	16.83
XII	28	India	72.40	3.39	48.74	42.43	20.63

capitulum length (19–25 mm), size of OIB (12–20 sq mm), seeds per capitulum (27–72), 100 seed weight (1.73–5.92 g), oil content (35.7–42.4%), seed yield per plant (12.6–61.6 g), oil yield per plant (4.97–22.56 g). Maximum genetic diversity was present between Cluster-IX and X (27.77) represented by Iran and Syria respectively, followed by Cluster-IX and XII (23.43). The minimum divergence was exhibited between Cluster-III & VII (8.96) represented by genotypes from Algeria, Sudan and USA and Portugal, Turkey and Rumania respectively. The combinations of clusters which exhibited higher magnitude of genetic divergence were cluster-VIII and XI (22.37), IX and XI (22.21), VIII and XII (22.09), III and X (21.20) and XI and XII (21.03).

Table 2. Clustering pattern of 28 safflower lines

Cluster No.	No. of varieties	Name of the varieties with origin
I	4	JL-1446 Afghanistan JL-1284 Egypt JL-1006 Kenya JL-1375 Spain
II	5	JL-1518 Australia EC-36340 GDR JL-1325 Pakistan JL-1570 Japan JL-1544 USSR
III	3	JL-985 Algeria JL-1035 Sudan JL-127 USA
IV	4	EC-42477 Mexico JL-1038 Morocco JL-1136 Philippines Tara India
V	2	JL-896 Ethiopia JL-1342 Jordan
VI	2	JL-915 France JL-1337 Israel
VII	3	JL-1391 Portugal JL-1356 Turkey JL-991 Romania
VIII	1	JL-1329 Iran
IX	1	JL-1462 Greece
X	1	JL-1439 Syria
XI	1	IC-1394 India
XII	1	CTS-7218 India

The Intra-cluster distance ranged from 0:00 to 12.24. The intra-cluster distance was highest in Cluster-I (12.24) followed by Cluster-VI (11.02). The minimum intra-cluster distance other than those where single genotype formed clusters was 6.80 for cluster VII represented by JL 1391, JL 1356 and JL 991 from Portugal, Turkey and Romania, respectively.

It would be interesting and perhaps also more useful for the breeders to assess whether the genotypes differ when all the characters are considered simultaneously. It was also helpful in the choice of the parent material for specific breeding objectives, since it is known that exploitation of heterosis for yield and success of obtaining desirable recombinants is dependent on degree of divergence between the parents chosen. The utility of multivariate analysis and D^2 analysis in quantifying the degree of divergence between populations to understand the trend of evolutionary pattern, to assess the relative combination of different components of yield to the total divergence and to determine the nature of forces operating at intra and inter cluster levels has been emphasised by various workers in different crops. viz. brown sarson (Murthy and Quadri, 1966), groundnut (Sangha, 1973), *rai* (Trehan *et al.*, 1975), and in safflower (Patil *et al.*, 1982; Agrawal *et al.*, 1982; Alba *et al.*, 1984 and Patil *et al.*, 1984). Such study would also help in picking up genetically divergent parents to obtain desirable recombinants in segregating generation (Ram and Pawar, 1970).

The representation of various clusters showed that in many clusters, the genotypes falling in them originated wide apart in space suggesting thereby that distance in space is not related to genetic divergence in safflower crop. However, the representation of genotypes in few clusters have showed the geographical relationship in safflower (Agrawal *et al.*, 1982, Alba *et al.*, 1984 and Patil *et al.*, 1984). Twenty three varieties were grouped into seven clusters and remaining five in single variety clusters confirming different genetic base even in the strains of same origin, eg., three varieties of indigenous origin grouped in 3 clusters i.e. Cluster-IV, XI and XII. The maximum genetic diversity was observed between Cluster IX and Cluster X represented by genotypes from Iran and Syria respectively, while minimum divergence was exhibited between Cluster-III and VII. This offers ample scope for selecting desired genotypes from cross combinations involving genotypes from these diverse groups, rather than utilizing genotypes falling within the same group, since this will be based on narrow genetic differences and is bound to limit the scope for useful genetic advance.

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BAMBOO GERMPLASM-DIVERSITY AND CONSERVATION IN NORTH-EAST INDIA*

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Results of survey, collection and live-conservation of bamboo germplasm between 1984-90 at ICAR Research Complex for NEH Region, AP Centre, Basar under the All India Coordinated Research Project on Under-Utilized and Under-Exploited plants are discussed. North-East India is the home of diversity of bamboo germplasm and accounts for half of the total species variability in the country. Sixty three species were reported to occur in this region. Thirty species have established well in the live-collections out of 8 genera viz. Bambusa (12 species), Dendrocalamus (6 species), Cephalostachyum (3 species) Arundinaria (2 species), Phyllostachys (2 species), Pseudostachyum (1 species) and Teinostachum (1 species). Their prevalence, local name(s), habitat frequency and preliminary categorization for general vigour or utility class is discussed. The live collections of bamboos could be broadly classified into tall and sturdy (14 species), medium tall (3 species), medium short highly prolific (5 species), wild but cultivable (2 species) and wild types (6 species). Nine species were reported for food from young sprouts, 5 were suggested useful for live fencing of jhum (shifting cultivation) fields, 9 were used for pulping and 18 could be used for light timber. Status of live collections as in June 1990 is documented.

Bamboos are integral part of life of tribal folks in India. These serve rural people in several ways from cradle to coffin e.g., for shelter, food, industry, medicine, ethno-religious rituals and energy plantation. Though bamboos are basically tropical plants (ers. comm.) yet nearly half of their species diversity in India is available in North-Eastern region alone. The existing diversity in this region was reported to be 58 species belonging to 16 genera as against 116 species from all over India (Varmah and Bahadur, 1980). Subsequent reports included an inventory of North-East Indian

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bamboos showing the distribution of 54 species, representing 15 genera, in the seven states (Shukla, 1986) and a preliminary appraisal for the occurrence of 40 species of bamboos in different altitude zones of Arunachal Pradesh (Haridasan *et al.*, 1986), thereby adding up 8 species which were not common in the former. Another rare species, *Pleioblastus simonii* (Carriers) Nakai, was reported from Arunachal Pradesh (Naithani and Bennet, 1986). Thus, the number of species of bamboos in the North Eastern region counts to 63. A few might be added further to this list.

Systematic efforts were taken up under the All India Coordinated Research Project on Under-utilized and Under-exploited Plants to survey, collect, conserve and document this variability besides other related studies. The studies were conducted between 1984-1990 at ICAR Research Complex for NEH Region, Arunachal Pradesh centre located at Basar (27°95' N latitude, 94°70' E longitude and 660 m altitude above a.s.l.), Kochhar (1986), in the approach paper for present studies, apprehended the variability in bamboos to be confounded due to polymorphism, indefinite non-identification of many collections because of long flowering cycle or lack of other marker traits and likelihood of repeat sampling due to different growth stages of some material yet having different tribal names. The higher-order of available diversity is further clear from the fact that the number of identified species from this region increased from 48 in the Gamble's list to above 63. Nonetheless, the need for preserving germplasm was strongly emphasized because the number of predominating semi-cultivated types was very low (5-7 species) in contrast with the splendid variability of bamboos available in the North-East.

During these studies extensive survey was conducted in the states of Arunachal Pradesh, Assam, Meghalaya, Nagaland and Tripura. In Arunachal Pradesh, survey was conducted in representative areas of almost all geographical districts whereas in other states these were limited to a few pockets (Fig. 1). One to two exploration trips were conducted every year in addition to short duration specific collection tours. A total of 53 classified or unidentified types (biotypes or variant species) were collected out of which 37 distinct types established at Research Farm, AP Centre, Basar. This conserved germplasm belongs to 8 different genera and 30 identified species (Table 1). A nearly equal number of more variants were collected during these exploration trips which, however, could not survive when planted at Basar. The objective of this paper is to document only the conserved variability of bamboos (Upto June, 1990) for future reference of the users.

GENERIC DIVERSITY AND DISTRIBUTION

Out of the eight genera represented by the bamboo collections available at AP Centre, Basar (Table 1), the maximum diversity is shown in the genus

Table 1. Particulars of various species of bamboos established at Arunachal Pradesh centre, Basar upto June, 1990

Sl. No.	Species	Common Name	Place, District of Collection	Month/Year of planting	Number of clumps	Status	General Category	Usage Class(es)
1	2	3	4	5	6	7	8	9
I. <i>Bambusa</i> (12 species)								
1.	<i>B. tulda</i>	Ejo (1), Diban(2), Hojo/Hoji (5), Jati (8), Serangjai/Serangtah (10), Bari (11)	Basar, W. Siang Lal Mati, Kohima Mowlin (NH 40), Khasi Hills; FRI, Dehradun	04/85 10/85 10/87 11/87	9	I (5) II (2) II (2)	I	I-V
2.	<i>B. pallida</i>	Eso (1), Someng/Some (2), Hosi (5), Bijuli (8), Murlibah (12) (Bio-type), Skien (10)	Basar, W. Siang NH 36, Karbi Anglong	04/85 10/85	5	I (5)	II	II-IV
3.	<i>B. nutans</i>	Dibang (2), Mokai/Mokol(8), Sejangtiah/Serangjai (10)	Chessa, L. Subansiri	06/85	2	I (6) IV (1)	I	I-V
4.	<i>B. polymorpha</i>	Paura (11)	Sipaijola,	10/85	2	I (2)	I	II-IV; O
5.	<i>B. cacharensis</i>	Boom (11)	Chodeh Devta, W. Tripura	10/85	2	I (2)	I	I-IV
6.	<i>B. nana</i> syn. <i>B. glauscens</i> <i>B. glauscens</i>		Chessa, L. Subansiri	06/85	2	I (2)	III	III-V; O
7.	<i>B. multiplex</i> syn. <i>B. glauscens</i>	Hedge Bamboo (17)	Chessa, L. Subansiri	06/85	1	I (1)	III	III-V; O

Cont....

Table 1 Cont....

Sl. No.	Species	Common Name	Place, District of Collection	Month/Year of planting	Number of clumps	Status	General Category	Usage Class(es)
1	2	3	4	5	6	7	8	9
8.	<i>B. baloa</i>	Boluka (8) Dzutere (14)	Chessa, L. Subansiri	06/85	2	I (2)	I	I-IV
9.	<i>B. arundinacea</i>	Katva (16)	Chessa, L. Subansiri	06/85	1	I (1)	I	I-V
10.	<i>B. variegata</i>	Variegated Bamboo (17)	Shillong lake, Khasi Hills	10/87	1	II (1)	III	II-IV; O
11.	<i>B. vulgaris</i>	-	Naharlagan, L. subansiri	04/89	1	II (1)	I	II-V
12.	<i>B. khasiana</i>	Tabum (1)	Sododoke, W. Siang	07/88	2	II (2)	V	IV
II. <i>Dendrocalamus</i> (6 species)								
13.	<i>D. hamiltonii</i>	Eni (1), Eom (2), Epo (3), Eb1/Heni (5), Yai (6), Et E/Het E (6) (wild forms), Karan Wah (7), Kako (8) Rahto (13), Bakkan (15), Barak/Sil Barak (11)	Basar, W. Siang Zoram, L. Subansiri Akashi Ganga, W. Siang	04/85 09/88 08/89	5	I (2) II (3)	I	I-V
14.	<i>D. hookerii</i>	Seijong (10) Et E/Hus (E5) Tama Bans (9)	Umbir (Nh 40), Khasi Hills	10/87	1	II (1)	I	I-IV
15.	<i>D. giganteus</i>	Surung (2) Aph1 Bo (13)	Sema, Dnapur	10/87	2	II (2)	I	I-V
16.	<i>D. sikkimensis</i>	Egi (1)	Basar, W. Siang	04/85	2	I (2)	I	II-IV

Cont....

Table 1 Cont....

Sl. No.	Species	Common Name	Place, District of Collection	Month/Year of planting	Number of clumps	Status	General Category	Usage Class(es)
1	2	3	4	5	6	7	8	9
17.	<i>D. sahnii</i>	Helap (5)	Zoram, L. Subansiri	09/88	1	II (1)	II	II-IV
18.	<i>D. longispethus</i>	-	F.R.I. Dehradun	11/89	1	IV (1)	I	I-IV
III. Cephalostachyum (3 Species)								
19.	<i>C. pergracile</i>	Madang (2) Magang (4)	Pasighat, E. Siang	08/89	1	II (1)	I	II-V
20.	<i>C. fuschianum</i>	Taok (1)	Garu, W. Siang	08/89	1	IV (1)	I	II-IV
21.	<i>Cephalostachyum</i> Sp. novo		Likabali, W. Siang	08/89	1	IV (1)	I	II-IV
IV. Chimonobambusa (3 species)								
22.	<i>C. griffithiana</i> syn. <i>Arundinariid griffithiana</i>	Boji (1) Budh (5) Tabyo (6)	Basar, W. Siang Highest point, L. Subansiri	04/86 09/88	2	II (2)	IV	IV; O
23.	<i>C. callosa</i> syn. <i>Arundinaria callosa</i>	Tao (1), Reji (5)	Sago, W. Siang	09/88	1	IV (1)	V	IV
24.	<i>C. armata</i> syn. <i>Arundinaria armata</i>	Ebum/Hibum (5)	Ziro-Daporijo Road	08/98	1	II (1)	IV	II-IV

Cont....

Table 1 Cont....

Sl. No.	Species	Common Name	Place, District of Collection	Month/Year of planting	Number of clumps	Status	General Category	Usage Class(es)
1	2	3	4	5	6	7	8	9
V. <i>Arundinaria</i> (2 species)								
25.	<i>A. hirsuta</i>	Sejnaka (10)	Shimit, Khasi Hills	10/87	2	II (2)	III	III-IV; 0
26.	<i>A. manii</i>	Tajir (1)	Doke, W. Siang	09/88	1	II (1)	V	IV
VI. <i>Phyllostachys</i> (2 species)								
27.	<i>P. manii</i>	Tabo (1)	Mebo, E. Siang Basar, W. Siang	08/88	2	II 92)	III	III-IV; 0
28.	<i>P. assamica</i>	Tabo/Tabye (5) Bije (6)	Zoram, L. Subansiri	09/89	2	II (2)	II	II-IV
VII. <i>Pseudostachyum</i> (1 species)								
29.	<i>P. polymorphum</i>	Tador (1), Tadol (4)	Gori, W. Siang	04/88	1	II (1)	V	IV
VIII. <i>Teinostachyum</i> (1 species)								
30.	<i>L. helferii</i>	-	GTC, Pasighat, E. Siang	09/89	1	IV (1)	V	(IV)

Dialect code : Adi Gallong (1); Adi Minyong (2); Adi Borhi (3); Adi Padam (4); Nishi (5); Apatani (6) Khanti (7)—All from Arunachal Pradesh); Assamese (8); Nepalese (9); Khasia (10); West Tripuri (11); Karbi Anglong (12); Angami Naga (13); Nagamese (14); Manipuri (15); Hindi (16); English (17)

Status (of establishment) code : Fully growth (I); Established (II); Juvenile (III); Tentative (IV)

General category Code : Tall & sturdy (I); Medium tall (II); Medium short (III); Wild cultivable (IV); Wild (V)

Usage Class Code: Pulping (I); Timber (II); Handicraft & Furniture (III); Miscellaneous (IV); Food (V); Live fencing (0)

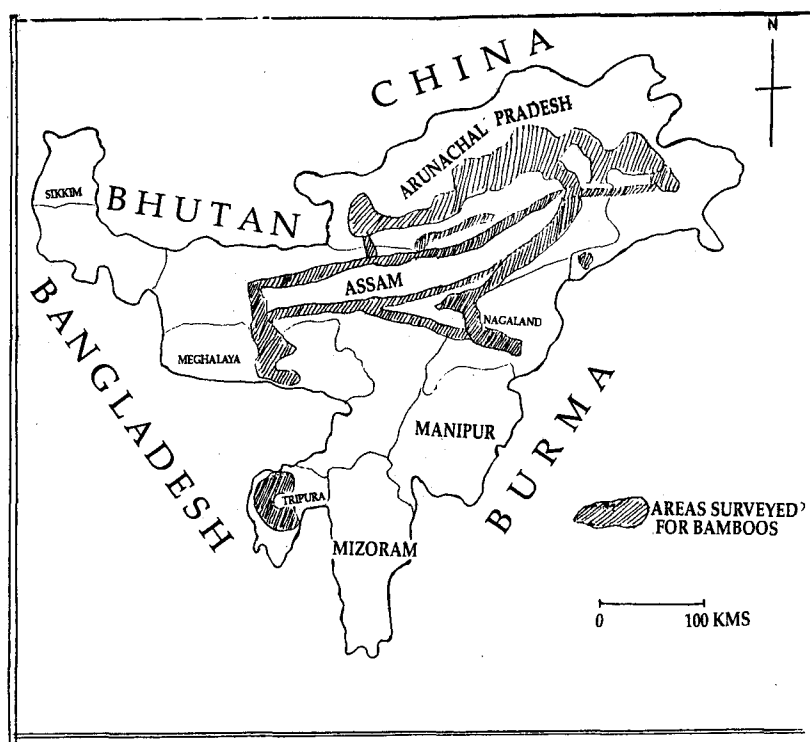


Fig. 1. Areas surveyed for Bamboos (1984-1990)

Bambusa. Twelve species of *Bambusa* established well which comprise 4 species viz., *B. tulda*, *B. pallida*, *B. nutans* and *B. balcoa* spread over the entire North Eastern region, two species (*B. polymorpha* *B. cacharaensis*) found frequently in the southern part of the region, i.e., the states of Tripura and North Cachar. One species, viz., *B. khasiana* was found in frequent wild patches in Arunachal Pradesh and the rest were non-native cultivated species.

The genus *Dendrocalamus* ranked second to *Bambusa* in terms of conserved diversity. It was represented by 6 species, out of which *D. hamiltonii* and *D. hookerii* were abundant in different zones within the region. These two species together cover more than half the tonnage potential of bamboos in the North Eastern States. Two species, *D. giganteus* and *D. sikkimensis* were found semi-cultivated to semi-wild in low frequency. *D. sahnii* was a rare species from Zoram, lower Subansiri district whereas *D. longispathus* was a non-native cultivated species yet tentatively established.

Two genera viz. *Cephalostachyum* and *Chimonobambusa* were represented by 3 species each. *C. fuschianum* is a scendant, wild, hill bamboo available frequently in Siang; *C. pergracile* is a cultivated species native of the Far East and seen in very low frequency during survey whereas another

Cephalostachyum sp. novo was a new report from Likabali, West Siang and is tentatively established. The spinous-at-nodes bamboos from the genus *Arundinaria* were recently regrouped botanically under the genus *Chimonobambusa*. Two confirmed species, *C. friggithiana* and *C. callosa* found frequently, and one *C. armata* syn. *A. armata* Gamble available in rare frequency, all wild and hilly, are now established in live collection.

The genera *Arundinaria* and *Phyllostachys* are represented by 2 species each. *A. hirsuta* and *P. assamica* are highly cultivated species in Shillong and lower Subansiri areas respectively. *A. manii* (wild) and *P. manii* (semicultivated) have got ethno-religious importance particularly in Siang and Subansiri. All these species are well established. *Pseudostachyum polymorphum* is the only species representing its genus in the live collections. It is a wild, abundant to frequent species in the understory of forest thickets in patches, in the entire northern part of the region; considered of least significance due to thin culms, yet used extensively for various purposes like fencing, rope making, walking sticks in thickets etc. Similarly, *Teinostachyum helferii*, is a singly represented species for the genus. It is a rare wild species surveyed in Siang and is tentatively established.

In addition to the above conserved species, the variability in bamboos was surveyed and collected for species belonging to the genera *Melocana*, *Melocalamus*, *Oxytenanthera* and *Pleioblastus*. More than 10 botanically unidentified local types were also collected. These materials, however, failed to establish, died after initial establishment or died on flowering after establishment (e.g. *Mritinga*, *W. tripuri*) and hence are not documented.

APPRAISAL OF SPECIES DIVERSITY

A brief description of individual species of bamboos conserved is given in Table 1. This conserved diversity is viewed and presented with respect to local tribal name (s), place of collection, planting date, number of clumps, their status of establishment, general category (clump morphology) and usage class(es). Salient features of the species for the above parameters along with their availability (frequency), habitat, niche, polymorphic forms and common or anticipated utility are discussed.

I. BAMBUSIA

Bambusa tulda : It is a tall and sturdy semi-cultivated, masculine bamboo highly preferred for cultivation in low altitude to mid-hills throughout the region particularly the northern part. Profuse branching at lower nodes is characterized in *B. tulda*. The habitat ranges from open valley to mid hill slopes adjoining the thick forest areas. A definite change in population behaviour was observed within species in the contrasting habitat. In the valley area, average clump height and general vigour as

determined by number of culms per clump, culm diameter and internode length were higher as compared to the corresponding performance at mid-evaluation range; culm thickness, however, showed a reverse trend (Kochhar *et al.*, 1989). Eight different tribal names were recorded for *B. tulda* during the survey and collection trips (Table 1). The species is good for timber, pulping and furniture making, young sprouts are edible but not commonly preferred for consumption. Nine clumps of 4 different morphotypes of *B. tulda* one each from Siang, Nagaland, Meghalaya and Dehradun were established well. Sporadic flowering was recorded in this species at Doimukh, Lower Subansiri (Arunachal Pradesh) in 1987. A variant *Khupari* from Medziphema, Nagaland is botanically unconfirmed yet but resembles more with *B. tulda*.

Bambusa pallida : It is a medium tall, slender, semi-cultivated, bamboo found under cultivation all along with North Eastern Hill region. The species is conspicuous due to smaller leaves with white powdery ventral surface. Habitat varies widely from cultivated to semi wild conditions, in the valleys to mid-hills. The population behaviour of *B. pallida* in contrasting environments varies similar to that of *B. tulda*. A distinct biotype with longer internodes and lesser culm diameter, used for flute making, was available in Assam valley. Seven different tribal names were recorded for *B. pallida* (Table 1). The species is widely used for light decorative work, flooring and indoor walling in the bamboo mole houses, furniture work and young edible sprouts. The live collection of *B. pallida* is represented by two biotypes collected one each from Siang and Karbi Anglong. Flowering was seen in this species in larger patches in Siji, Kamki and Doje in West Siang and in sporadic fashion at a few more sprouts during 1987-88 (Kochhar and Rai, 1987). Improvement studies through chemical treatment were taken up from natural seedlings collected from Siji and a good response of ethereal treatment was obtained (Kochhar *et al.*, 1991).

Bambusa nutans : It is a tall, semicultivated, slender but sturdy bamboo having close resemblance with *B. tulda* for height and vigour and with *B. pallida* for leaf size and few branches at nodes. Its frequency is lower than the above two species. Five tribal names are recorded for this species in Table 1, out of which 3 are common with those of *B. tulda*. It is commonly used for timber and usable for pulping. Young sprouts are edible but less preferred. It is represented by one fully grown and another tentatively established clump. A few clumps were seen in flowering in district North Lakhimpur in 1987.

Bambusa pulymorpha : It is a tall growing cultivated species. It is used for timber, making handicrafts and as wind break. The sample was collected from fully grown natural seedlings in 1985 from Tripura where

it is locally known as *Paura*. A severe incidence of thrips was recorded on both the established clumps of this species at Basar during 1989.

Bambusa cacharensis : It is the taller, sturdy bamboo in live collections at present because giant bamboo has shown slow initial growth. Its common name was *Boom* in Tripura from where it was collected in 1985 as rhizome sample. *B. cacharensis* has good potential for timber and pulping. The species showed better adaptability potential on mid-hill slopes at Basar.

Bambusa nana syn. *B. glauscens* and *Bambusa multiplex* syn. *B. glauscens*: These are medium short, highly/prolific, non-native, cultivated species adapted well in plains as well as mid hills. Although the two species have been renamed into single *B. glauscens* yet there are enough phenotypic differences to warrant these two separate types for cultivation purposes. *B. multiplex* is having very thin culms and leaves as compared to with *B. nana*. The sprouts are edible. Further, due to high prolificacy and dense clumps these species can be used for live fencing in the local *jhum* (shifting-cultivation) fields.

Bambusa balcoa : It is the tall, cultivated, strongest bamboo prevalent mostly in valley areas in Assam. It is characterized by a thick tuft of branches at lower nodes like *B. tulda*. The middle branch is curved like sicklet. Its frequency was found occasional in Siang, Subangiri and Kohime districts during survey. The species is good for timber and pulping. Initial growth of *B. balcoa* was slower at Basar than in valley areas.

Bambusa arundinacea : It is a cultivated non-native species earmarked as National Check. It is a tall, sturdy bamboo characterized by spines on culm branches. It is extensively used for pulping and the young sprouts are edible. At Basar, it suffered with a heavy incidence of sooty mould and black ants during 1989 on the sole surviving clump.

Bambusa vulgaris : It is a tall, cultivated, non-native species characterized by green and yellow vertical stripes on culms. It is used for garden purposes and the young sprouts are edible.

Bambusa khasiana : It is a scandant, wild hill bamboo characterized by the persistent culms sheaths which are violet when young and have a conspicuous bulged ring at the sheath and blade joint. It was found frequent in paches in Siang and Subansiri and is locally known as Tabum (Adi Gallong dialect). The species has two distinct morphotypes; a thin-leaved and another broad leaved. The leaf size in latter case is exceptionally big (15-20 cm wide). It is commonly used for rope making, fencing or roof tops of thatched houses. The thin leaved species is established well at Basar and it flowered in 1991. The reference location for the other biotype is 11 km

from Likabali near Akashi Ganga towards Basar on Likabali—Along Road, West Siang.

II. *DENDROCALAMUS*

Dendrocalamus hamiltonii : It is a tall, semi wild species characterized by arching over the drooping culms. It is one of the endemic species of the region, dominant in larger patches, covering upto 40 per cent area of forests in its adaptability zone which stretches upto an elevation of 1200 m above a.s.l. An increased height, clump vigour and diameter of culm was observed at population level in *D. hamiltonii* in valley areas as compared to mid-altitude 600 m above a.s.l. (Kochhar *et. al* 1989). However, in the undisturbed habitat at higher altitude (Mow, West Siang, 1200 m above a.s.l. (Kochhar *et al.*, 1989). However, in the undisturbed habitat at higher altitude (Mow, West Siang, 1200 m above a.s.l.), very tall clumps (above 25 m) were seen in which the branches emerging at lower nodes were diagonally placed between culms and measured the size of an ordinary bamboo clump at lower elevations. As many as 15 local names were recorded for *D. hamiltonii* during survey which are presented in Table 1. The species was found good for pulping and is one of the major component species for the Nagaland paper mill. It is also used for timber, handicrafts, irrigation channels and vessels. The sprouts of *D. hamiltonii* are a delicacy and are most commonly used for food. Three morphotypes, two from Siang and one from Subansiri were duly established at Basar. Sporadic flowering was recorded on this species in West Siang near Nigmoi in 1987 and Nyorak (Basar) in 1989.

Dendrocalamus hookerii : It is a tall, very dark green wild, drooping bamboo having bigger but thinner leaves. It is characterized by apparent semi-wilting of leaves during hotter period of day due to fast transpiration which is restored to normalcy during night. The species is abundant at medium high altitude zone above 1200 m a.s.l. like *D. hamiltonii* at the lower altitude. Miles and miles of forest cover was seen under this predominant species in Subansiri and Khasia hills. It is used for pulping, timber, handicraft, irrigation channels and vessels etc. One clump has established well whereas other succumbed to red-ants attack in the second year.

Dendrocalamus giganteus : It is the tallest bamboo, also commonly known as giant bamboo. The species was found cultivated in Siang and Kohima districts in low frequency where individual culms measured 30 m tall and 20 cm in diameter. It was slow in initial growth, like *B. balcoa*, at Basar. The culms of this species can be used for various purposes and the young sprouts are edible.

Dendrucalamus sikkimensis : It is a tall, sturdy, light green semi-cultivated bamboo found in very low frequency in West Siang where it is locally known as Egi (Adi Gallong dialect). It is usable for timber, pulping making, handicraft etc.

Dendraocalamus sahnii : It is a medium tall, arching over, rare species collected from Zoram, Lower Subansiri. It is characterized by spiny ligules on culm sheaths. The species is used for timber, water channels etc. It could establish well on treatment of boric acid @ 100 ppm by drenching the rhizome samples during collection and spray of the same on nodal buds after planting.

Dendrocalamus longispathus : It is a tall, cultivated, non-native, sturdy bamboo collected from Forest Research Institute, Dehradun in October, 1989. The species is yet tentatively established.

III. CEPHALOSTACHYUM

Cephalostachyum pergracile : It is a tall, slender, feminine, non-native cultivated bamboo characterized by white powdery culm surface. A few isolated clumps were seen under cultivation in Siang during survey. The species is good for furniture making. Young sprouts of *C. pergracile* are edible.

Cephalostachyum fuschianum : This is a wild, scandant, hill bamboo. Its culms upto lower 1/3rd portion were found solid in some samples in West Siang at 1200 m above a.s.l. It is used for rope making etc. and is locally known as Taok (Adi. Gallong dialect). The species could be established at Basar after 3-4 replantings. The clump flowered on planting in 1991.

Cephalostachyum Sp. Novo : It is a tall, sturdy, semi-cultivated arching over bamboo reported from Likabali, West Siang. The species is usable for timber, pulping and making furniture. It was collected in 1989 and was yet tentatively established. The reference location is 1 km from zero-point on Likabali-Along road at the base of watershed towards hill side from main road.

IV. CHIMONOBAMBUSA

Chimonobambusa griffithiana syn. *Arundinaria griffithiana* : The species was earlier kept under the genus *Arundinaria*. It is a medium tall, wild prolific bamboo having spines at each culm node. Its frequency was high in Subansiri and Siang at mid-high altitude (1500-170 m above a.s.l.). Three tribal names were recorded for this species (Table 1). It is used for making bamboo mats and light handicraft etc. Two different samples from Siang (Boji) and Subansiri (Tabyo) are well established at Basar.

Chimonobambusa callosa syn. *Arundinaria callosa* : It is a wild, aborescent,

thin, drooping bamboo having spines at culm nodes. its adaptability zone is common with that of *A. griffithiana*. It is differently known in various tribal dialects of Siang and Subansiri. This species is yet tentatively established in the live collections after 4-5 attempts. The reference location is 5 km from Hapoli towards the highest point on Ziro-Kimin road in lower Subansiri where it is abundant in around 1 sq km area.

Chimonobambusa armata syn. *Arundinaria armata* : It is a medium tall, dark green wild species having underground runner which give individual culms at regular intervals thereby giving the appearance of avenue trees. The habitat is moist and shady area in the thick forest along the watershed. The species is originally described in the supplementary of Gamble's 'Bambusae of British India' under *Arundinaria* and is tentatively kept under *Chimonobambusa* due to spines at culm-nodes. The species is locally known as Ebum or Hibum which means black and handsome in Nishi dialect. One clump survived due to treatment with boric acid @ 100 ppm by drenching the rhizome stock of the sample collected and frequent spray on the nodes after planting.

V. ARUNDINARIA

Arundinaria hirsuta : It is a short, stiff, cultivated bamboo having D shaped culms when young. It grows in single culms arising at short intervals on a leptomorph (underground runner) rhizome. It is highly cultivated in Khasi hills around Shillong (1500-1600 m above a.s.l.) along the boundaries of houses and cultivated fields. It is usable for batons and fishing rods etc. The species showed a fast initial growth at Basar.

Arundinaria manii : It is a wild, scandant, hill bamboo having long, flexible, near solid culms. It is available on hill slopes at medium high elevation range of Siang and Subansiri in low frequency and is locally called Tajir. It has got sacred ethno-religious value and is used as incense-sticks during religious performances of Adi tribals. It is used for rope making, like cane, also. The species could establish well at Basar after 3-4 replantings.

VI. PHYLLOSTACHYS

Phyllostachys manii : This is a short, stiff, semi-wild bamboo having single culms arising from an underground runner rhizome. It has got ethno-religious importance and can be used for decorative brushes etc. at rituals of Adi tribals and also for making fishing rods. Two samples from West Siang and Mebo circle, East Siang are well established at Basar.

Phyllostachys assamica : Two morphotypes of this species, one medium short and another medium tall are widely cultivated in Nishi and Apatani

tribal areas of lower Subansiri. Slender and sturdy single culms arise from the underground runner rhizome. It is used for timber, fencing and walking sticks etc. 2 clumps showed fast initial establishment at Basar.

VII. *PSEUDOSTACHYUM*

Pseudostachyum polymorphum : It is a wild, aborescent endemic species seen frequently in forest undercover or abandoned cultivation fields. Culm thickness is very less. It is used for farm fencing rope or walking stick in thickets. The species could establish well after 3 plantings at Basar. It was seen sporadic flowering in Siang during these years on multiple occasions but seed formation was not observed.

VIII. *TEINOSTACHYUM*

Teinostachyum helferii : It is a wild, arching over, semi-scandant bamboo collected during last leg of the survey and is tentatively established. It is rare and the reference location is 5 km from Pasighat at the bank of a stream on the hill side at Pasighat-Along road towards Along.

PRELIMINARY CATEGORIZATION OF CONSERVED SPECIES

Preliminary data were recorded on various phenological and morphological characters from third year onwards of clump establishment individual species. Three categories of established clumps of 8 fully established species viz. tall and less prolific; medium tall and medium prolific and short and highly prolific types which could be used for pulping, timber, handicraft and food canopy, handicraft and light timber; and live fencing of shifting cultivation (*Jhum*) fields, respectively (Kochhar and Rai 1987). Further observations on status of establishment of new collections and categorization for clump habit and usage class(es) are summarized in Table 1. A perusal of the table shows that the live bamboo collections at AP Centre, Basar can be subdivided into 5 distinct categories, viz., (i) tall and sturdy types (14 species), (ii) medium tall, semi-cultivated types (3 species), (iii) medium short, highly prolific types (5 species), (iv) wild but cultivable types (2 species) and (v) wild types (6 species). *Chimonobambusa griffithiana* syn. *Arundinaria griffithiana* and *Arundinaria armata* (Gamble) due to their clump habit and better utilization potential were earmarked for category (iv) i.e. wild but cultivable.

The utilization potential of individual category and species can be ascertained on further studies. However, the preliminary information from literature or local communication a few generalizations could be made. These collections are grouped into 6 usage classes, viz., pulping, timber; handicraft and furniture making, miscellaneous uses which include

making ropes, bamboo mats, irrigation channels, walking sticks, fishing rods etc. food from juvenile sprouts and live fencing. Nine species were recorded for their usability as food from young sprouts (Table 1), out of which *D. hamiltonii* is predominantly used. Five species from general category (iii) i.e. medium tall and highly prolific and 1 species, *Chimonobambusa griffithiana*, from general category, (iv) (wild but cultivable) were suggested for live fencing of shifting cultivation fields due to their short stature, prolificacy and fast growth. The last one is further useful due to its spininess at nodes. Out of the medium tall or tall species this categorization is not done because of their shading effect on crops. However, *B. polymorpha* was clearly used for wind break and soil binding in a boundary of hilly, terraced cultivation fields at its collection site in Tripura. Nine species were found and soil binding in a boundary of hilly, terraced cultivation fields at its collection site in Tripura. Nine species were found usable for pulping and 18 for timber or light timber. A systematic and seasonal recording of observations on various traits related to growth, morphology and production potential will be useful for classification of this conserved variability in bamboos for species prospects and promise for future use. A data sheet is finalised for use of bamboo workers (Anon, 1990) which takes into account the above parameters.

To conclude with, it is essential to collect and conserve variability in bamboos which is pre-requisite for apt classification and ascertaining the potentials of this useful group of plants. Nearly half the variability in bamboos from North Eastern India is duly collected and preserved live. This includes further higher proportion of economically useful types. Nonetheless, collection of wild and less frequent or rare species is equally important. Bamboo types which were surveyed, collected and planted but did not survive at Basar should be re-collected on priority through location specific collection trips in order to give a final shape to the live collection bamboo garden at Basar.

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SEMIQUANTITATIVE ANALAYSIS OF GENETIC RESOURCES OF *DESI* COTTON (*G. ARBOREUM* L.)*

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An assessment of potential variability and genetic diversity was undertaken in the genetic resources of G. arboreum using metroglyph and hybrid index score technique. The 150 accessions evaluated were identified into 15 distinct groups for economic and morphological characters. The suitability of the technique for preliminary classification of a large number of germplasm and classifying them into distinct group for qualitative and quantitative characters were found effective.

The current collection of germplasm at the National Gene Bank for cotton at Central Institute for Cotton Research, Nagpur includes over 1455 accessions of *Gossypium arboreum*. These collections mainly comprise materials collected from various cotton growing areas, as well as those developed out of various breeding programmes from within India. A limited number among the *G. arboreum* (desi) accessions are exotics, primarily from China, Pakistan, Bangladesh, Myanmar and Sri Lanka. These also represent the four races of the species.

Variability in *G. arboreum* cotton has been reported for limited number of accessions and for a few characters only (Singh, 1969; Singh and Kalsy, 1979; Singh and Nandeshwar, 1983, 1984 and Singh and Singh, 1984). There is considerable genetic variability in *G. arboreum* cotton with regard to different morphological and quantitative characters (Singh, 1969) and varieties of race *cernuum* are low yielders with sympodial habit, high G.O.T., high boll weight, high number of seeds per boll and high locule retentivity (Singh and Nandeshwar, 1983).

A fresh assessment of potential variability and genetic diversity using reliable criteria was done to get new information for classification into various basic types and for making a judicious choice of parents for breeding programmes. Adequately large sample of germplasm were assessed and a semi-quantitative analysis was performed in assessing the variability present in the gene bank of *Gossypium arboreum*.

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MATERIALS AND METHODS

One hundred fifty accessions were raised under field conditions during 1984-85 in an augmented block design. The spacing adopted was 60 x 45 cm. Accordingly, 20 plants were accommodated in a row, the length of the row being 12 m and 8 m respectively. The recommended cultural practices including fertilizer application and plant protection measures were adopted. Data were taken for 11 morphological and economic characters on five randomly selected plants and these were subjected to Anderson's metroglyph analysis in conjunction with hybrid index scores. The 11 characters used for the semi-quantitative classificatory analysis were leaf length, leaf hairiness, bract length, plant height, sympodia number, boll number, boll weight, boll volume, seeds per boll, ginning out turn and mean halo length. The metroglyph analysis and hybrid index scores procedure (Anderson, 1936, 1957) were carried out using the mean values of 11 characters for 150 accessions (Stebbins, 1950; Singh and Chaudhary, 1985).

For plotting the metroglyph, two most variable and widely different characters namely leaf length and mean halo length were used on X and Y axis respectively. The actual means of Y values were plotted against the means of X values for each accession on a glyph in the graph. For another eight characters, the values were classified into three arbitrary classes or groups for each character and used accordingly for plotting the rays at an appropriate axis on the glyph. For leaf hairiness, the grade was indicated on the glyph itself by shading it fully (high hairy), partially (medium hairy) and leaving empty (glabrous or least hairy). The ray for a specific character was given the same position on each glyph. The length of the rays on the appropriate position of glyph was short (1 mm), medium (2 mm) or long (3 mm) for low, medium or high range of values, respectively for each character. The index values were decided on the basis of range of variability. The whole scatter was demarcated into 16 sectors by running parallel lines vertically and horizontally at equal intervals. In each of the 16 sectors thus demarcated, the total accessions were counted and assigned to the metroglyph cluster groups I-XVI.

Using the suitable class intervals, the range of variability for each character was classified into three groups assuming an index score of 1 for the lowest grade, 2 for middle grade and 3 for the highest grade. All the characters were given the index score grades from 1-3 (Table 1). The sum of index values for the 11 characters in each accessions was taken as an indication of its total worth. Histogram of index scores was constructed using these data. The frequency distribution of index scores for groups of accessions representing geographic/racial collections was also tabulated. The total index scores of all the accessions in each cluster group was added and mean index score of each cluster was calculated.

Table 1. Ray position on metroglyphs and Index scores for 11 characters in *G. arboreum*

Sl. No.	Character	Glyph position	Range	Mean	INDEX SCORES		
					Low (1)	Medium (2)	High (3)
1.	Leaf length (cm)	X axis	7.1 -12.1	9.30	7.1 -8.7	8.8 -10.4	10.5 -12.1
2.	Mean halo length (mm)	Y axis	14.3 -25.7	21.20	14.3 -18.1	18.2 -22.0	22.1 -25.7
3.	Leaf hairiness grade		Glabrous to highly hairy	Medium hairy	Glabrous/less hairy	Medium hairy	Highly hairy
4.	Boll weight (g)		1.4 -4.2	2.08	1.4 -2.3	2.4 -3.3	3.4 -4.2
5.	Sympodia/plant		10.7 -34.0	19.77	10.7 -18.4	18.5 -26.2	26.3 -34.0
6.	Bract length (cm)		2.3 -4.6	2.94	2.3 -3.0	3.1 -3.8	3.9 -4.6
7.	Seeds/boll		14.8 -32.3	22.87	14.8 -20.7	20.8 -26.7	26.8 -32.3
8.	Bolls/plant		7.8 -23.8	14.88	7.8 -13.1	13.2 -18.5	18.6 -23.8
9.	Ginning outturn (%)		29.6 -46.8	37.98	29.6 -36.2	36.3 -42.9	43.0 -46.8
10.	Plant height (cm)		75.5 -178.5	120.42	75.5 -109.8	109.9 -144.2	144.3 -178.5
11.	Boll volume/boll (cc)		5.8 -17.3	8.71	5.8 -9.6	9.7 -13.5	13.6 -17.3
		Ray length			1 mm	2 mm	3 mm

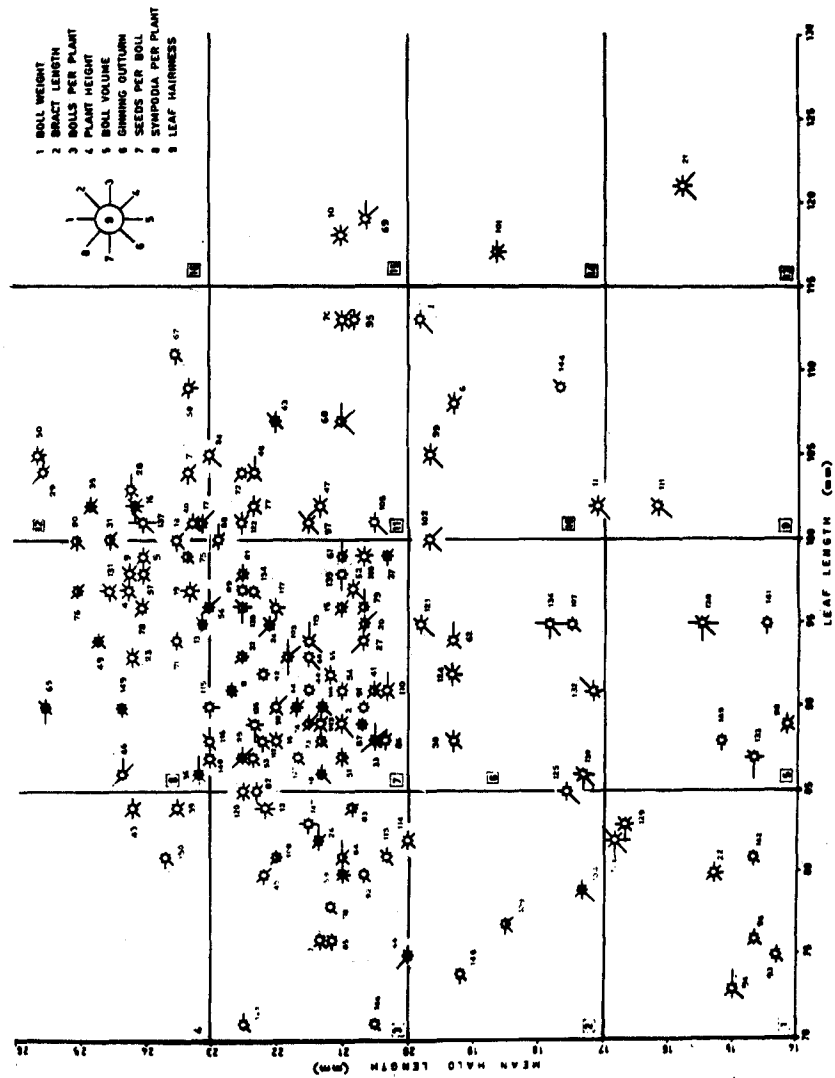


Fig. 1. Scatter diagram of metroglyphs of 150 germplasm accessions of *G. arboreum* L.

RESULTS AND DISCUSSION

Genetic variability in 150 *G. arboreum* accessions which included accessions developed in North India (33), North-East Hill region (18) and Central India (92) besides 5 from South India and two exotics were analysed. Based on racial origin, 126 accessions represented race *bengalense*, 18 of race *cernuum*, five of *indicum* and one of race *sinense*. Average performance, mean, range and variance for the 11 characters have been presented in Table 2 alongwith estimates of SE and CV. The construction and results of metroglyph analysis were also presented (Fig. 1). The 150 glyphs shown in the metroglyph scatter diagram were divided into four groups for fibre length as short (14 to 17 mm), medium (17.1 to 20 mm),

Table 2. Range, Mean, CV, SE and Variance analysis

Sl. No.	Characters	Range	Mean	CV	SE	Variance
1.	Leaf length (cm)	7.10 – 12.10	9.30	10.75	0.08	1.00
2.	Leaf hairiness					
	grade	9.01 – 1.10	0.24	0.35	0.01	0.01
3.	Bract length (cm)	2.30 – 4.60	2.94	4.83	0.03	0.14
4.	Plant height (cm)	75.50 – 178.50	120.42	17.06	1.67	422.30
5.	Nof of sympodia					
	per plant	10.70 – 34.00	19.77	89.09	0.34	17.64
6.	No. of bolls					
	per plant	7.80 – 23.80	14.88	83.15	0.29	12.39
7.	Boll weight (g)	1.40 – 4.20	2.08	9.05	0.04	0.19
8.	Boll volume (cc)	5.80 – 17.30	8.71	35.98	0.14	3.13
9.	No. of seeds					
	per boll	14.80 – 32.30	22.87	19.09	0.25	9.18
10.	Ginning					
	outturn (%)	29.60 – 46.80	37.98	10.26	0.32	15.21
11.	Mean halo					
	length (mm)	14.30 – 25.70	21.20	30.66	0.21	6.50

superior medium staple 20.1 to 23 mm) and long staple (above 23 mm). Similarly, four arbitrary categories of leaf length namely short (70 to 85 mm), medium (86 to 100 mm), long (101 to 115 mm) and very long (above 115 mm) were also made so as to classify all the genotypes into 16 groups. Composition of metroglyph clusters are presented in Table 3. The genotypes falling under each group showed a wide range of variability in this species and are described below :

CLUSTER GROUP CHARACTERISTICS

In cluster I, seven genotypes exhibited high scores for boll weight but short leaf and short fibre were combined with low boll weight, low boll

Table 3. Composition of metroglyph clusters

Metroglyph Cluster Number	Number of accessions	Name of accessions
I	7	AC 36, G 27, 30804, 79/Lohit, 30815, G 26, G 29
II	4	Gao 145-B-5, Malvil, 30800, Maljari,
III	17	Arboreum (Kanpur), AC 48, AC 629, AC 17, B 5, Bani 306, CJDC-37-W, Cocanada 20, G 23, Dokras 9-2-8-3, LD 153, AKA 603, 5-63-572, 3058, 8410-3, IC 377/8, 331,
IV	3	AC 617, AC 624, AC 730
V	5	G 45, 30814, 30824, Desi 56, 79/BH-113,
VI	8	AC 261, LD 133, 30798, 30822, 30817, 30839, B 15-30, 7662
VII	47	A 4, A 41, AC 21, AC 22, AC 32, AC 42, AC 50, CC-1-1-3-2, Cernuum, Gao-CB-9, CC-1-137-PN-10, Chinese Broad Leaf, G 2, Dhulia 2-1-5, AC 541, AC 543, AC 567, AC 570, Dhulia 2-2-5-W, Arvensis. 0-91, G 53, AC 619, AC 623, AC 627, AC 733, AC 41, AKH 2, AKH 214, 30847, Desi 97, Adonicum, B 10-24-A-84, B 11, BA 2 W, G 1-35-49-W, Kumptha Black Seeded, 7249, Sanguineum BL-RF, 1773, CC-1-1-3, G 22, 7526, 30810, 30835, 30837, 30844,
VIII	21	A 14, A 27, AC 1, AC 18, AC 30, AC 38, AC 630, AC 729, Arboreum (Surat), BA 15-W, BJ 6, CC-1-1-3-4, 1391-N, CC-1-1-3-33, NAA 2, 30820, 30860, CC-1-1-3-BK, 554, AC 546, B 3
IX	1	35-1
X	6	A, A 32-8-W, AC 15, G 47, G 92, Desi 101,
XI	12	AC 727, AC 728, B 32-48, Bishnoor, G 1 Banilla Faint Spot, Burma Silk, G 33, 7763, CC-1-1-3-41, G 27-51, Gao 61-6
XII	15	A 33, AC 23, AC 24, AC 25, AKH 4, B 4, AC 65, AC 418, AC 544, AC 545, Banilla, AC 730, AC 618, CC-2-1-11-15, 30840
XIII	1	AC 35
XIV	1	G 54-1
XV	2	AC 3, BDN 5628
XVI	0	—

volume and short plant height. The four genotypes of cluster II exhibited low score for boll weight, plant height, boll volume and medium score for seeds per boll coupled with high ginning outturn. Cluster III was large with 17 genotypes having 11 medium hairy types and three each of hairy and densely hairy types exhibiting low scores for boll weight, bract length and boll volume. Cluster IV included only three long staple accessions with medium hairy leaves and none exhibited high boll weight. The 5 glyphs of cluster V had low scores for most of the traits. Most of the 8 accessions of cluster VI showed high ginning per cent coupled with medium scores for seeds per boll and plant height. In cluster VII with highest number of 47 glyphs more than half had low scores for leaf hairiness coupled with boll weight, sympodia number and boll volume and 6 had high values for number of bolls per plant coupled with medium values of seeds per boll. Cluster VIII was the second largest group involving 21 accessions having medium lead and long staple and most of the genotypes had medium scores for bolls per plant, ginning per cent and plant height and low values for boll weight and boll volume. Cluster IX had a single glyph exhibiting high scores for ginning per cent, medium value for seeds per boll, sympodia per plant and bract length. Of the 6 glyphs of cluster X, four had high scores for ginning per cent, medium scores for seeds per boll, bolls per plant and plant height. In cluster XI, all the glyphs exhibited low scores for boll weight and boll volume. Cluster XII showing long leaf and long staple included 15 genotypes mostly having medium hairy leaves and medium boll weight with medium scores for boll volume and bract length. The single glyph in cluster XIII exhibited high score for ginning per cent, plant height and number of sympodia. There was a single genotype in cluster XIV with medium scores for most of the characters. In cluster XV, two genotypes were present with very long leaf and superior medium staple and medium scores for sympodia per plant, bract length, seeds per boll and low score for boll volume. There was no glyph conforming to cluster XVI.

HYBRID INDEX SCORES

Though central India had the largest number of accessions (92), its average index score (19.0) was almost similar to those of North Indian accessions (19.6), which also had the highest average index score with 18 accessions (Table 4). North Indian accessions (33) had the next best average index score of 17.2. South Indian and exotic accessions having a few entries only had almost similar average index score of 16.6 and 16.0 respectively.

About fifty per cent (74) of the total accessions (150) represented the three index score 18, 19 and 20 classes. Maximum number of accessions (28) were found in the index score category of 19 followed by 24 accessions under index score of 18. The lowest number of accession (1) was found in the index score class of 24 followed by class of 14 which had 3 accessions.

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Accessions from/ Race	Total No. of Accessions	INDEX SCORES																							Total Index Score	Average Index Score	
		13	14	15	16	17	18	19	20	21	22	23	24														
NORTH INDIA	33	3	3	4		5	8	5	2	3															568	17.2	
NORTH EAST INDIA	18			1	2	1		3	7		1	3														352	19.6
CENTRAL INDIA	92	1		4	9	7	16	19	13	11	6	5	1													1747	19.0
SOUTH INDIA	5	1					3		1																	83	16.6
EXOTICS	2			1		1																				32	16.0
TOTAL	150	5	3	10	11	17	24	28	22	14	7	8	1													2782	18.5
race bengalense	126	5	3	8	9	13	23	24	15	14	6	5	1													2327	18.5
race indicum	5			1		2	1	1																		86	17.2
race cernuum	18			1	2	1		3	7		1	3														352	19.5
race sinense	1									1																17	17.0
TOTAL	150	5	3	10	11	17	24	28	22	14	7	8	1													2782	18.5

The highest number of 126 accessions belonged to the race *bengalense* which had an average index score of 18.5, while the race *indicum* having only 5 accessions recording the average of 17.2. The highest average index score (19.5) was obtained in the accessions (18) representing race *cernuum*.

Table 5. Germplasm accessions form D² analysis

Metroglyph cluster group	Number of germplasm accessions	Mean index Score	Number of accessions selected for D ² analysis	Mean index score of selected accessions
I	7	16.9	2	20.00
II	4	16.0	2	15.50
III	17	16.4	5	15.80
IV	3	17.3	2	17.00
V	5	16.6	1	16.00
VI	8	19.0	3	19.70
VII	47	18.8	9	18.90
VIII	21	19.5	4	19.70
IX	1	17.0	1	17.00
X	6	18.7	1	21.00
XI	12	19.1	3	19.00
XII	15	19.8	4	20.20
XIII	1	24.0	1	24.00
XIV	1	19.0	1	19.00
XV	2	21.5	1	21.00
XVI	0	0	0	0

The single *sinense* accession had a mean index score of 17.0. It was observed that the largest number of genotypes had been grouped under the average index score categories of 16-21 indicating that maximum number of accessions had medium values for various characters.

Proportionate representation for the accessions from various metroglyph clusters was made while selecting them for further studies. The distance of the accessions from the centre was considered important while selecting the genotypes besides total hybrid index scores within the cluster. Maximum number of accessions (9) were selected from cluster VII followed by 5 from cluster III, 4 each from VIII and XII and 3 each from VI and XI. From the remaining clusters one or two genotypes were taken and a total of 40 accessions were selected from each metroglyph cluster and their mean index score values are presented (Table 5).

A close examination of the clusters revealed that there were two homogeneous clusters (IV and XV) which included 3 and 2 entries, respectively, from central India alone. Almost all other clusters were heterogeneous with respect to the origin of the component entries. Cluster VIII included 19 accessions of central India clubbed with two from the North-Eastern (N.E) region. Similarly, the cluster XII had 14 central Indian accessions clubbed with a single accession of the N.E. region.

The frequency distribution of total index scores of accessions of different geographic origin in India (Table 4) also reflected on the distinct pattern of variability in the present material. The highest index score of 19.6 was exhibited by the accessions of N.E. region followed by north Indian accessions (19.0). South Indian and the two exotic accessions had the lowest average index scores of 16.6 and 16.0, respectively. Central Indian accessions had the maximum range (13 to 24) of total index scores, with genotypes of all categories, followed by accessions from north India.

Accessions representing same race, similar geographic area and arising from similar parentage got distributed into distinct clusters. North-east region accessions recorded higher average hybrid index scores followed by central Indian, north, south Indian and exotic accessions in that order. This indicated the significant contribution made by particular combinations in characters to diversity.

Based on the elucidation obtained about the distribution and diversity in the species accessions, the metroglyph analysis in conjunction with hybrid index score, appeared to be a useful technique for preliminary classification of large number of germplasm for several qualitative and quantitative characters and identifying diverse types for breeding programmes.

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DIVERSITY AND DOMESTICATION OF MINOR MILLET SPECIES IN INDIAN SUB-CONTINENT

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*The Indian sub-continent and African continent are the most important centres of millet cultivation. The Indian sub-continent has several endemically domesticated millet species such as little millet (*Panicum sumatrense*). Indian barnyard millet (*Echinochloa frumentacea* Link), kodo millet (*Paspalum scrobiculatum* L.) and foxtail millet (*Setaria glauca* L. Beauv) and others. The millet species originated in Africa and those domesticated in Eurasia are also cultivated as important millet crops in this region. These include *Sorghum bicolor* (L.) Moench. (sorghum), *Eleusine coracana* Gaertn. (finger millet), *Pennisetum typhoides* (pearl millet), *Setaria italica* (L.) Beauv. (foxtail millet), *Panicum miliaceum* L. (proso millet) and *Coix lacryma-jobi* L. (Job's tear) respectively. Minor millet species are grown from extreme southern tip of India at sea level to the temperate north Himalayan areas upto an altitude of ca 3000 meters with consequent variation in photoperiod from short to long days. Out of total area of 126.67 m ha under food grain, the minor millet area in India is just 5.78 m ha. In production, their contribution was 3.85 m tons of total 146.22 m tons of food grains in the country. Japanese barnyard millet, proso and foxtail millet have all been important in the past, and are still important particularly in Asia. Finger millet is an old tropical millet still widely grown in eastern Africa and south Asia. Kodo and little millets continue to be important in Asia in time of famine or difficulty. This paper reviews the account of domestication and diversity of different minor-millet species in Indian sub-continent.*

The antiquity of Indian sub-continent as a seat of domestication/ diversification of agri-horticultural plants is well known. The Indian gene centre is characterised by among others, specific minor millet genetic wealth exhibiting diversity in *Coix lacryma-jobi* (soft shelled forms). *Digitaria cruciata* var. *esculenta*, *D. sanguinalis*, *Echinochloa colonum*, *Eleusine coracana*, *Panicum sumatrense* and *Paspalum scrobiculatum* (Paroda and Arora, 1986).

DISTRIBUTION AND DOMESTICATION OF CROP SPECIES

In India, seven species of minor millets are cultivated from time immemorial and used as grain and fodder in different parts of the country. Paradoxically these crops have always grown on marginal lands with poor soil nutrients. Their survival in competition with rice and wheat attests to the significance of these millets in agro-ecosystem of south-east Asia (Umesh Chandra and Thomas, 1989). Two of these, *Panicum miliaceum* L. and *Setaria italica* (L.) Beauv. are grown across temperate Eurasia, with foxtail millet extending into the semi-arid tropics of Asia. Raishan (*Digitaria cruciata*) is cultivated by the Khasi tribes in Assam (endemic to Shillong plateau, Khasi hills). Hooker and Stapf (1896) recognised this as a species of *Paspalum* and Bor (1940) mistakenly included it in *Digitaria corymbosa* (Roxb.) Merrill. Later Bor (1955) correctly transferred raishan to *D. cruciata* and recognised the cultivated types as *var esculenta*. Raishan persists as millet in Assam probably because it provides excellent and essential food for livestock during winter when grazing is scarce. Individual plants produce as many as 30 flowering culms with each inflorescence maturing at slightly different times. It yields upto 800 kg/ha. The species was probably domesticated by hill tribes in Assam, south-east Asia (Singh and Arora, 1972). The genus *Echinochloa* widely distributed, and includes 20 species, several of which are weeds. The most noxious weed *E. oryzoides*, invades paddy, mimics the crop in vegetative morphology and flowers a few days earlier than the cultivar it accompanies as weed. Barnyard millet (*E. crus galli*) is common weed and is cultivated in China, Korea and Japan. Archaeological records indicate that it was grown in Japan dating back some 5000 years ago (Watanabe, 1970). *E. colona* has yet not been identified from among the plant remains of numerous sites excavated in India (Vishnu-Mittre, 1977). The species is, however extensively grown in central India where it is commonly known as sawa (de Wet *et al.*, 1983 a). Sawa is indigenous millet to India. The species is weedy, spontaneously invades cultivated fields, and is often unintentionally harvested with other minor millets. Sawa is grown from Kashmir to Sikkim in north and to Tamilnadu in south and Orissa in the east. In paddy fields, *Paspalum* species with small sized grains, *Panicum* spp., *Echinochloa colona* and other spp. and mimic type of *Coix gigantea* to rice plants were found. Upland rice have mimic types of *Paspalum scrobiculatum* with large sized grains, *Setaria glauca*, weedy *Panicum sumatrense* and *Echinochloa colona* (Kobayashi, 1987).

Kodo millet (*Paspalum scrobiculatum* L.) is another indigenous cultivated millet in India. The species is weedy, distributed in damp habitats across the tropics and sub tropics of the old world. It is known to have grown in southern Rajasthan and Maharashtra for atleast 3000 years ago (Kajale, 1977). It is grown today from Uttar Pradesh to Bangla Desh in north and

Maharashtra and eastern Madhya Pradesh in central India and Kerala and Tamilnadu in south India (Umesh Chandra *et al.*, 1987 b).

The most common kodo millet is characterised by racemes with the spikelets arranged in two rows on one side of a flattened rachis. Variations on spikelet pattern often occur in the same field with spikelets arranged in two to four irregular rows along the rachis and in other, the lower part of each raceme has four irregularly arranged rows of spikelets, while spikelet arrangement becomes more regularly two rowed in the upper part of raceme (de Wet *et al.*, 1983 b.) Hybridization between cultivated types and between cultivated and weedy types are common. This explains the absence of clear racial differentiation, even after 3000 years of cultivation as millet in India. In kodo millet fields of south India, the mimic type of *Setaria glauca* (varagu-sakkalathi) was observed. In Orissa, *Brachiaria* sp. called chusara-mata meaning strong associated plant with kodo millet, and *Echinochloa colona* called dhera were found. They showed little or no behaviour, like the domesticated plants. This explains, kodo millet, cultivated *S. glauca* and *Brachiaria* sp. called korne, are speculated to be secondary crops in origin through their associated or mimic weed. Further, strongly different characteristics of cultivated *S. glauca* in south India and in Orissa indicate that they evolved separately. One with short spikes and slender leaves, a mimic to little millet in south India, probably evolved as secondary crop of little millet. The other with long spikes and wide-long leaves resembling weedy *S. glauca* in upland rice, may indicate its origin as a secondary crop of upland rice (Kobayashi, 1987).

Job's tear (*Coix lacryma-jobi* L.) is grown under shifting cultivation as a rainfed crop by the hill tribes of tropical Asia from Assam to the Philippines (Arora, 1977). White, greyish, black, creamish and other types-both smooth and striped shelled forms occur. In Assam, the grain is ground into flour and used to make bread or a sweet dish is prepared by frying the grain and adding sugar.

Foxtail millet (*Setaria italica* (L. Beauv.) is highly variable apparently because of its long record of domestication. It is considered that weedy green foxtail *Setaria italica* sub sp. *viridis* is the ancestor of *S. italica* from which the latter is distinguished by the size of its grain (Umesh Chandra *et al.*, 1987 a). The more robust *S. italica* is characterized by the larger, lobate panicles, which produce smooth, shiny seeds that disarticulate above the glumes in *S. viridis* and the fertile lemma is finally transversely rugose. Wild and cultivated *S. italica* cross naturally and produce fertile hybrid (de Wet Oestry-Stidd and Cubero, 1979). Derivatives of such hybrids are abnoxious weeds. The antiquity of foxtail millet cultivation is uncertain. The species could have been domesticated anywhere across its natural range extending from Europe to Japan. It is absent from known early

farming sites in India (Vishnu-Mittre, 1968). This however does not necessarily indicate a late introduction of foxtail millet into the tropics and sub-tropics in south Asia. Its wide distribution and morphological variation suggest a long history of cultivation in Indian sub-continent. Cultivars from India are morphologically distinct from those of Europe and far east and are recognised as race *indica* (Prasada Rao *et al.*, 1987). Plants are typically robust with inflorescence bearing branches that are loosely arranged along the primary axis. Collections from Meghalaya have long, slender inflorescence with small spikelets. Karnataka collections have slender erect inflorescence with short lateral branches somewhat resembling *S. pumila* in inflorescence & spike structure. A domesticated form of *S. glauca* found in a very localized area between Chittoor of Andhra Pradesh and Kolar of Karnataka, may be considered to have attained the characteristics of non-shattering grains and the position as a secondary crop in minor millet fields or as a main crop in the mixed cropping with minor millet, weedy *S. glauca*, associated with kodo millet and finger millet, generally displays non shattering grains which is a characteristic of domesticated types (Kobayashi, 1987).

The progenitor of proso millet (*Penicum miliaceum*) is native to Manchuria. Little millet (*P. sumatrense*) is grown as millet in the eastern ghats of India. This species represents the domesticated complex of the weedy *P. psilopodium* (de Wet *et al.*, 1984). The commonly cultivated type differs from wild *P. psilopodium* with which it crosses to produce fertile hybrid. The race of *same* is highly tolerant to heat and drought stress.

The cultivation and diversity of finger millet in Africa as well as in India led to considerable controversy over time and place of domestication and as to its progenitor. De Condolle considered it to be an Indian domesticate. Because of long history and morphological diversity in India, it was concluded that finger millet is of Indian origin since several wild species are common there (Hilu and de Wet, 1976 a). Finger millet first occurs in the archaeological records of early African agriculture dating back some 3000 years. (Hilu and de Wet, 1976 b.), and was introduced in India atleast 3000 years ago (Vishnu-Mittre, 1968). Two groups of cultivars of *E. coracana* are recognised; (a) African highland types bearing a resemblance to *E. indica* sub sp. *africana* with long spikelets, long glumes, long lemmas and grains enclosed within the florets, (b) Afro-Asian types with a close resemblance to *E. indica* sub sp. *indica* with short spikelets, short glumes, short lemmas and the mature grains exposed distally. Mehra (1963 a, b) considers it probable that both types originated from sub sp. *africana* and the African highland forms were selected from large-grained mutants. Mehra believes that afro-Asian cultivars then evolved from African highland forms by mutations for short glumes and exposed grains. On the basis of

this hypothesis, Perseglove (1974) considered that Uganda or neighbouring territory could have been the centre of origin. India became secondary centre of evolution of the crop. Cultivated finger millet is extensively variable, and this variation is recognised as five races (de Wet, Prasada Rao, Brink and Mengesha, 1984). Race *coracana* is particularly well-adapted in eastern highlands in Africa and Ghats of India. Other races *vulgaris*, *elongata*, *plama* and *compacta* probably evolved from race *coracana* under cultivation. The indigenous weed of Eleusine in India, *E. indica* (L.) Gaertn; is now a cosmopolitan species found in tropical to warm temperate regions all over the world but this weed is not able to produce fertile hybrids in cross with *E. coracana* (Kempnana, 1969). There is a belief in Kumaon farmers that *madua* (*E. coracana*) becomes *jhhadua* (off type-probably hybrid of sub sp. *coracana* and sub sp. *africana*) in a few years and then becomes *khadua* (*E. indica* and *E. coracana* sub sp. *africana*)-highly sterile, widely spread spikelets on spike and shattering of grains (Sakamoto, 1987).

CROP DIVERSITY IN INDIAN SUB-CONTINENT

India possesses rich and diverse native genetic wealth specially in kodo-millet (*Paspalum scrobiculatum* L.), little millet (*Panicum sumatrense*), Indian barnyard millet (*Echinocloa frumentacea* Link) and in foxtail millet (*Setaria italica* (L.) Beauv). Studies/collections made so far, point out to the prevalence of considerable genetic variability in kodo millet in the states of Madhya Pradesh, Rajasthan, Uttar Pradesh, Kerala and Tamil Nadu; finger millet in Karnataka, Tamilnadu, Andhra Pradesh, Orissa, Maharashtra, Uttar Pradesh, Bihar and Gujarat. These eight states, together account for more than 95 per cent of total area under this crop. The other minor millets, viz., foxtail, proso, little and barnyard are mainly grown in Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka, Uttar Pradesh, Maharashtra and Orissa and in small patches in the hilly region of Himachal Pradesh and Uttar Pradesh, Jammu and Kashmir and north-eastern states. The major area under little millet (*Panicum sumatrense*) is in the states of Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu and Uttar Pradesh. Germplasm represents reasonably diverse material collected from different regions in the country but it does not include all the minor millet growing areas and to fill these gaps, priority areas were identified for minor millet crop species germplasm collection which include largely tribal dominated belts as follows :

- (a) Finger millet : Western Ghats of Maharashtra, southern peninsular region, Sikkim and north Bengal, in north-eastern region; sporadic hill pockets of west western Himalayas in mid-elevation zone.
- (b) Foxtail millet : • North-eastern region, peninsular tribal zone, sporadic in north-western part.

- (c) Kodo millet : Parts of Maharashtra, Gujarat, Madhya Pradesh, Bihar, Andhra Pradesh and Tamil Nadu-drier belts mainly.
- (d) Little millet : Orissa, Bihar, Uttar Pradesh, Madhya Pradesh and Maharashtra, eastern and central peninsular tracts mainly.
- (e) Proso millet : Bihar, Uttar Pradesh, north-western Himalayas in J & K & H.P. and U.P. hills upto 3000 m.
- (f) Barnyard millet : Maharashtra, Uttar Pradesh, eastern peninsular tract.

The National Bureau of Plant Genetic Resources (NBPGR), during the past 10 years, has been engaged actively in exploring the areas extensively in the states of Madhya Pradesh, Maharashtra, Karnataka, Orissa, Tamilnadu and Andhra Pradesh to collect the available diversity in minor millets. Three crop specific missions in collaboration with Japanese team were also undertaken. Over 4,500 diverse landraces (viz., *Setaria italica* spp. 964; *Eleusine coracana*-1,285; *Paspalum scrobiculatum* -346 and *Panicum sumatrense*-438; *Echinochloa* spp.-266; *Panicum miliaceum*-321 and miscellaneous minor millet species-911 collections) were collected from north eastern hill region, western coastal part, north-western Himalayas, western and eastern ghats areas, southern Indian states, Chhotanagur region and central peninsular region of India (Table-1).

Minor millet crop species are in general, drought hardy, short duration that can be grown in arid semi arid regions and in situations of delayed rains where growing period gets reduced. These can also be cultivated on soils of low fertility and can give economic yield, on soils too poor to support other economically important grain crops. They are cultivated mostly inter-mixed with other crops or different minor millet crop species.

In *Eleusine coracana* (finger millet), variability is conspicuous in plant height, tillering potential and length of fingers. This crop has wide range of adaptability for varying temperature, moisture and soil types and it exhibits great diversity in ear shape, size, bristling, pigmentation, grain size, grain colour and maturity duration. In predominant ragi growing areas of Karnataka, several high yielding improved varieties/hybrid derivatives such as INDAF series 1 to 12 have replaced the local landraces. The native landraces are still under cultivation mainly for fodder purposes as the improved types produce fodder of non palatable type where the straw is more fibrous and stiff. *E. indica*-a wild relative of *E. coracana* occurred in the field of dwarf *E. coracana* which seemed to be a sterile hybrid of them. In *Setaria italica* (navana in Kannada), variation was significant for characters such as anthocynin pigmentation, bristle length and grain

Table 1. Diversity collected in different minor millets species in India (1976-1990)

Areas/regions explored	Finger millet	Foxtail millet	Kodo millet	Barnyard millet	Proso millet	Little millet	Misc. millet sp.	Total
North-eastern Hill region	150	89	01	01	03	—	108	352
Western Coastal region	53	38	20	—	—	35	—	146
North-western Himalaya	239	203	02	95	106	36	256	937
Central peninsular India	164	324	158	83	29	158	319	1,235
Western Ghats	43	07	06	23	03	33	—	115
Eastern Ghats	278	64	09	25	37	56	51	520
Saurashtra areas	—	—	—	—	—	—	24	24
Southern India (Andhra Pradesh, Tamil Nadu and Kerala)	351	231	141	34	138	110	153	1,158
Chhotanagpur region	07	08	09	05	05	10	—	44
Total	1,285	964	346	266	321	438	911	4,531

colour. With regards to bristle, three distinct types occur (i) long bristled, (ii) short bristled and (iii) bristles being absent types. *Paspalum scrobiculatum* (kodo millet) is one of the staple food crops in some areas. Ecology of the area where this crop is grown is very typical with sandy soil least moisture availability, slopy and sometimes rocky/stony. Due to relatively high temperature, plants appear bushy with profuse branches and forked inflorescence. Variability is prominent in number of tillers (6-14), leaves (drooping/erect), finger (short/long). *Panicum miliaceum* (Proso millet) is called *baragu* in Karnataka. The panicles are generally very loose with bold grains and drooping branches. In *P. sumatrense*, variation in panicle types, viz., green lax panicle, green dense, purple lax, purple dense and purple semi-dense are common. There is no variation in grain. In Tamil Nadu, there is variation in panicle shape ranging from open to closed one. In Nilgiri hills, a specific form of *P. sumatrense*-very short plant with deep purple colour is cultivated (locally known as *batta*). In majority of sites where *Setaria italica* is common, *S. glauca* also occurred as weed. *S. glauca* presented two distinct forms-one with long ear-heads and bold seeds while the other with short ear head producing very small seeds. The former did not shatter while latter shatters on maturity. Non-shattering, tall plant type with large number of tillers has a tendency for domestication and it is grown as a regular crop for human consumption on the border of Andhra Pradesh and Tamilnadu in the Chittoor district. Four types of *Panicum sumatrense* (little millet) viz. *manchi-sama*, *pola-sama*, *varugu-sama* and *ara-sama* found in Andhra Pradesh. Indian barnyard millet has diversity in ear head type and plant height.

In central peninsular region from Andhra Pradesh and Maharashtra (Vidarbha) and eastern Madhya Pradesh, several collections have early maturing types with longer spikes and better yielding capacity. Good fodder potential types were prevalent in West Bengal and Gujarat areas. *Panicum sumatrense* in Maharashtra usually had very big panicles and transplanted on the borders of finger millet or paddy fields. More variability exhibited in finger millet, mainly in finger size (short, long and straight/curved curling). Dwarf, medium and tall types occurred with both red and white grains (Umesh Chandra *et al.*, 1987 a & b).

In Orissa, finger millet is usually scattered and grown in pure stand or mixed with little millet. In foxtail millet (*kangu*-in Oriya), grain colour has variation from orange to black colour (in rare cases). Little millet with non or red-pigmented plant body and panicles are grown sporadically in finger millet fields. In high moisture fields, little millet and cultivated *Setaria glauca* grow well. Red heads with red bristles and yellowish-white heads are very common. Weedy *S. glauca* with large plant type is prevalent in every millet and upland rice fields. Weedy *S. glauca*-called *ghas lingudi* meaning weedy lingudi at west of Koraput, *kukurun lange* of Duliguda

village, *ghoda langi* meaning horse tail and *lota* for bushy type at Ramisharda Tilemal Village, *bilai lang* meaning cat tail at Phulbani, *kukulange* and *bilai lang* at Kolrapaju (Phulbani district). The domesticated type of *S. glauca* found in Orissa had thicker long stems with large, wide leaves, large long heads and short bristles, compared to the domesticated type found in southern India (Kawase, 1987; Kobayashi, 1987). Kodo millet (*Paspalum scrobiculatum*) has many kinds of weeds such as *Brachiaria* sp. called *ghusara pata*, *Echinochloa colona* called *dhera* and *Setaria glauca* called *nehri*. *Ghusara pata* and *dhera* showed little shattering behaviour. They are eaten with kodo millet.

In Madhya Pradesh, the concentration of diversity was more in finger millet though little millet occurred predominantly besides finger millet and barnyard millet. In *Panicum sumatrense*, the variability exhibited in plant height, sparse/ dense rachilla, number of grains per panicle and pigmentation of panicle. In finger millet, the variability was limited to number of fingers and straight/curved nature of fingers. Barnyard millet exhibited distinct variability only in plant height (60-150 cm). In foxtail millet, the populations have diversity in panicle length (10-20 cm.) grain size and grain colour (black, yellow and brownish yellow).

There are areas within and outside the country where large diversity exists and representations from such areas will broaden the existing variability. On the basis of priorities discussed earlier, the germplasm need to be tapped before they are eroded.

WEED RELATIVES VIS-A-VIS CROP-WEED COMPLEX

Some weeds grow in association with a particular crop. These weeds are called associated weeds. Most of them develop the characteristics of little or non-shattering which is one of the most typical characteristics of the cultivated crops. Vavilov (1926) stated many kinds of associated weeds with bread wheat, such as *Cephalaria syriaca* (L.) Roemer et Schultes, *Brassica* spp., *Sinapis* spp., *Pisum arvense* (L.) Gaertn, and with emmer wheat as *Avena* spp. and *Secale* spp. He proposed that among these associated weeds, some cultivated plants were resultant as secondary crops, such as *Brassica* spp., *Sinapis alba* L., *Pisum sativum* etc. The study of associated weeds is a key to uncovering the mechanism of the origin of cultivated plants. Millets and their wild relatives contain many important problems concerning crop-weed complexes. Indian barnyard millet (*Echinochloa frumentacea* (Roxb.) Link.), kodo millet (*Paspalum scrobiculatum* L.) and little millet (*Panicum sumatrense*) originated and are cultivated in the Indian sub-continent and its surrounding areas.

As discussed earlier, a domesticated form of *Setaria glauca* was found near the boundary between Chittoor of Andhra Pradesh and Kolar of

Karnataka. The association of mimic weeds or weedy types of finger millet, kodo millet, little millet and *Setaria glauca* was found in their fields. Among these associated mimic weeds, association of *Brachiaria* sp. to little millet and weedy *Setaria glauca* to kodo millet suggest a relationship between the mimicry and agricultural methods. Weedy *S. glauca*, associated with kodo millet and finger millet generally displays non-shattering grains which is a characteristic of domesticated millets. In paddy fields, *Paspalum* sp. with small sized grains, *Panicum* sp., *Echinochloa colona* and other spp. and mimic type of *Coix gigantea* to rice plants were found. Upland rice was observed to have mimic types of *Paspalum scrobiculatum* with long grains, *Setaria glauca* and weedy *Panicum sumatrense* and *Echinochloa colona*. de Wet *et al* (1983 b) reported that wild *Paspalum scrobiculatum* invaded fields of kodo millet, that the spikelets of these weeds were often as large as those of the crop and that weedy kodo was harvested with the crop; making it difficult to distinguish a wild and cultivated complex of *P. scrobiculatum*. Grains of weedy *P. scrobiculatum* found in upland rice field were larger than cultivated kodo millet. Those large and non-shattering grains were the results of (i) winnowing after threshing of rice contaminated with weedy *P. scrobiculatum* (ii) the collection of those grains by labourers to eat in addition to their wages for harvesting and threshing upland rice (iii) originally *Paspalum* spp. had little shattering grains. Weedy ones may have promoted such behaviour to associated weeds. Mimicry is seemed to be achieved mainly through hand weeding practices.

In little millet, *Brachiaria* spp. was observed. Cultivated *Setaria glauca* seems to have evolved as secondary crop for little millet through crop insurance in drought years as illegal wife of *Brachiaria* sp. From the above discussion, kodo millet, cultivated *S. glauca* and *Brachiaria* sp. are speculated to be secondary crops in origin through their associated or mimic weed (Sakamoto, 1987).

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METROGLYPH AND INDEX SCORE ANALYSIS OF TURMERIC GERMPLASM IN NORTH EASTERN REGION OF INDIA

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Twenty-three genotypes of turmeric collected from Meghalaya, Assam and Tripura were evaluated at Barapani Farm, Meghalaya. BD-7-105 (18), DKH-26 (13), AH6/2(12) and BD-17(8) were among five top ranking genotypes for six characters. There were four distinct morphological complexes recognised on the basis of total yield per plant and weight of primary rhizomes. Within group, morphological variations were of low order. Majority of the high scoring genotypes were in group III and IV characterized by high yield.

Turmeric (*Curcuma longa* L.) is grown almost all over the country. It is an important condiment used in daily routine diet in India. It is said to be native of South East Asia and extends towards India, Bangladesh, Sri Lanka and Indonesia. There is a vast genetic variation believed to be present among the indigenous materials grown in North Eastern (N.E.) Region. In last few years, several genotypes of turmeric had been collected from different states of N-E region. The genotypes collected from different altitudes of different states have shown diversity which could be grouped to form one or more complexes in broad sense. Little attempts had been made to distinguish among these genotypes for identifying their genetic potential. In the present investigation, an attempt has been made to classify 23 genotypes of Assam, Meghalaya and Tripura of North Eastern region into distinct complexes and to establish their genetic worth as germplasm.

MATERIALS AND METHODS

The materials consisted of twenty three genotypes namely BD-23(1), DKH-40(2), DKH-30(3), BDS-693(4), BD-21(5), BD-14(6), DKH-20(7), BD-17(8), DKH-22(9), BD-20(10), BDS-694(11), AH6/2(12), DKH-26(13), BD-12(14), DKH-36(15), DKH-34(16), BD-13(17), BD-7-105(18), DKH-23(19), DKH-27(20), DKH-32(21), BD-7-11/91(22), and AH6/1(23). Rhizomes of uniform size were planted in a randomized block design with two replications at NBPGR Regional Station farm, Barapani, Shillong (Meghalaya) (100 m mean sea level). The plot size was 1.80 x 1.50 metre having row to row

distance of 60 cm and plant to plant distance of 30 cm. Cultural practices common for the region were followed. Observations were recorded on five plants in each replication for yield and other characters and performance presented (Table 1). Metroglyph and index score analysis was carried out according to the method suggested by Anderson (1957). The class interval for various morphological traits and symbol used for different character is represented in Table-2. The index score were obtained by allotting numerical values (1, 2, 3, 4 and 5) to the five grades of each expression recognised in respect of each character and finally summing up the scores obtained by each genotypes for all the characters under study.

RESULTS AND DISCUSSION

Mean performance of selected genotypes for different characters is presented in Table-1. Highest total yield per plant was exhibited by BD-7-105 (258.9 g) followed by AH6/2 (216.5 g), DKH-26 (211.5 g), DKH-30 (188.0 g) and BDS-694 (119.9 g). The genotypes BD-7-105, DKH-26, AH6/2 and BD-17 had high performance for more than six characters as well. They were among five top ranking genotypes for most of the characters.

The results of metroglyph analysis drawn on the basis of yield per plant and weight of primary rhizome per plant are shown in Fig. 1. These two characters are the most important from breeding point of view and, therefore, they were used in plotting the glyphs, remaining eight characters have been represented by different symbols at different position on glyph (Table 2).

An examination of scatter diagram (Fig. 1) revealed that four groups could be distinguished on the basis of morphological variation. The first group consisted of eight genotypes obtained from Assam and one each from Meghalaya and Tripura. The genotypes of this group were characterized by low yield, lesser weight of primary rhizome, higher dry weight and lower plant height, number of leaves and suckers per plant. It had a narrow score range varied from 14 to 19. This group mainly included the germplasm of Assam (between 200-1300 m mean sea level). However, one germplasm BD-12(14) of Meghalaya and other BDS-693(4) from Tripura (obtained below 200 m mean sea level) were also characterized in the same group.

The second group consisted of 9 genotypes which were characterized by average total yield per plant and weight of primary rhizome. This group exhibited higher number of suckers, high percentage of dry weight recovery, medium to high weight of secondary rhizome and number of primary rhizomes. The variation in different characters was more in this group as indicated by wide range of its index scores (17 to 35). The genotypes of this

Table 1. Mean performance of selected genotypes of turmeric

S. No.	Accession No.	Plant height (cm)	No. of leaves	No. of suckers	No. of mother rhizome	Weight of mother rhizome	No. of primary rhizome	Weight of primary rhizome	Weight of secondary rhizome %	Dry weight of rhizome	Total yield/ plant (g)
1.	DKH-30	73.00	11.00	1.62	2.49	58.80	7.27	91.00	38.16	17.07	187.97
2.	DKH-20	57.57	10.50	1.50	1.37	47.87	5.04	69.10	15.42	19.60	132.42
3.	BD-17	73.40	13.12	2.12	1.33	58.03	6.83	61.40	35.00	19.90	151.92
4.	BD-20	48.07	11.50	1.62	1.50	73.37	7.25	57.54	41.37	21.37	170.28
5.	BDS-694	59.12	10.87	1.12	1.00	43.75	4.00	75.00	38.83	19.75	180.70
6.	AH 6/2	96.34	15.87	2.33	1.37	51.87	4.50	75.55	27.81	19.30	216.48
7.	DKH-26	96.34	15.87	2.33	1.62	67.12	6.00	121.55	27.31	19.20	211.48
8.	BD-13	46.61	8.25	1.00	1.00	36.42	4.00	87.33	34.28	17.25	158.08
9.	BD-7-105	80.63	13.70	1.95	1.50	98.50	7.50	112.63	47.75	20.00	258.88
10.	DKH-27	78.71	10.87	1.50	2.12	60.62	4.87	32.54	24.08	22.12	117.24
11.	DKH-32	51.34	16.25	3.00	2.00	49.76	6.27	59.51	10.65	18.20	119.92
12.	BD-7-11/91	54.32	11.87	1.75	1.37	35.62	6.87	63.83	46.58	20.40	142.05
Mean		60.75	11.47	1.68	1.36	47.77	4.94	62.02	27.26	19.29	140.17
C.D. (05)		31.51	0.47	12.91	1.19	0.52	0.31	3.29	0.72	13.93	2.15
C.V.		25.51	19.30	27.07	28.34	34.35	29.37	39.34	44.79	12.31	34.01

Table 2. Index range and symbols used for different scores for different character in turmeric

Character	Range of mean	Score-I Index range (1) Symbol	Score-II Index range (2) Symbol	Score-III Index range (3) Symbol	Score-IV Index range (4) Symbol	Score-V Index range (5) Symbol
Plant height (cm)	38.09-96.34	38.09-49.74 ○	49.75-61.39 ○	61.40-73.04 ○	73.05-84.69 ○	84.70-96.36 ○
Number of leaves	8.25-16.25	8.25-9.85 ○	9.86-11.45 ○	11.46-13.05 ○	13.06-14.65 ○	14.66-16.25 ○
Number of suckers	1.0-3.0	1.0-1.40 ○	1.41-1.80 ○	1.81-2.20 ○	2.21-2.60 ○	2.61-3.00 ○
Number of Mother rhizome	1.0-2.50	1.0-1.30 ○	1.31-1.60 ○	1.61-1.90 ○	1.91-2.20 ○	2.21-2.50 ○
Weight of Mother rhizome (g)	26.62-98.50	26.62-41.00 ○	41.01-55.38 ○	55.39-69.76 ○	69.77-84.14 ○	84.14-98.50 ○
Number of primary rhizome	3.12-7.52	3.12-4.0 ○	4.10-4.88 ○	4.89-5.76 ○	5.77-6.64 ○	6.65-7.52 ○
Weight of secondary rhizome (g)	7.32-47.75	7.32-15.41 ○	15.42-23.50 ○	23.51-31.59 ○	31.60-39.67 ○	39.68-47.75 ○
Dry weight	10.25-22.12	10.25-12.62 ○	12.63-14.99 ○	15.00-17.36 ○	17.37-19.73 ○	19.74-22.12 ○

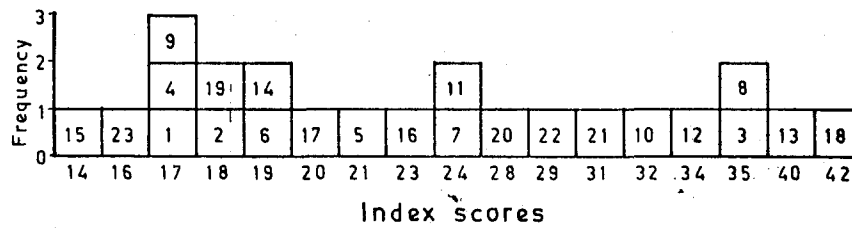
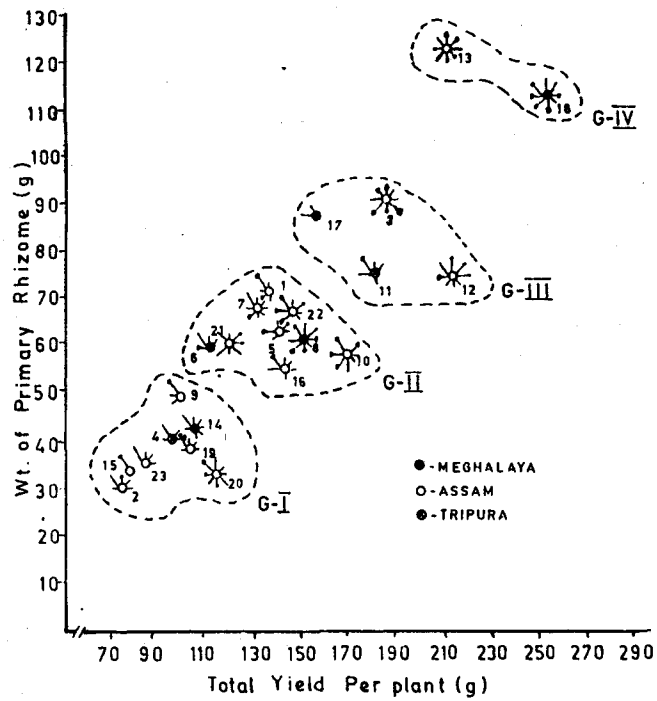


Fig. 1. Frequency diagram

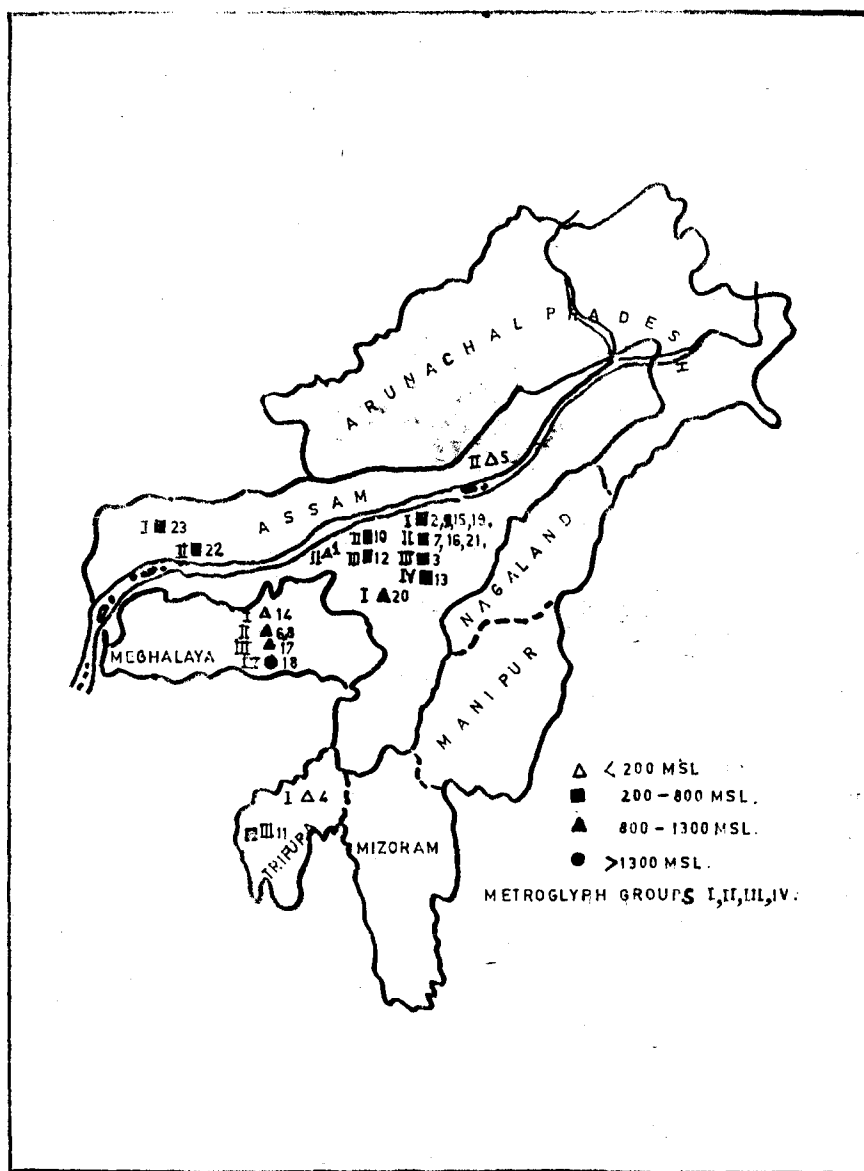


Fig - 2

Fig. 2. Distribution of four groups of germplasm of turmeric at different altitudes of North-east region

group mainly belong to Assam from varying altitudes ranging from 0 to 900 m mean sea level. However, two genotypes collected from Meghalaya (800 – 1300 m mean sea level) (Fig. 2) were also characterized in this group.

The third group consisted of four genotypes characterized by medium to high total per plant and weight of primary rhizome. Two of the four genotypes belonging to Assam (200 – 800 m mean sea level) and one each from Tripura (200 – 800 m mean sea level) and Meghalaya (800 – 1300 m mean sea level). The genotypes of Assam exhibited medium to high range for almost all the characters whereas those collected from Meghalaya and Tripura ranged from low to medium. This also lead to high range of index scores varied from 25 to 35 (Fig. 1).

The fourth group was represented by only two genotypes namely DKH-26(1) and BD-7-105(18) from Assam (200-800 m mean sea level) and Meghalaya (above 1300 m mean sea level), respectively. This group was characterized by the highest score for all the characters except for number of mother rhizome per plant which had medium score. The extreme scores (40 and 42) were obtained by accessions DKH-26 and BD-7-105.

Germplasm collected from Assam at an altitude mostly below 800 m mean sea level could be classified into four broad groups as discussed above. The germplasm of Tripura were collected from two altitude which was grouped separately in group I and group III whereas germplasm of Meghalaya were collected from various altitudes were grouped separately. These results indicate that different altitudes were important as a rich resource of various desirable germplasm of turmeric and there exist some relationship of germplasm obtained from different states irrespective of political boundary of the states.

The extreme scores 40 and 42 were obtained by DKH-26(13) and BD-7-105(18) respectively. These genotypes could be selected for further breeding programmes for various characters. Their actual worth could however be known through subsequent testing. The large variation existed in almost all the plant characters and many of these characters offer valuable criteria for systematic cataloguing of the germplasm.

On the basis of the results from the graphic analysis in turmeric, four tentative germplasm complexes could be recognised into which these genotypes sort out themselves. This information could be utilized in breeding programmes in order to combine the characters from different germplasm complexes.

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RICE GERmplasm COLLECTION IN TRIPURA STATE

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Tripura in the North-eastern region of India is a very rich resource of rice germplasm diversity. The landraces adapted to upland (tillas) and lowland valley areas responsive to low potash and phosphorus, and less prone to floods and various insect-pests diseases, are of immense value in country's rice improvement programmes. Keeping this in view, extensive collection programme was undertaken in all the areas of Tripura state to ascertain the present status of rice landraces of Tripura; to find out gaps in germplasm collection and to indicate if any genetic erosion has occurred. Wide variation in the upland and wet land rice landraces in Tripura was found. However, due to modernisation of agriculture especially in the valley areas and adjoining hills (tillas), many of the landraces of rice have already disappeared. The rate of loss in the past 15-20 years period varied from 12.5 to 73.3 per cent. In the hills dominated by tribals, some indigenous types are still in cultivation. This may be due to poor transport and other communication links and the low interaction of the extension agencies. There is still ample scope for the collection of rice germplasm tolerant to moisture stress, responsiveness to low phosphorus and potash soils from certain parts. Such potential areas are Jampui hills, North Tripura bordering Mizoram and parts of Chittagong hill tracts in the South Tripura districts.

Tripura is the smallest state in the north-eastern region of India. It is situated between 22°30' and 24°30' north latitude and 91.20° and 92°41' east longitude which comprising of long hill ranges alternating with valleys. Forests cover about 54.5 per cent of the total geographical area in the state. The crop cultivation is restricted to 23.9 per cent of the area only. The climate is mild tropical (temperature ranges 6°C to 37°C, average annual rainfall 2780 mm and mean relative humidity 79.9 %). The altitude ranges from below 0 to 900 m above sea level. The soils are generally medium in organic matter, deficient in available phosphorus and potassium. Rice is a major cereal crop. This study attempts to bring out a complete account of rice landraces available in Tripura state which had and those even existed earlier (and now no more available). The inhabitation of large number of tribes differing in their rice preferences, cultivated a large number of varieties. It was worthwhile to know these landraces. Since the state is surrounded by Bangladesh on three sides, a change in varietal pattern there is being reflected here due to the introduction from across the border

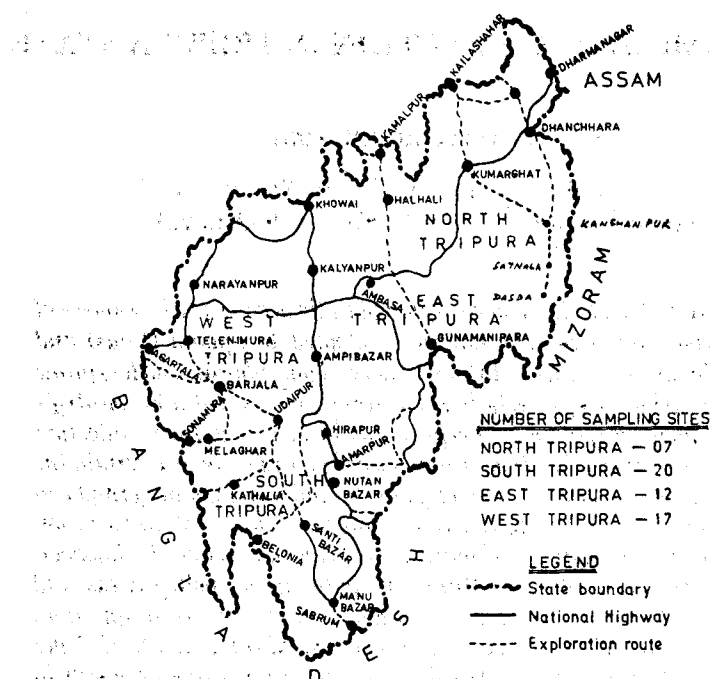


Fig. 1 Routes followed during collection of rice Germplasm in Tripura State in 1986, 1988 and 1990.

of all high yielding types mainly IRRI material or selections from it. These factors and opportunities to explore these areas were conducive to the work being reported herein.

MATERIAL AND METHODS

During three exploration trips in 1986, 1988 and 1990, the diverse agro-ecological areas were extensively surveyed. A total of 103 rice germplasm samples were collected (Table 1) from 56 sites located in East Tripura-12; West Tripura-17; North Tripura-7 and South Tripura-20 represented in Fig. 1.

Table 1. Summary of rice germplasm collected in Tripura State of N-E India upto 1990

Year of collection	Number of samples	Rate of loss (%)
Before 1975	105	12.5
1976-1978	92*	23.3
1986	42	65.0
1988	34	71.7
1990	32	73.3

* Collections by Tripura Centre of ICAR Research Complex for N-E Hills Region

RESULTS AND DISCUSSION

Tripura state comprises of three districts (North, West and South) and has a large number of tribes and subtribes which have peculiar preferences for rice varieties. These people inhabit *tillas* (hillocks) and practice *jhum* (shifting) cultivation. Main tribes are Bhil, Bhutia, Chaimal, Chakma, Garo, Halam, Jaintia, Khasi and Kuki. There are 22 subtribes such as Balte, Belalhur, Chhalya, Fun, Hajango, Jangtei, Khareng, Khephong, Kuntei, Laifang, Lentei, Mizal, Namte, Paitu, Rangchan, Rangkhohle, Thanglua, Lepcha, Lushai, Mog, Munda, Rieng, Santhal, Tripura, Tripuri, Tippera, Uchai, Rupini, Mulsoom, Manipuri. Rieng tribe is considered to be the most primitive among others. The tribals practise *jhum* cultivation. Plain valleys or flat lands are occupied by Bengalis and Muslims displaced from Bangladesh. There are thus wide variations in likings and dislikings for rice varieties among the people of Tripura. So, the rich rice diversity in the state is partly due to varied preferences and partly due to agro-ecological diverse conditions. Moreover the geographical situation of Tripura is such that it has the benefit of interaction or exchange of genetic materials with the people of Bangladesh, Assam, Mizoram, Manipur, Meghalaya, through tribal affinities as well as with Myanmar through Mizo hills and Bangladesh (Chittagong hills). Owing to this reason, as many as 115 to 120 landraces were found to be in cultivation in Tripura state. However, out of these, only 103 landraces were available about 15 to 20 years back.

The landraces found in Tripura are broadly classified as wet land rices for plain valleys, deep water paddy for river beds, *jhum* and upland types according to their habitat and soft rice for local preparations such as *petha*, *muree* (Parched rice), *Cheera* (Flaked rice), *Khoi* (Parched paddy); scented and fine grain types according to their uses. The grain of *jhum* varieties were generally broad or round type. Scented varieties usually have small slender grains.

These landraces of rice are categorised as per the habitat and quality wise, viz., –

Wetland rices : These need standing water for their cultivation. These are Khalisatiya, Chanmouri, Rangoon Buh, Binni (white), Sonamukhi, Meli, Rangagellong, Sarendyama, Charui, Billrong, Dulakanrong, Gheegoj, Bandosal, Mantotoi, Nadirsail, Latasal, Chaplaish, Jhikot, Lalmoti, Kushari, Malhail, Bowelia, Garcha, Binny Rongmala, Katikalam, Motori, Basa, Koshari, Sengamuri, Chewomuri, Jhingot, Chamlai, Phultengri, Tilak Kachhari, Hailchinal, Chankunia, Lingachikon, Rongichawal, Gorchalati, Gorchasada, Chalmuni, Mulai, Pakla, Jhingar, Kalpaha, Nagarasail, Biron, Kartik-kalam, Mainasal, Binny (red), Gorasail, Maluti, Kalamkati, Chikansal, Maichaha, Seroy (red), Jotinidhan, Laichha, Murari, Beti, Maichicon, Phakang, and Maidani.

Upland (Jhum) types : Posses drought resistance, adaptation to low phosphorus and potash soils. These are Badia, Maisai-ningha, Marao, Maima, Gelong, Binny (white), Bhadoia, Lankapora, Kamranga, Lumuru, Kanaktara, Koprok, Maiasaw, Jhum-maloti, Saroidhan, Sonamukhi, Betti, Seroy, Kanchali,

Garo-maloti, Tripura Chinar, Bhjrah, Bidi kaprov, Rang kaprov, Kala kaprov, Badiya, Salungens, Sereh, Sutu Bhadity and Misini.

Deep water types : These can tolerate continuous submerged and flood water conditions. These are *Aus dhan, Batisar, Paresdhan, Nalbajal and Marabajal.*

Soft rice types : These are used as quick foods and for preparation of peetha (sweet), local beer etc. The varieties are *Baljuri, Pipralaish, Bindi and Manoharsali.*

Scented types : *Govind bhog* (black), *Khasa Govind bhog* and *Koliajiri.*

GENETIC EROSION

In recent years, there has been considerable genetic erosion for landraces. The number of indigenous varieties in 1990 has been further reduced to 32 whereas during 1986, the number of indigenous varieties was 42. Between 1986 to 1990, the available land races were

Wet land types : *Kalpang, Mainasal, Maloti, Nagarsail, Biron, Kartik kolom, Bindi, Kamranga, Nadirsal, Kalamkathi, Chikansal, Seroy* (red), *Maichaha, Kushehri, Jotinidhan, Tripura chinar, Laichha, Murari, Maichikon, Phakang and Maidani*

Upland (Jhum) types : *Jhum Maolti, Seroy* (white), *Binny* (red), *Kanchali, Gorasal Beti and Garo Maluti*

Deep water types : *Paresdhan, Mohriwatlok and Ausdhan*

Soft rice types : *Manohar Sal, Binny* (white), *Baljuri and Gheegoz*

Scented types : These are high quality rice varieties and are the costly varieties. These are *Gobind bhog* (black), *Sada Khasa, Kola Khasa, Sada Gobindbhog and Koliajiri.*

The primary reason for this genetic erosion is the modernisation of agricultural and consequent awareness among farmers for the cultivation of high yielding improved varieties (*viz., DR 92, IR 8, IR 20, Jaya, Masuri, JR 9, JR 11, Jalaj, Kalinga-2, Basudev, Shyamali, Sona, Sonali, Ratna, Rasi, Bala* etc.), some of which even have come from Bangladesh and are the improved lines from the material received from the International Rice Research Institute, Manila, Philippines (e.g., *JR 11*). The result was the replacement of over 73 per cent of indigenous rice germplasm diversity.

Efforts to study change in rice diversity scenario over the past 15-20 years were rewarding in order to know the extent of genetic erosion (Table 1). The rate of loss of landraces varied from 12.5 per cent to over 73 per cent in 1990. This alarming loss of local germplasm warrants vigorous action for collection to avoid occurrence of a parallel situation in other north-eastern states.

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VARIABILITY AND ASSOCIATION STUDIES IN GUAYULE *PARTHENIUM ARGENTATUM* A. GRAY

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Analysis of variance for twelve quantitative characters in 10 genotypes of guayule showed significant variability and potential for improvement through breeding. Plant height, basal branches per plant, main stem diameter, and leaf length and width had high genotypic coefficient of variability, high heritability and high genetic advance (% of mean). This shows that effective selection for improvement of these characters is possible in guayule. Rubber content had negative significant correlations with stem diameter. Rubber yield plant⁻¹ showed positive significant correlation with plant circumference, basal branches plant⁻¹, fresh and dry shrub yield plant⁻¹ and plant diameter. Basal branches plant⁻¹ also recorded highest GCV (30.00), GA (61.72 %) and high heritability (99.4 %), thus can be used as a non-destructive predictor of high rubber yield. Possibilities to improve number of basal branches by selection are good. As stem diameter showed negative correlation with rubber content (%), the plant breeders will have to compromise at certain co-level of stem thickness and number of stems (basal branches) to get higher rubber yield per unit area from guayule cultivation.

Guayule, *Parthenium argentatum* A. Gray, is a member of family compositae. Out of the 16 species of this genus, *Parthenium argentatum* is the only species known to produce rubber. Rubber is contained mainly in the bark portion of the stems and roots with little or none found in the leaves and flowers (Curtis, JR., 1947). Besides *Hevea brasiliensis* (H.B. & K.) Muell, Aug., Guayule is the only source of natural rubber (Baird, 1975). *Hevea* can be cultivated only in the tropical zone whereas, guayule is cultivated in arid zones. With the increasing population growth, guayule, offers an opportunity for productively utilizing marginal lands by providing jobs and income to desert dwellers. *Hevea*, on the other hand, requires fertile land and a humid climate, which limits the possibility pressure of expansion of its cultivation owing to the mounting pressure on agricultural land for food production (Bhatia and Masohan, 1983).

Guayule's native habitat is a semiarid plateau 1,200 to 2,100 m high with temperature range -18° to 44°C and annual rain fall between 230-400 mm. The plant grows best in well-drained soils and can not tolerate water logging. More than 640 mm annual rainfall cause excessive vegetative growth, instead of rubber formation (Anon., 1977).

Guayule was introduced in India to develop an alternative source for natural rubber (Bhatia and Masohan, 1983). Much work has been done regarding guayule's utilization (Mc Ginnies and Haase, 1975); chemical composition (Haagen-Smit and Siu, 1944), method of rubber extration (Anon., 1977), etc. but reports on variability, character-association and aids to selection are few. It takes 2-4 years to study rubber yield and component characters as the rubber accumulates with the age of plant in guayule. Keeping this in view, the present studies were undertaken to determine the variability parameters, heritability (in broad sense), expected genetic advance and correlation between various quantitative traits to aid the plant breeder in predicting both rubber percentage and rubber yield of guayule.

MATERIALS AND METHODS

The experiment was carried out at the Research Farm, Haryana Agricultural University, Hisar in India, a subtropical region situated in between 28°59' to 29°49' N latitude and 75°11' to 76°18'E longitude. It has arid/semi-arid, tropical climate. The annual mean temperature is more than 25°C with a wide range (-2.9° to 47.9°C). Annual mean rainfall is 450 mm ranging from 180 to 790 mm (Rao *et al.*, 1987). Ten genotypes of guayule received through National Bureau of Plant Genetic Resources (NBPGR), New Delhi were nursery raised in October, 1987. Transplanting was done on 2 February 1988 at the four seedling stage in randomized complete block design with three replications. Each plot consisted of five rows, 5 m long and spaced 75 cm apart. Plant to plant distance was maintained at 45 cm. Seedlings were dwarf enough because guayule remains dormant during winter months (Anon., 1977). Observations were recorded after about three years of transplanting i.e., in January, 1991 on 10 randomly selected competitive plants in each plot. These plants were harvested by digging the entire shrub. Rainfall during 1988, 1989, and 1990 was 672 mm, 189.6 mm and 539.1 mm, respectively. In 1989, a few irrigations were supplemented during summer months. 1-2 irrigations were given during 1988 and 1990 also. Waterlogging was avoided by timely drainage of excess water from the field which is detrimental to the growth in guayule. Data were collected on (1) plant height, (2) plant circumference, (3) basal branches per plant, (4) leaf length (5) leaf width, (6) fresh shrub yield per plant, (7) dry shrub yield per plant, (8) plant diameter (width), (9) main stem diameter, (10) per cent dry matter, (11) rubber content and (12) rubber yield per plant. Dry shrub yield per plant excluded

the weight of dry leaves as they contain non-significant rubber (Anonymous, 1977; Dierig *et al.*, 1989). Height and width (diameter) measurements were recorded for each plant prior to harvest. Rubber content was also determined (Donald *et al.*, 1981). The dried samples (excluding leaves) were put through chipper to obtain a coarsely ground sample. Thereafter, this sample was finely ground using a SEW Laboratory Willey Mill containing a 1.75 mm mesh screen. Samples of 20 grams were analysed for rubber content. The main stem diameter of each plant was measured at 5 cm above the ground.

Plot means were used for statistical analysis. Analysis of variance was carried out (Steel and Torrie, 1980) and genotypic, phenotypic and error variances were calculated (Prasad *et al.*, 1981).

The variance components were used to compute the genotypic coefficient of variation (GCV), heritability (in broad sense) and genetic advance. The GCV was computed (Kumar *et al.*, 1985; Burton, 1952) whereas heritability and expected genetic gain were estimated according to Allard (1960) assuming a selection intensity of 5 per cent. Simple correlation coefficients were worked out among all the characters.

RESULTS AND DISCUSSION

Analysis of variance for twelve guayule characters studied is indicated in Table 1. The mean squares for genotypes were highly significant for all the characters under study.

Table 1. Analysis of variance for 12 traits in guayule

Character	Mean square values for accessions	F value
Plant height (cm)	514.43	34.88 **
Basal branches per plant	42.49	174.62 **
Plant circumference (cm)	977.12	421.28 **
Plant diameter (cm)	89.36	16.98 **
Main stem diameter (cm)	2.74	43.50 **
Leaf length (cm)	10.73	287.84 **
Leaf width (cm)	1.22	1475.71 **
Fresh shrub yield (g plant ⁻¹)	8339.37	29.30 **
Dry shrub yield (g plant ⁻¹)	1097.33	9.28 **
Per cent dry matter	5.05	3.32 *
Rubber content (%)	2.25	5111.36 **
Rubber yield (g plant ⁻¹)	42.46	75.60 **

*, **, Significant at P = 0.05 and P = 0.01, respectively

Table 2. Range, mean, standard error and least significant difference (LSD) for 12 characters in 10 guayule genotypes

Characters	Range in values and genotypes			Mean	S.E. [±]	LSD
	Min. value	Genotype	Max. value			
Plant height (cm)	54.33	General	99.30	HG-8	64.15	1.38
Basal branches per plant	8.73	HG-10	19.53	HG-8	12.51	0.40
Plant circumference (cm)	233.50	USDA	295.90	HG-8	256.04	1.90
Plant diameter (cm)	74.84	USDA	94.20	HG-8	82.05	1.87
Main stem diameter (cm)	3.26	Arizona-101	5.84	HG-8	4.71	0.21
Leaf length (cm)	5.83	HG-10	11.42	HG-8	7.72	0.002
Leaf width (cm)	1.57	Arizona-101	3.73	HG-8	2.35	0.001
Fresh shrub yield (g plant ⁻¹)	690.00	USDA	873.00	HG-8	758.70	5.56
Dry shrub yield (g plant ⁻¹)	362.00	USDA	432.33	HG-8	388.80	2.01
Per cent dry matter	49.33	HG-10	53.10	G-3	51.34	1.01
Rubber content (%)	4.72	General	7.37	Arizona-101	6.11	0.09
Rubber yield (g plant ⁻¹)	18.17	General	28.47	HG-8	23.51	0.39
						2.08

P = 0.05

The ranges in minimum and maximum values, the genotypes expressing these values, the mean, the standard error and the least significant differences (LSD) at $P = 0.05$ for the twelve characters are presented in Table 2. The best rubber yield plant¹ was recorded from HG-8 and the lowest from General which also showed lowest expression for plant height and rubber content. Maximum rubber content was recorded for Arizona-101 coupled with thinnest main stem. It is worth mentioning that HG-8 recorded maximum expression for all the characters except per cent dry matter and rubber content. Generally, a fairly good range of gross variation was found for all characters except for per cent dry matter and rubber content.

Estimates of genotypic and error variance components for the twelve characters are given in Table 3 which indicates that the variability observed in the phenotype is influenced more by genetic factors than non-genetic. The GCV, h^2 and GA as per cent of the mean are also given in Table 3. Which indicated that the variability observed in the phenotype is influenced more by genetic factors than non-genetic. The GCV, h^2 and GA as per cent of the mean are also given in Table 3.

Characters, viz., basal branches per plant, leaf width and leaf length showed high GCV values. Moderate GCV values were found for plant height, main stem diameter, rubber content and yield per plant and low values for rest of the traits.

Heritability values were more than 89 per cent for all the characters except 69.82 for per cent dry matter (Table 3). The genetic advance expected from selecting the top 5 per cent of the genotypes, varied from 3.63 for per cent dry matter to 61.62 for basal branches per plant (Table 3). Leaf width, leaf length, fresh shrub yield per plant, plant height and main stem diameter have shown high values in the order mentioned. Rubber yield per plant and rubber content have indicated a potential for moderately high genetic advance. Plant diameter, dry shrub yield per plant and per cent dry matter showed high heritability with very low genetic advance thus indicating selection to be less effective.

Correlations coefficients between various characters are presented in Table 4. Stem diameter had highly significant negative correlation with rubber content. The implied relationship is that as stem thickness increases, per cent rubber decreases. Since rubber is contained primarily in the bark rather than the wood portion, thicker stems, having a lower bark : wood ratio than thinner stems, would also have a lower rubber percentage. Dry shrub yield per plant had non-significant correlations with rubber content as also observed (Ray *et al.*, 1933; Benitez and Kuruvadi, 1985 and Thompson *et al.*, 1988); on the contrary, negative significant correlation between dry shrub weight and rubber content was observed (Dierig *et al.*, 1989).

Table 3. Estimates of genotypic variance (Vg), error variance (Ve), genotypic coefficient of variability (GCV), heritability (H), genetic advance (GA) and GA as percentage of mean

Characters	Vg	Ve	GCV (%)	H (%)	GA	GA as per cent of the mean
Plant height (cm)	166.56	4.91	20.12	97.13	26.20	40.84
Basal branches per plant	14.08	0.080	30.00	99.44	7.71	61.62
Plant circumference (cm)	324.93	0.773	7.04	99.76	37.09	14.48
Plant diameter (cm)	28.03	1.75	6.45	94.11	10.58	12.89
Main stem diameter (cm)	0.892	0.021	20.06	97.70	1.92	40.83
Leaf length (cm)	3.56	0.012	24.45	99.44	3.87	50.20
Leaf width (cm)	0.405	0.0003	27.07	99.99	1.31	55.78
Fresh shrub yield (g plant ⁻¹)	2684.92	94.87	6.82	96.59	331.64	43.71
Dry shrub yield (g plant ⁻¹)	326.37	39.41	4.65	89.23	35.15	9.04
Per cent dry matter	1.17	0.507	2.11	69.82	1.87	3.63
Rubber content (%)	0.750	0.0001	14.16	99.99	1.78	29.18
Rubber yield (g plant ⁻¹)	13.97	0.187	15.90	98.73	7.60	32.24

Table 4. Simple correlations among various traits in guayule

	PC	BB	LL	LW	FSY	DSY	RC	RY	PD	% DM	SD
PH	0.735*	0.646*	0.711*	0.695*	0.728*	0.743*	0.170	0.513	0.741*	-0.485	0.417
PC		0.413	0.425	0.522	0.999**	0.956**	0.391	0.749*	0.980**	-0.834**	0.081
BB			0.894**	0.551	0.260	0.496	0.585	0.683*	0.659*	-0.140	-0.124
LL				0.530	0.426	0.504	0.612	0.593	0.532	-0.146	-0.143
LW					0.504	0.529	0.271	0.419	0.597	-0.297	0.249
FSY						0.960**	0.402	0.763*	0.981**	-0.834**	0.073
DSY							0.417	0.779**	0.955**	-0.643*	0.131
RC								0.429	0.518	-0.293	-0.777**
RY									0.825**	-0.583	-0.415
PD										-0.786**	-0.014
% DM											0.095

PH = Plant height (cm), PC = Plant circumference (cm), BB = Basal branches/plant, LL = Leaf length (cm), LW = Leaf width (cm), FSY = Fresh shrub yield (g/plant), DSY = Dry shrub yield (g/plant), RC = Rubber content (%), RY = Rubber yield (g/plant), PD = Plant diameter (cm), % DM = Per cent dry matter, and SD = Main stem diameter (cm)

*, ** Significant at P = 0.05 and 0.01, respectively.

Rubber yield had significant positive correlations with plant circumference, basal branches per plant, and fresh and dry shrub yield plant⁻¹. Present experiment involved various characters which may serve a non-destructive predictor for rubber yield such as plant circumference, plant diameter and basal branches per plant i.e. more vigorous plants would yield more rubber. This is in agreement with the view of Federer (1946) who indicated that there appears to be good possibility for increasing rubber yields by selecting larger plants.

Basal branches per plant, a non-destructive predictor for higher rubber yield showed positive significant correlation with leaf length (Table 4) which suggests that selection of plants with larger leaves to get higher rubber yielding ones is appropriate.

Basal branches per plant also recorded highest GCV (30.0), genetic advance as per cent of mean (61.62) and appreciably high heritability (99.44). These values indicate very good chances to increase number of basal branches through simple selection. Stem diameter showed negative and significant correlation with rubber content (-0.777) which is not a desirable association. Therefore, task of a breeder becomes more complex as he will have to compromise at certain co-level of stem thickness and number of stems per plant to get better rubber yield. Looking at the GCV and heritability values for rubber content, it seems that selection would prove effective, so the breeder can go for the selection of bushy plants with thinner stems having fairly good rubber content.

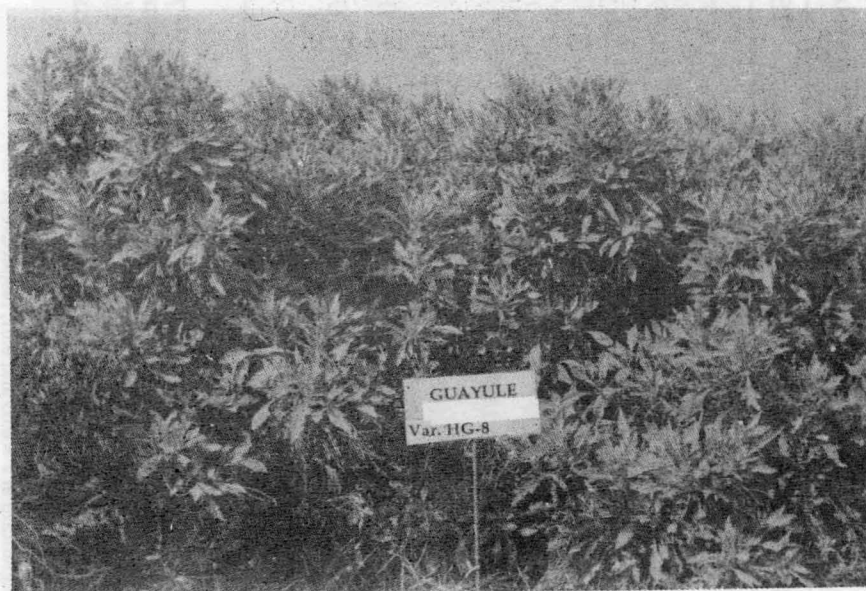


Fig. 1. Guayule Var. HG-8

Among the genotypes studied, HG-8 (Figure 1) may serve the best donor for all the characters except per cent dry matter, stem thickness and rubber content. Whereas Arizona-101 recorded maximum rubber content. This genotype also expressed lowest value for stem thickness which is important to have plants with high rubber content. Direct selection for number of basal branches per plant and plant diameter can be made to get plants having higher rubber production but the selection based on the former trait would be more effective.

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GERMINATION AND VIGOUR OF STORED SORGHUM PIGEON PEA AND GROUNDNUT SEEDS

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Seed lots of Sorghum, pigeonpea and groundnut harvested in different years and stored for durations varying from one to ten years (1977-1986) under controlled conditions of medium term storage (4°C/20% RH) were germinated under different temperatures and substrate moisture conditions. The germination and seedling vigour were studied to find out optimum conditions while monitoring seeds in gene bank. Minimum mean germination period was noted at intermediate levels of moisture content. Mean germination period was maximum at the lowest moisture level. Mean germination period decreased with the increase in temperature. Seed lot stored for longer duration had longer mean germination period than the seed lot stored for shorter duration. In sorghum and pigeonpea, maximum germination was observed at intermediate levels of water content irrespective of temperature of germination. Among the temperature studied, germination was maximum at 25°C. High moisture level and high temperature promoted shoot length. Seedling vigour decreased with a decrease in temperature. Effect of all the three factors viz. temperature, moisture and year and their interaction was found significant at 5 per cent level.

Germination capacity of seeds is strongly influenced by environmental factors such as temperature and water stress (McGinnier, 1960; Tadmore *et al*, 1969). Seeds stored under controlled conditions in a genebank are taken out for monitoring germination at regular intervals to ensure that viability does not drop to unacceptable low levels. In the genebank management, current advice provided by IBPGR is that the germination testing environment be able to provide within one test environment or procedure those conditions which enable all viable seeds of that species to be able to germinate. That is, the germination environment should not be stressful to even poor quality seeds. During monitoring, the maximum germination can not be achieved until the germination behaviour of stored

seeds is known. In the present investigation, seed lots of three crops viz., sorghum, pigeonpea and groundnut, harvested in different years, and stored for varying durations were germinated under different temperature and moisture conditions. The details are given in Table-1. The germination response and seedling vigour were studied to find out the optimum conditions for germination while monitoring seeds stored in the genebank.

MATERIALS AND METHODS

The experiment was conducted at ICRISAT, Patancheru in September 1987 and subsequently at NBPGR, New Delhi. Seeds of sorghum, pigeonpea and groundnut stored in closed containers (Aluminium cans with rubber lined lids in case of sorghum and pigeonpea and plastic jars in case of groundnut) for various durations under controlled conditions of medium (4°C, 20% RH) term storage were used in this study. The seeds were stored at $7 \pm 1\%$ MC. The details of materials as well as the conditions of growth are shown below in Table-1.

Table 1. Duration of storage and conditions during germination of the various seeds lots

Crop/Identity	Year of harvest	Duration of storage (years)	Substrate moisture level (ml)	Temperature (°C)
Sorghum IS 11758	1977	10	2.5, 5, 10	15, 25, 35
	1984	3		
	1986	1		
Pigeonpea ICP-1	1981-82	5	5, 10, 20	15, 25, 35
	1982-83	4		
	1986-87	1		
Groundnut ICG-2851	1985	2	5, 10, 20	15, 25, 35
	1986	1		

The seeds were surface-sterilised with sodium hypochlorite (0.25 %) and germinated on top of filter paper (Whatman No. 181) moistened with measured amounts of water in petri-dishes, enclosed in polyethylene bags. Two replicates, each of 50 seeds, were used for the rate of germination, while four replicates, each of 50 seeds, were used to test germination and vigour.

Seeds of sorghum (radicle length 5 mm) and pigeonpea and groundnut (radicle 10 mm length) were considered as germinated. Germination counts were taken on each day for calculating the mean germination period. Final germination counts were made following ISTA Rules (Anon.,

1985); shoot and root length were measured to quantify the vigour of seedlings.

Mean germination period was calculated following Ellis and Roberts, 1980.

$$\text{Mean germination period (days) } \bar{D} = \frac{\sum (D-n)}{\sum n}$$

Where n is the number of seeds which germinate (radicle emerged) and D is the number of days counted from the beginning of germination test.

The variance of germination time was calculated as :

$$\text{Variance of germination time (days)} = \frac{\sum [(\bar{D} - D)^2 n]}{\sum n}$$

The data were statistically analysed.

RESULTS AND DISCUSSION

Sorghum seeds harvested in 1977 and stored for 10 years did not germinate in any set of conditions. Minimum mean germination period at the same temperature was noted at intermediate moisture level of the substrate *viz.*, 5 ml in sorghum and 10 ml in pigeonpea and groundnut (Table 2). Mean germination period (reciprocal of the rate of germination) was maximum at the lowest moisture level *viz.*, 2.5 ml in sorghum and 5 ml in pigeonpea and groundnut. At the same moisture level, the mean germination period decreased with increase in temperature in all cases except at 35°C for sorghum seed harvested in 1984. A positive linear relationship between temperature and rate of germination in a seed population has been shown in previous studies (Covell *et al.*, 1986; Garcia-Huidoboro *et al.*, 1982). At the same temperature and substrate moisture level, seed lot stored for longer duration (relatively more aged seeds) had longer mean germination period than the seed lot stored for shorter duration (relatively less aged seeds). Previous studies have shown that loss in viability in aged seed lots was preceded by an increase in the mean time taken by surviving seeds to germinate and is a common feature of seed ageing (Ellis and Roberts, 1980). Temperature affected both the maximum fraction of seed germinated after a fixed period of time and the rate of germination. The analysis of variance showed that the effect of all the three factors *viz.*, temperature, moisture and year of harvest and their interactions were significant at 1 per cent except groundnut where it was significant only at 5 per cent level. Its interactions with other two variables *viz.*, moisture and temperature were not significant.

In pigeonpea, aged seeds did not germinate in water and temperature stress conditions especially at low temperature. Previous studies (Ellis and Roberts, 1981 and Ellis *et al.*, 1986, 1987 a) have shown that within a genotype seed quality can have a marked effect on the profile of total percentage germination with respect to temperature as well as the time required for germination. Three patterns of changing temperature requirements for seed germination during storage were described (Roos, 1980), resulting in the narrowing of temperature range for germination. Either the maximum or minimum germination temperature changes gradually or both change which results in the inability of seeds to germinate at one or both of the temperature extremes.

Table 2. Mean Germination period (days) of seeds of different crops at various temperature and moisture range

Crop/identity/ year of harvest	Temperature (°C)	Substrate moisture level (ml)		
		2.5 ml	5.0 ml	10.0 ml
Sorghum (IS 11758) 1984	15	5.69 (0.24)	4.43 (0.44)	4.60 (0.70)
	25	2.60 (1.72)	2.17 (0.23)	2.51 (0.82)
	35	3.39 (0.98)	2.21 (0.34)	2.34 (0.64)
Sorghum (IS 11758) 1986	15	3.37 (0.22)	3.12 (0.16)	3.20 (0.21)
	25	2.45 (0.24)	2.15 (0.15)	2.16 (0.17)
	35	1.72 (0.14)	1.43 (0.23)	1.63 (0.24)
		5 ml	10 ml	20 ml
Pigeonpea (ICP-1) 1981-82	15	0	0	0
	25	4.88 (0.32)	3.79 (0.61)	4.16 (0.77)
	35	0	2.75 (0.18)	3.19 (0.71)
Pigeonpea (ICP-1) 1982-83	15	0	4.83 (0.13)	0
	25	4.62 (0.31)	3.34 (0.44)	4.12 (0.73)
	35	3.70 (0.33)	2.73 (0.47)	2.70 (0.70)
Pigeonpea (ICP-1) 1986	15	5.50 (0.25)	4.40 (0.25)	4.70 (0.46)
	25	3.87 (0.23)	2.85 (0.41)	3.09 (0.40)
	35	3.40 (0.60)	2.23 (0.33)	2.40 (0.38)
Groundnut (ICG 2851) 1985	15	5.55 (0.84)	4.55 (0.46)	4.88 (0.50)
	25	3.30 (0.66)	2.5 (0.47)	2.60 (0.24)
	35	2.70 (0.58)	2.4 (0.12)	2.05 (0.10)
Groundnut (ICG 2851) 1986	15	5.05 (0.64)	4.18 (0.61)	4.38 (0.65)
	25	3.20 (0.56)	2.4 (0.47)	2.35 (0.22)
	35	2.47 (0.41)	2.21 (0.42)	2.30 (0.37)

Values in parenthesis indicate the variance in germination time.

0 Values show lots which did not germinate.

In sorghum and pigeonpea, maximum germination was observed at intermediate levels of water content irrespective of temperature at which germination was carried out (Table 3). Therefore, this moisture level may be considered as optimum. Between the temperature, germination was maximum at 25°C. These results are in agreement with prescription of ISTA (Anon., 1985). High moisture level and high temperature promoted shoot length. Seedling vigour as measured by the length of shoot and root decreased with decrease in temperature. Among the seeds germinated at different temperatures, germination was the least at low temperatures. Although 35°C was optimum in terms of most rapid germination and maximum seedling vigour, it was noted that a large number of seedlings showed abnormalities at this temperature.

Table 3. Seed viability and seedling vigour observations at different temperatures and substrate moisture level

Crop identity Year	Temp. °C	Water content (ml)	Percent normal seedling	Percent abnormal seedling	Shoot length (cm)	Root length (cm)
Sorghum IS 11758 (1986)	35	2.5	65	28	1.73	6.1
		5.0	73	23	4.55	9.12
		10.0	71	16	6.22	8.58
	25	2.5	76	23	1.38	5.5
		5.0	81	10	4.0	7.16
		10.0	73	6	7.0	8.18
	15	2.5	56	0	0	1.43
		5.0	62	20	0.58	2.33
		10.0	58	16	0.60	3.5
Sorghum IS 11758 (1984)	35	2.5	49	27	1.0	5.2
		5.0	60	19	1.9	6.4
		10.0	59	16	2.0	7.6
	25	2.5	54	13	0.0	3.1
		5.0	61	9	1.7	3.4
		10.0	56	7	1.8	5.0
	15	2.5	28	15	0.0	1.3
		5.0	35	60	0.0	1.2
		10.0	31	8	0.0	2.5
Pigeonpea ICP 1(1986)	35	5.0	82	9	2.8	11.5
		10.0	92	1	6.8	5.5
		20.0	84	2	4.3	4.5
	25	5.0	92	4	2.1	6.2
		10.0	95	3	4.1	5.0
		20.0	93	4	4.4	5.8

Cont...

Table 3. (Contd.)

Crop identity Year	Temp. (°C)	Water content (ml)	Per cent normal seedling	Per cent abnormal seedling	Shoot length (cm)	Root length (cm)
Pigeonpea ICP 1(1982-83)	15	5.0	64	0	0.3	1.14
		10.0	75	0	0.80	2.18
		20.0	71	4	0.66	1.63
	35	5.0	41	29	3.2	4.2
		10.0	52	21	4.8	5.4
		20.0	48	20	5.7	5.6
	25	5.0	50	15	1.5	4.0
		10.0	64	18	3.4	4.4
		20.0	61	10	3.9	4.2
Pigeonpea ICP 1 (1981-82)	15	5.0	0	0	0	0
		10.0	32	8	0.61	2.10
		20.0	0	0	0	0
	35	5.0	0	0	0	0
		10.0	42	8	4.1	3.7
		20.0	38	7	3.5	3.1
	25	5.0	32	2	1.0	2.8
		10.0	51	1	1.5	2.2
		20.0	44	3	1.9	1.6
Groundnut ICG 2851 (1986)	15	5.0	0	0	0	0
		10.0	0	0	0	0
		20.0	0	0	0	0
	35	5.0	71	20	1.7	5.1
		10.0	82	15	1.5	6.5
		20.0	75	0	1.8	7.0
	25	5.0	84	0	1.6	4.0
		10.0	91	0	1.6	4.5
		20.0	90	9	1.0	7.3
ICG 2851 (1985)	15	5.0	70	0	0.2	3.0
		10.0	85	0	0.4	4.5
		20.0	75	25	0.7	3.6
	35	5.0	73	25	1.5	3.9
		10.0	70	29	1.6	3.5
		20.0	79	23	2.0	4.82
	25	5.0	78	6	0.6	3.5
		10.0	80	0	1.0	4.07
		20.0	87	7	1.5	4.1
	15	5.0	31	15	0.5	1.5
		10.0	37	9	0.8	2.7
		20.0	35	10	1.5	3.0

Results show that the regime in which the seed population is tested can influence final germination markedly, as has been shown earlier (Ellis *et al.*, 1987 b). The significance of these results for monitoring germination of stored seed in the genebank is that, differences in germinability can be exhibited by seed lots stored for various duration, and also in response to the germination environment. The use of optimum temperature and moisture levels only could achieve maximum germination while monitoring genebank accessions.

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VARIABILITY IN INDIAN ALOE

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Forty-four populations of Indian Aloe were evaluated for agrobottanical characters and aloin content. Analysis of the data has shown that aloin content was positively correlated with short, broad and thick leaves. Eight promising lines have been identified for comparative evaluation and domestication. A chemical test has shown that 13 lines were showing Klunge negative test suggesting a need for further taxonomic validation of Indian material under Aloe barbadensis.

Aloe barbadensis is a xerophytic perennial herb with short stem, fleshy convex leaves having distant spiny margin and tapering towards the top. The leaf lamina is streaked with small dull-white spots or lines. The species is occasionally raised as a potted plant and is propagated by suckers. It is native of north Africa, Canary islands, Spain but has spread during distant past to Italy, China, India, East and West Indies and host of other countries. Its main active principle is aloin or barbaloin (Groom and Reynold, 1987) which has been shown to occur in 85 out of 240 *Aloe* species (Reynold, 1985). However, this is the solitary species reported in India and it has 2 or 3 easily recognisable varieties (Anon, 1985). *Aloe* species are used extensively in drugs and cosmetics industries. Aloin, the main purgative principle, is a mixture of anthracene derivatives (Fairbairn, 1949). Chemically it is a 10-glycopyranosyl derivative of aloe emodin anthrone [10-(1-deoxyglycosyl) aloe emodin anthrone]. The Indian species (*Aloe barbadensis*) also contains isobarbaloin; wherein another commercially prominent species *Aloe ferox* contains an amorphous barbaloin and aloinosides A and B (Anon., 1967).

Although aloe is commercially produced and traded under the name **mussabar** in Indian market for drug purpose, the populations growing in India have never been a subject of detailed evaluation for economic potential. It was decided to collect and evaluate the germplasm with emphasis on relative contribution of qualitative characters of the plant in biosynthesis of aloin.

MATERIALS AND METHODS

Explorations were organised to collect *Aloe* species from different districts of Rajasthan in the year 1987 and 1990 during October and November. This was augmented by materials collected from some growers

in the state nurseries and obtained from the stocks maintained at Regional Research centres of Central Council of Research for Ayurveda and Siddha medicines. The NBPGR has assembled and grown a total stock of 44 populations at Issapur Experimental Research Farm, New Delhi. These plantlets were raised on a small plot each representing a (6 m long) row. A spacing of 60 cm between the rows and 30 cm between the plantlets in a row was maintained. This crop was irrigated once a month except May and June when two irrigations per month were given. Leaves were collected for analysis during November and December, 1990 for their qualitative characters and aloin content. For this purpose, five mature leaves of nearly same age were picked from the outer part of the plant from each germplasm populations. Observations were recorded for following qualitative characters based on an average of the five leaves. (1) Fresh weight/leaf (gm), (2) Length/leaf (cm), (3) Breadth (lower)/leaf (cm), (4) Breadth (middle)/leaf (cm), (5) Breadth (Upper)/leaf (cm), (6) Thickness (Lower)/leaf (cm), (7) Thickness (upper)/leaf (cm) and (8) Volume of latex/leaf (ml).

After recording the above characters, transverse incisions were made on the leaves and latex oozed out and collected in the beaker. A part of the latex was allowed to dry and aloin content was determined as aloin per cent of dry weight. of latex. The second part of the latex was transferred to separating funnel and repeatedly extracted (4 x 25 ml) with ethyl acetate. The combined ethyl acetate extracts were evaporated under reduced pressure and low temperature (< 50°C). This dried extract was analysed for aloin content per 100 ml of latex by the usual colorimetric method (Anon., 1967).

An isobarbaloin test was also simultaneously carried out. This is based on Klunge test (Anon., 1983) and used for the differentiation of *Aloe barbadensis* from other allied species.

RESULTS AND DISCUSSION

The variation in population for qualitative characters and aloin content in the germplasm is shown in Table 1 and 3. In one year old plant (collected during the year 1990), the fresh weight varied from 40 gm to 373 gm per leaf. Similarly volume of latex exudate varied from 1 ml to 65 ml and its aloin content (mg/100 ml) from 1.62 to 68.74 or in term of aloin percentage being 0.23 to 5.17. The statistical analysis of the values shown through correlation matrix (Table 2) suggested a strong positive correlation amongst different characters such as between length, breadth, fresh weight, thickness and volume of exudates. It was significant to find negative correlation between the length of the leaf and aloin content of the exudate at 5 per cent level of significance.

The variations in agro-botanical and chemical traits are found to be maintained with age in four year old plants collected and planted during the year 1987 (Table 3) and the trend for correlation (Table 4) amongst the values of characters is more or less similar to those recorded for one year old plants. However, an interesting correlation was observed between breadth and thickness of the leaf with its aloin content at 1 per cent level of significance.

Table 1. Range of variation in agrobotanical and chemical characters of 44 germplasm lines (one year old plants)

Characters	Minimum	Maximum
1. Av. length/leaf (cm)	19.00	46.00
2. Av. breadth/leaf (cm)	2.10	8.20
3. Av. breadth/leaf middle (cm)	2.00	6.20
4. Av. breadth/leaf upper (cm)	1.00	4.10
5. Av. thickness lower (cm)	0.40	2.50
6. Av. thickness upper (cm)	0.20	1.30
7. Av. volume of latex/leaf (ml)	1.00	65.00
8. Aloin content ,g/100 (ml)	1.62	68.74
9. Aloin content percent dry wt. of latex	0.23	5.17
10. Av. fresh wt./leaf (gm)	40.00	373.00

Based upon this study, we may conclude that small size plant with broad and thick leaves is the ideal type for domestication; it produces higher yield of aloins. The chemical analysis has identified some promising lines in term of aloin content viz. IC-112526 (4.21 %), IC-112529 (4.63 %), IC-112535 (4.21 %), IC-112536 (5.17 %), IC-111267 (4.71 %), IC-111271 (4.07 %), IC-111273 (4.31 %) and IC-111280 (4.83 %). Since mature leaves from the outer periphery of the plant, were used for analysis of aloin content in this experiment, this was found to be low (up to 5.17 %) compared to the aloin content in younger leaves attached just below the apex. In fact, a very high percent of aloin in the young leaves of different species have been recorded (Groom and Reynold, 1987) and maintained at Kew Botanical Garden. Aloin level decreases in older leaves but weight by weight, these leaves constitute the main farm produce.

Table 2. Correlation matrix between agrobotanical and chemical characters

	1	2	3	4	5	6	7	8	9	10***
1	1.00									
2	0.577**	1.000								
3	0.602**	0.858**	1.000							
4	0.277	0.709**	0.861**	1.000						
5	0.398*	0.781**	0.676**	0.593**	1.000					
6	0.277	0.527**	0.485*	0.434	0.745	1.000				
7	0.502*	0.629**	0.507**	0.269	0.507	0.246	1.000			
8	0.305	0.257	0.091	0.118	0.353	0.141	0.169	1.000		
9	0.412*	0.084	0.094	0.052	0.110	0.057	0.127	0.936**	1.000	
10	0.607	0.610**	0.437*	0.095	0.509**	0.206	0.846**	0.134	0.108	1.000

* Significant at 5 % level

** Significant at 1 % level

*** Numbers indicate the characters mentioned in Table 1.

Furthermore, Klunge test (Anon., 1983) has been used to identify isobarbaloin containing populations in the Indian material. This has brought

Table 3. Range of variation in agrobotanical and chemical characters of 44 germplasm lines(4 years old plants)

	Characters	Minimum	Maximum
1.	Av. length/leaf (cm)	14.80	37.50
2.	Av. breadth/leaf (Lower) (cm)	3.20	7.08
3.	Av. breadth/leaf (Middle) (cm)	2.30	5.25
4.	Av. breadth/leaf (Upper) (cm)	1.00	2.25
5.	Av. thickness (Lower) (cm)	1.00	2.00
6.	Av. thickness (Upper) (cm)	0.50	1.04
7.	Av. volume of latex/leaf (ml)	4.00	37.50
8.	Aloin content (mg/100) (ml)	5.73	53.06
9.	Aloin content (percent dry wt. of latex)	0.56	4.83
10.	Av. fresh wt/leaf (gm)	32.00	227.00

out that 13 germplasm lines amongst a total 44 accessions examined showed absence of isobarbaloin compound *i.e.* showing Klunge negative test. Obviously, these do not confirm to description of the taxa under *Aloe barbadensis*. This has opened up a need for detailed study and redefining taxonomic characterisation of the Indian taxa by making further grouping.

Table 4. Correlation Matrix between agrobotanical and chemical characters

	1	2	3	4	5	6	7	8	9	10
1.	1.000									
2.	0.756**	1.000								
3.	0.749**	0.975**	1.000							
4.	0.586*	0.632**	0.695**	1.000						
5.	0.366	0.722**	0.729**	0.625**	1.000					
6.	0.387	0.648**	0.633**	0.687**	0.904**	1.000				
7.	0.813**	0.819**	0.805**	0.678**	0.517	0.537	1.000			
8.	0.323	0.492	0.470	0.667**	0.477	0.611**	0.422	1.000		
9.	0.247	0.457	0.406	0.462	0.521	0.642**	0.433	0.825**	1.000	
10.	0.848**	0.812**	0.785**	0.590*	0.343	0.402	0.882**	0.328	0.349	1.000

* Significant at 5 % level

** Significant at 1 % level

*** Numbers indicate the characters mentioned in Table 3.

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UNTAPPED TROPICAL FRUIT PLANTS FOR MEDICINAL PLANTS INDUSTRY AND THEIR IMPROVEMENT

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A large number of tropical fruits in India are used in Ayurvedic and Unani medicines. Some of these have consistent demand in the country and can be developed into bulk source of raw materials for drugs and allied industries. By and large, these lesser known fruit plants have not received enough research support. Exploitation of genetic variability occurring in natural populations and selective breeding could improve their yield and quality. A wide adaptability of many of these tropical fruit plants make their raising on plantation scale more profitable over inhospitable landscape.

India has a vast variety and diversity in tropical fruit plants, many of which are evolutionary climaxes in specific niche. These plants have a close association with local beliefs and rituals and are used in health-care needs in the rich ethnic life of our people. Quest for natural source of medicament is growing all over the world for these products have milder action in various body functions in preference to synthetic drugs. In terms of their therapeutic value, the fruits provide nutrition, strength and vigour to the body and restore loss of minerals, biflavonoids and amino-acids and thus protect the users against many deficiencies/diseases. Studies in chemical analysis of several fruits used by tribals and ethnic groups have shown that these are richer in calcium and several other minerals and have higher bio-medical properties than many other popular fruits.

In this respect, our country has inherited a rich treasure-house of knowledge from ancient medical-men who characterised several tropical species to yield specific drugs and medicaments as recorded in treatise dealing with Ayurvedic, Unani and Siddah Systems of Medicine. However, most of these fruit trees have remained semi-domesticated due to lack of research support for improvement as well as unorganised marketing of the produce. Many species have become rare and endangered due to large scale urbanization or extension of cultivation under high yielding cereals. Nonetheless, the economics of cultivation has brought the focus back on fruit trees. Plantation of fruit trees promises an alternate land use system which is environment-friendly and would yield a host of raw materials

from their different parts. In consideration of these new trends in horticulture and plantation sector, an attempt has been made to enumerate untapped resources of tropical fruit plants for medicinal plants industry. A long term research support through selection, breeding and appropriate management of crop and soil moisture can bring dramatic change in economic yield of these lesser known fruit trees. Taken together the benefits of fruits, fuel, timber and fodder yield and the protection of soil in several inhospitable landscapes, these species would provide good economic return. This strongly calls for developing a regular research programme on biological and chemical screening of the relatively less known tropical fruit plants in India for their use in medicinal plants industry. A list of lesser known tropical fruit plants of India along with distribution and uses is drawn from literature (Table 1) to generate research in their economic utilization.

Medicinal properties of tropical fruits

A glimpse in the old medical literature (Chopra *et al.*, 1956, 1969) provides information on characteristics and uses of fruits and fruit products which has stood the test of time and is verified through chemical and clinical evaluation. Accordingly, fruits possess both restorative and curative principles. These could be aromatic, cooling, digestive, stomachic, stimulant, useful in seasoning, maturation and fermentation of culinary, processed food and drinks. Some others have chemical principles responsible for their astringent, alternative anthelmintic, anodyne, emenagogue and emollient properties. There are a few others which possess specific properties such as diuretic, diaphoretic, sedative or stimulant to nerves, vasodilatory, improver of peristaltic movement of intestine and liver ailments, cardio-tonic, relieving cough, cold, bronchitis, asthmatic spasm, high blood pressure etc. Some fruits and their essential oils from peel, foliage or roots have carminative and germicidal properties and are prescribed to expel intestinal worms. Some of these plant-based raw materials are in commercial demand in the medicinal plant industry in our country. However, this presentation is limited to hitherto commercially untapped tropical fruits which could be developed as raw materials for drugs and pharmaceutical Industry in India.

Tropical fruits for traditional medicine

Neem (*Azadirachta indica*), is by far, the most important medicinal plant of India but world's largest neem plantation is established in an area of 10 sq. km in the plains of Arafat, Saudi Arabia. Its berries, leaves, bark, alkaloids and related other products have demand in a wide range of industries like pharmaceuticals, pesticides, slow release fertilizers, soaps and cosmetics. However, its seed has very fugitive viability of 5 to 6 weeks. In this respect, the work carried out at Forest Research Institute, Dehra Dun has shown that seed could be maintained for 6 months if kept in well-

aeriated containers at 15°C against the common belief of storage in sealed containers at a low temperature (5°C). The economics of raising neem plantation vis-a-vis timber species has not been studied in depth. Selections of faster growing genotypes producing longer berry yield for recommendation under commercial plantation are also not available.

Aonla (*Emblica officinalis*) is another important fruit plant of India, and has wide utility because of its being the richest source of Vitamin C. Several new varieties have been developed in the last two decades having increased fruit size and yield. It is to note that Vitamin C content of varieties *Banarasi-aonla* which was developed through selective breeding is much higher (645.5 mg/100 g) over *desi* culture (540.7 mg/100 g) on individual fruit basis.

Bael (*Aegle marmelos*) is another important medicinal fruit of arid regions in India. It has adapted well to soils of poor fertility where yield varying from 200 to 400 fruits per tree could be obtained in fruiting season. The fruit pulp has numerous seeds (74 to 200) which if reduced, will make it a choice fruit for food processing industry. The ripe fruit has high amount of non-reducing sugars, rich in Vitamin C (13.4 to 22.7 mg/100 g) and is considered appetizing, stomachic, cooling and restores vitality. It has substantial amount of phenolics which contribute astringent taste. *Marmelosin* is the therapeutically active compound, which is high in unripe fruit and therefore it is prescribed in treatment of diarrhoea and dysentery. It should be noted that ripe fruit has 17 amino acids and 11 minerals which compares favourable with citrus fruits; it is richer in aspartic acid and iron content is found 21 times more abundant in *bael* than in orange or grape fruit. Similarly Zn, Cl and Na concentration is also found in higher unit. (Barthakur and Arnold, 1989). Acharya Narendara Dev University of Agriculture and Technology, Faizabad has made an impressive collection of cultivars of this species and identified selections for economic plantations.

Papaya (*Carica papaya*) is an age old introduction from south America and is extensively grown all over the country. Its unripe fruit, on incision, yields crude *papain* (dried milky extract) which improves digestion, tenders meat and meat products, clears beer (liquor) and is used in cosmetic, dental paste and textile industry. India is one of the major exporter of *papain* to the world market and there is a growing demand. Recent studies have shown that 90 days fruit-set is to be tapped for this purpose and 4 incisions are given, 3 to 4 times each, at an interval of 2-6 days. The flow of latex is low if temperature is below 10°C. The latex is dried at 50 to 55°C and a yield of 60 to 80 kg/ha of *papain* is obtained without affecting fruit ripening, yield and quality.

Rudraksha (*Eleocarpus saphericus*) is yet another endemic fruit tree which is held in high esteem in India and is tied into necklace worn for

Table 1. Tropical fruit plants used in medicinal plants industry

Name	Botanical name	Distribution	Properties/uses
Aonla	<i>Embelia officinalis</i>	Deciduous tree, throughout India	Fr. acidic, cooling, rich in Vit. C. and tannins, useful in bacillary dysentery, diuretic, liver tonic etc.
Nux-vomica (Kuchla)	<i>Strychnos nux-vomica</i>	Moist tropical forests, rising upto 1200 m elevation	Seed contains strychnine and brucine, neuro-stimulant.
Kokam	<i>Garcinia indica</i>	Tall tree, W. Ghat, lower slopes of Nilgiris.	Seed-butter useful in skin ointments
Hardey	<i>Terminalia chebula</i>	Throughout deciduous forest.	Fr. astringent, laxative, alterative stomachic, dentrifice.
Neem	<i>Azadirachta indica</i>	Tree, throughout sub-tropical India.	Fr. emollient, anthelmintic, purgative stimulant, alterative and useful in skin diseases.
Anardana	<i>Punica granatum</i>	Shrub in foot-hills of J & K and H.P.	Fr. acidic, stomachic, larger demand for culinary.
Unnab	<i>Zizyphus sativa</i>	Large shrub, drier tracts in Western Himalayas	Dried fruits useful in cough, cold and bronchitis and related disorders.
Nut-meg	<i>Myristica fragrans</i>	Small tree, Cultivated.	Unripe fruits yield papain, useful in flatulence and nausea.
Papita	<i>Carica papaya</i>	Small tree, introduced into cultivation.	Unripe fruits yield papain, useful in tendering proteins.
Ankola	<i>Alangium salvifolium</i>	Small tree, peninsular India	Fr. and tree bark yields alkaloids, useful in hypertension and increase peristaltic movement of intestine.
	<i>Semecarpus anacardium</i>	Tree, sub-tropical India	Oil of nuts used externally for rheumatism and nervous debility.
Kajuput	<i>Melaleuca * leucodendron</i>	Small tree, introduced into gardens avenue tree.	All parts yield ess. oil, used to potentiate insecticides.

Cont....

Table 1. Cont....

Name	Botanical name	Distribution	Properties/uses
Amaltas	<i>Cassia fistula</i>	Tree, throughout sub-tropics, planted along roadside.	Fr. pulp laxative, prescribed to infants and pregnant women.
Bael	<i>Aegle marmelos</i>	Small thorny tree. Dry sub-tropical forests and foot-hills	Fr. cooling, soothing, laxative stomachic, useful in diarrhoea/dysentery.
Baheda	<i>Terminalia belicica</i>	Through-out deciduous forests	Fr. purgative, astringent, useful in piles, dropsy; in dyeing and tanning.
Maniphthal	<i>Randia dumetorum</i>	Small tree, sub-mountainous tract.	Fr. pulp anodyne antihelmintic, given in colic, expelling intestinal worms.
Mahua	<i>Madhuca indica</i>	Large tree, planted on arid poor soils.	Fl. useful in cough and bronchitis; it yields alcohol on fermentation.
Priyangu	<i>Aglaia elaeagnoides</i>	Konkon, Western Ghat and peninsular India.	Fr. cooling, astringent, used externally to cure inflammation and leprosy.
Nirmali	<i>Strychnos potatorum</i>	Tree in Kerala, Bengal Orissa	Seed used for purifying drinking water, useful in gonorrhoea and conjunctivities.
Indrayan	<i>Citrullus colocynthis</i>	Trailing herb, arid tracts	Fr. pulp is bitter, given in colic pain.
Rudraksha	<i>Eleocarpus sphaericus</i>	Tree, Eastern Himalayas	Fr. useful in epilepsy, cardiotoxic. Hard tubercled nuts are made into rosaries and necklaces.
Gorakh-imli	<i>Adansonia digitata</i>	Tree, West coast of India planted as avenue tree.	Fr. pulp aperient, astringent, diuretic and diaphoretic, food seasoner and for making cooling drink.
Kaith	<i>Feronia limonia</i>	Small tree, distributed over arid tracts throughout India.	Fr. astringent, stomachic, stimulant.
Laurel	<i>Laurus nobilis</i>	Small tree, Nagaland	Fr. used in diarrhoea, dropsy; leaves used in essential oil perfumery and food flavouring.

Abbreviations used:

Fl = Flower; Fr = Fruit, Vit. = Vitamins, Ess. oil = Essential Oil

* Introduced species

protection against mental and cardiac troubles. Its alcoholic extract has been found to induce sedation and anti-convulsant effects, useful in *grandmal* epilepsy and hypertension. This plant has not received due attention, particularly to identify and propagate mono-carpellary (one sutured) drupe, which is considered sacred in Hindu mythology and commands higher price.

Several allied species of Indian fruit trees occurring in neighbouring countries have shown significant pharmaceutical properties. Such reports provide new leads to us for chemical and clinical investigation to improve economic utilization of the Indian species. For example, glandular hairs on Kamla fruits (*Mallotus philippinensis*) is a popular remedy in jaundice and the dried hairs are commercially marketed as raw materials for manufacture of geleniactls in India. In an allied Japanese species viz. *M. japonicus*, two new phoroglucinol derivatives have been isolated which culture significant cytotoxic activity in K.B. cell culture system (Fujita *et al.*, 1987). Similarly, methanolic extract of *Evodia rutaecarpa* fruits is found to yield *evodimine* and *dihydrorutaecarpine* which showed highly significant cardiotonic activity on the isolated guinea pig atria (Shoji *et al.*, 1987).

Some medicinal fruit trees like *Alangium*, *Terminalia*, *Madhuca*, *Azadirachta* and *Pongamia* profusely secrete nectar and pollen for honey bee populations and are closely associated with apiculture (Gupta, 1989). Further studies on mycorrhizal flora around certain tropical trees have shown their utility for atmospheric nitrogen fixation and consequently in improvement of soil texture and fertility. Such studies on tropical fruit trees should be supported in our country. Many of these lesser known fruit plants would find place in forestry and in avenue plantations over eroded lands and riverine tracts where it would improve rural economy and provide green coverage to the inhospitable landscape. There are many tropical fruit plants like Jamun (*Syzygium jambolana*), Chironji (*Bachanania latifolia*), Kadliphall (*Musa paradisiaca*), Amara (*Mangifera indica*), Indrajaui (*Holarrhena antidysenterica*), Gular (*Ficus glomerata*) and Lishoda (*Cordia myxa*) which are planted for their bark and roots have poular medicinal properties and are extensively used in home remedies in rural India. A great opportunity therefore awaits in research and development of these lesser known tropical fruit trees. In essence, exploration of available natural genetic variability within a species and development of hybrid lines should be attempted in these species with a view to improve their yield and quality for use in pharmaceutical industry.

Genetic diversity for economic characters and its utility in plant improvement

The native tropical fruit plants have both pantropic and localised distribution. Their long history of evolution through interaction with

environment have given rise to cytotypes and rise in ploidy levels mainly to prepare the species to survive the vagaries of change in climate. This genetic variation in the taxa can be exploited to advantage through selection of populations for plantation purpose. Although very little work has been reported in cytological mapping of populations of these minor fruit plants, many valuable trends have been reported in recent publications. For example, cyto-morphological studies in Anar (*Punica granatum*) from Western Himalayas and Punjab plains have revealed that both wild and introduced cultivated taxa have same chromosome number ($n=8$). B-chromosomes in the populations of *Punica granatum* occurring in N.W. Himalayas have been identified. B-chromosomes have earlier been reported in a tetraploid cultivar of ber (*Zizyphus jujuba*). In fact, such occurrence of B-chromosome in a predominantly tropical taxon may be a possible adaptation to colonize over temperate lands. Inter-specific polyploids have been identified in *Syzygium jambolana*, *Randia dumetorum* and *Morus alba*. They have identified many genotypic variants in natural populations of *Cordia dichotoma*, *Schizium jambolana* and *Terminalia belerica*. Gill *et al.* (1989) studied 40 cultivars and their wild growing progenitors in *Zizyphus mauritiana* complex growing in the sub-Himalayan foot-hills and recorded inter-specific hybridization and intra-specific polyploidy. They have identified tetraploids ($2n=48$) and male sterile fruit trees showing normal fruit setting and proper stone formation in these populations. Abnormal meiosis and partial male sterility are believed to have given rise to variations in number of seeds per stone (1 to 3), average weight of seed, its shape, size and ornamentation suggesting that these changes have got fixed through domestication stress and are perpetuated through vegetative propagation. In this respect, the distribution of an allied medicinal fruit species Unnab (*Z. spina-christ* syn. *Z. sativa*) in north western parts of Punjab is remarkable as it occurs over stony, infertile soil, and has unique winter hardiness to withstand extreme temperatures of western Himalayas; its distribution extends westward to N.W. Frontier Province of Pakistan and further into West Asia. The dry Unnab fruit is considered most nutritious for its high riboflavin content (1.19 mg per cent) and is widely used in medicine to relieve cough, cold and periodic fever combined with laxative action.

Cytological studies on natural populations of *Terminalia chebula* reported occurrence of diploid, tetraploid and hexaploid cytotypes with characteristic pattern of distribution (Ray *et al.*, 1983). The diploids are confined to northern India whereas the other forms occur in central Indian forests. The polyploids with abnormal meiosis appeared to be allopolyploids having effect on their fruiting habit. In an allied species, *T. pallida*, endemic to certain parts of Andhra Pradesh, the analysis of fruits has shown the presence of 20 phenolic compounds whereas only 17 are present in *T. chebula*; eight flavonoids are common to both the species and are quantitatively higher in the former (Chetty and Rao, 1989). The utilization potential of

these compounds may vary in terms of quality of additional compounds of quantitative availability of total phenols, both of which can be useful index traits for improvement through selection.

Conclusion

The utility of henceforth untapped tropical fruit plants appears worthwhile. These should be explored for their use in medicinal plant industry or raising farm economy. The first step is to prioritise the lesser known native fruit plants for research and identify the region of maximum diversity in population or areas of endemic occurrence including ethnic pockets wherever they exist in semi-wild forms and build-up through selection over a period of time. This may be followed by genetic studies related to growth and fruit bearing. A list of priority taxa and their respective regions for *in-situ* protection in the country can be drawn which may be further raised in plantations for bulk supply to users.

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Short Communication

**OCCURANCE OF INTERMEDIATE FORMS (SHIBRAS)
IN CULTIVATED FIELDS OF PEARL MILLET**

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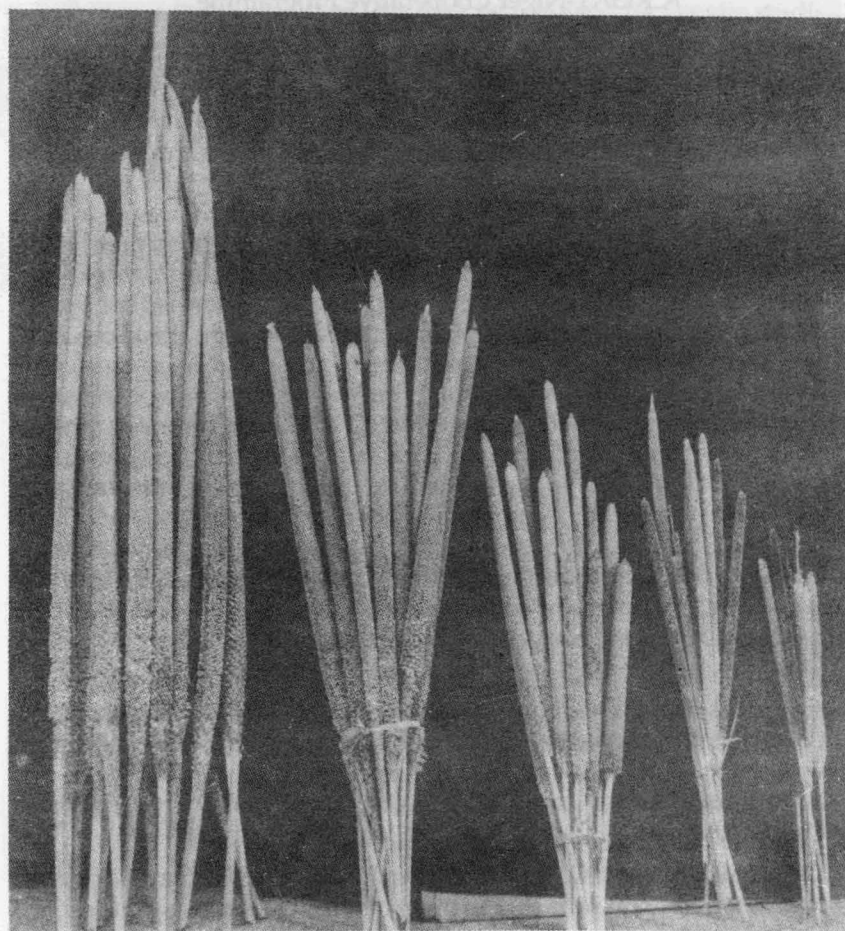
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) cultivated over more than 2 m ha annually ranks 1st in the area and production in the Republic of Niger, West Africa (Singh and Ouendeba, 1977). Niger falls within the region of pearl millet domestication (Brunken *et al.* 1977), where wild, weedy and cultivated forms occur in abundance. Cultivated pearl millet crosses with its wild relatives such as subspecies *monodi* (formerly known as *violaceum*) and *fallax* which result into creation of intermediate weedy forms which occur abundantly in many cultivated fields (Brunken *et al.* 1977). These intermediate forms continue to cross and back cross with cultivated types and inter cross among themselves appear to be the major factor land varieties in West Africa (Scholz, 1979). Though various farmers try to eliminate the weedy forms at various stages, the intermediate forms called shibras perpetuate in the farmers fields with varied morphologies, ranging from the forms close to cultivated pearl millet to their wild progenitors. Since the crop is cross fertilizing, the genes for shattering persist in the non shattering forms. The weedy forms produce relatively smaller heads, smaller grains and are sometimes harvested for food as they mature early before the maturity of the main crop.

As the occurrence of different cultivated, wild and intermediate forms in the farmers fields is common phenomenon in the Sahel region of West Africa, their careful consideration is essential in drawing samples during pearl millet exploration and collection in this region. The findings reported in the present paper is based on the data collected directly from the farmer's fields.

Pearl millet in West Africa is grown in hills spaced 1-1.5 m apart in the sandy and sandy-loam soils. At the onset of rainy season (May-June), hills for planting millets are created by hand tools equivalent to small bladed spade with a long handle. Thirty-fifty seeds are placed per hill manually and hills are covered with by foot. Twenty-five days after planting, thinning is carried out leaving 4-5 pearl millet seedlings in each hills.

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In order to examine the frequencies of various forms of ear heads in the farmer's field, ten (10) farmer's fields were sampled at random in typical pearl millet growing regions of the Republic of Niger (West Africa). A total of 100 hills selected randomly were observed in each farmer's field. Total number of tillers were counted for each hill and totalled for the 100 hills. The number of earhead bearing tillers were then counted and noted as productive tillers. When each earheads were examined carefully, five distinct types of earheads were observed (Figure 1). The grouping of different forms of earheads for each farmer's field and their respective percentage in relation to total productive tillers have been summarised in table 1.



1 Cultivated 2 Close to cultivated 3 Intermediate 4 Close to wild type 5 Wild type

Fig. 1. Different forms of earheads observed in the farmer's fields in Niger, W.A.

Of the total tillers counted for various farmer's fields, only 48 to 63.8 per cent tillers were found having grain bearing earheads (productive earheads). This is a common phenomenon in the hill planting which is due

Table 1. Frequency of different forms of pearl millet earheads observed in the farmer's fields in Niger, West Africa, rainy season 1985.

Field No.	No. of hills observed	Total No. tillers	No. of Productive tillers	Cultivated forms millet heads No. (%) Length (cm)	Earheads close to cultivated forms No. (%) Length (cm)	Earheads intermediate between cultivated & wild type	Earheads close wild type No. (%) Length (cm)	Earheads of wild type No. (%) Length (cm)
1.	100	1102	545 (49.5)	120 (21.6) 88.5	112 (20.6) 69.3	144 (26.5) 58.9	121 (22.2) 43.2	48 (8.1) 29.3
2.	100	1310	833 (63.5)	285 (34.2) 104.8	196 (23.5) 77.5	191 (22.9) 60.2	105 (12.6) 44.6	56 (6.7) 27.9
3.	100	862	478 (55.5)	128 (26.8) 88.4	89 (18.6) 67.5	122 (25.5) 57.1	60 (12.6) 46.0	79 (16.5) 28.8
4.	100	1041	500 (48.0)	136 (27.2) 82.1	138 (27.6) 63.3	133 (26.6) 60.3	45 (9.0) 33.4	48 (9.6) 24.7
5.	100	881	468 (53.1)	82 (17.5) 87.4	93 (19.9) 68.9	121 (25.9) 56.7	98 (20.9) 37.7	74 (15.8) 24.1
6.	100	1071	557 (52.0)	163 (29.3) 78.9	120 (21.5) 58.3	185 (33.2) 47.8	61 (10.9) 36.2	28 (5.0) 23.8
7.	100	1093	629 (57.6)	178 (28.3) 81.5	184 (29.3) 65.0	138 (21.9) 51.7	88 (13.9) 35.7	41 (6.5) 21.4
8.	100	1074	656 (61.1)	187 (28.5) 87.6	153 (24.2) 69.2	155 (23.6) 57.2	113 (17.2) 40.7	51 (7.8) 23.5
9.	100	848	541 (63.8)	168 (31.1) 94.0	116 (21.4) 72.6	145 (26.8) 55.7	68 (12.6) 42.5	44 (8.13) 23.9
10.	100	936	550 (58.8)	171 (31.1) 71.8	120 (21.8) 58.6	143 (26.0) 47.0	61 (11.1) 36.5	56 (10.2) 21.6
Total	100	10218	5757 (56.3)	1618 (28.1) 865	1321 (22.9) 670.2	1477 (25.7) 522.6	820 (14.2) 396.5	525 (9.12) 249
Mean	100 hills	1022	575	162 86.5	132 67.0	147 55.3	82 39.7	52 24.9

Values under brackets indicate per cent of productive tillers

to excessive competition among seedlings which emerge and which are maintained in each hill after thinning. In hill planting over less fertile sandy soils, mostly main tiller bear the productive tillers and side tillers are generally unproductive tillers resulting into abundance of unproductive tillers.

About 50 per cent of the total productive heads were found to be typically farmers preferred types comprising of 28.1 per cent long headed earheads and 23 per cent the forms closed to farmers preferred types with an average ear length of 86 cm and 67.0 cm, respectively. The frequencies of cultivated forms of pearl millet heads in various fields varied from 17.5 per cent in the field number 5 to 34.2 per cent in the field number 2 with the mean head length of 87.4 cm and 104 cm, respectively. The frequencies of earheads intermediate between cultivated and wild type millets varied from 21.9 per cent in field NO. 7 to 33.2 per cent in the field number 6 with the mean head length of 60.2 cm and 47.8 cm, respectively. When the average was computed over all the fields 25.7 per cent earheads were found to be intermediate between cultivated and wild type millets with mean head length of 55.3 cm. The mean frequency of earheads close to wild type pearl millets was observed to be 14.2 per cent of the total productive earheads with mean head length of 39.4 cm. The frequencies of these types ranged from 9 per cent to 22.2 per cent with mean head length of 33.4 and 43.2 cm respectively. Of the total productive heads examined 9.12 per cent represented wild type heads with headlength of 24.9 per cent cm and very small grains. The frequency of wild type head ranged from 5 per cent to 16.5 per cent in various fields with earheads length of 21.4 cm to 29.3 cm.

It is apparant from the data recorded from different farmer's fields that the frequencies of various forms of earheads are variable, which might have been due to different degrees of elimination of intermediate forms practiced by the farmers in the previous cropping season and the frequencies of shattered wild type and intermediate forms of grains in the earlier cropping season (Brunken *et al.*, 1977, Appa Rao *et al.*, 1986).

These observations clearly demonstrate that adequate number of earheads representing various forms should be sampled in each field to represent existing variability represented by heterogenous plants present in the farmers fields, while collecting the pearl millet germplasm in the West African region.

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Short Communication

EVALUATION OF FLOWERING TYPE *SACCHARUM OFFICINARUM* CLONES

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Saccharum officinarum is the most important cultivated species as it is the source of genes for sucrose accumulation and low fibre content. The species was under extensive cultivation in all major sugarcane growing countries before the advent of man-made hybrid varieties. Its low tolerance to biotic and abiotic stresses prevalent in all major sugarcane growing tracts was responsible for its replacement from commercial cultivation. In India, it is used as a reliable female parent for interspecific hybridization, but the use of *S. officinarum* clones is limited due to their shy nature of flowering. Of the 752 clones available in the World Collection of germplasm maintained at Sugarcane Breeding Institute, Research Centre, Cannanore, only about 60 clones are of flowering type. To identify elite genetic stocks for various characters, 53 flowering type *S. officinarum* clones were evaluated during 1989-90 in a randomised block design with two replications. The clones were planted in a row plot of 6 m length spaced 90 cm apart. Twenty three-budded sets were planted in each row with equal distance. Sample juice analysis was done at 10 month crop age and the trial was harvested at 12 month crop age. Data on 12 quantitative characters pertaining to stalk yield and juice quality were recorded.

The analysis of variance showed significant differences among clones for all the traits indicating the potentiality of the population for isolating parents which may produce better progenies. The clones were compared with the general mean of the population to identify elite genetic stocks for 12 characters. Top fifteen clones arranged in descending order of their performance were identified for each character (Table-1). The clones Gungera and Sarawak unknown were the best which were identified for all the characters except for juice extraction per cent in case of the former and sucrose per cent in juice at 10 months of the latter. The clone 57NG-126 for 10 characters, Saipan G and NG 77-81 for eight characters and NG 77-66 for seven characters were also identified as elite genetic stocks.

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Table 1. Elite genetic stocks (clones) of *S. officinarum* for various characters

SL No.	No. of millable stalks	Stalk diameter (cm)	Stalk length (cm)	Single stalk weight (kg)	Stalk yield/plot (kg)	Juice extraction %	Brix%	Sucrose %		Purity%	CCS%	CCS/plot (kg)
								10 mon.	12 mon.			
1.	M. Gayan*	Rayada*	NG77-62*	Sunkown*	Naz*	NG77-177*	Gungera*	Gungera*	Gungera*	Gungera*	Gungera*	Gungera*
2.	Naz*	28NG208*	Sinense*	Rayada*	M. Gayan*	Str. Mauritius*	Ng77-66*	28NG224*	NG77-66*	Sunkown*	Sunkown*	Gungera*
3.	51NG77*	Sunkown*	NG77-92*	57NG168*	Sunkown*	M. Red	NG77-60*	28NG210*	Sunkown*	Saipan G*	NG77-66*	57NG126*
4.	57NG126*	NG77-15*	NG77-43*	Gungera*	57NG126*	Bt. strn. Aubin	28 NG224*	28NG208*	NG77-99*	NG77-81*	NG77-81*	NG77-81*
5.	Sinense*	Green German	S. unknown*	NG77-62*	NG77-62*	Baragua	NG77-99*	Saipan G*	57NG126*	NG77-65*	57NG126*	NG77-62*
6.	NG77-62*	NG77-31*	Cebu. It. purpose	Str. Mau-	Gungera*	NG77-26	28NG208*	NC-116*	NG77-81*	Koels 11132*	NG77-99*	Baragua*
7.	Ng77-81*	57NG168*	Mant. 1583	Green German*	Baragua*	Red Cane	S. unknown*	NG77-60*	Saipan G*	NG77-63 str*	Saipan G*	Saipan G*
8.	Gungera*	Saipan G*	M. Red	NG 77-92*	NG77-81*	28NG208	57NG126*	NG77-99*	28NG208*	28NG215*	Koels11132*	NG77-66*
9.	Baragua*	Bt. Str. Aubin	57NG110	Mant.1585*	Saipan G	NG77-14	NG77-81	NG77-43*	Koels-	28NG221*	NG77-63 str*	Koels 11132
10.	57NG203*	Baragua	Gungera	Koels11132*	57NG168	Fij. 40	Saipan G	28NG215*	28NG224*	57NG126*	28NG208*	Sinense
11.	Fij. 15*	Gungera	M. Gayan	Saipan G str.	NG77-66	NG77-63-	Koels1113257	Ng126*	NG77-60*	NG77-66*	28NG221*	NG77-43
12.	NG77-26*	NG77-63str.	28NG224	57NG126	NG77-43	NG77-31	NG77-53 str.	NG77-92*	NG77-63str*	NG77-99*	NG77-65*	Green German
13.	NG77-66	NG77-81	57NG126	Baragua	M.Red	NG77-137	28NG221	Baragua*	28NG221*	28NG2-8	28NG224*	NG77-99
14.	Sunkown	No-116	Str. Mauritius	57NG177	Sinense	Oranboo	NG77-43	Koels 11132*	Ng77-65*	57NG222	28NG215*	M.Red
15.	57 NG 110	Red Cane	57 NG 57	No 77-15	Green German	S. Unknown	NG 77-137	57 NG 110*	28 NG 215*	Sinense	NG 77-60*	Naz.
Range+	11-138	1.70-3.45	0.96-2.48	0.41-1.43	7.0-92.0	25.6-70.0	12.44-21.73	6.57-17.66	7.57-20.02	60.99-92.14	4.08-14.08	0.68-10.65
G.M.	43.7	2.48	1.70	0.76	34.1	52.4	18.30	12.42	15.37	83.41	10.36	3.54
C.D.	15.2	0.43	0.42	0.18	17.7	10.7	1.65	1.52	1.93	5.41	1.55	1.75

*Significantly superior to general mean (G.M.) at P = 0.05

+Range : In the population

Table 2. Performance of top five *S. officinarum* clones for commercial cane sugar % (CCS %) at 12 month stage

Sl. Clone	CCS % yield/ plot (kg)	Stalk plot (kg)	CCS/ millable stalks	No. of diameter (cm)	Stalk length (m) (kg)	Stalk stalk/ weight	Single extraction %	Juice %	Brix %	Sucrose %		Purity %
										10 mon	12 mon.	
1. Gungera	14.08*	75.5*	10.65*	72*	2.78*	2.00	1.07*	53.8	21.73*	17.66*	20.02*	92.14*
2. Sarawak unknown	13.23*	79.0*	10.48*	56	3.15*	2.18*	1.43*	56.1	20.37*	13.62	18.77*	92.12*
3. NG 77-66	13.12*	44.1	5.78*	56	2.25	1.90	0.79	45.5	21.03*	12.63	18.84*	89.62*
4. NG 77-81	12.86*	61.5*	7.89*	73*	2.73	1.53	0.84	54.3	19.93	14.12*	18.27*	91.69*
5. 57NG126	12.83*	78.3*	10.00*	86*	2.60	1.95	0.92	55.5	20.29*	14.70*	18.35*	90.43*

* Significantly superior to G.M. at P = 0.05

S. officinarum is the source of genes for quality, the performance of five top quality (commercial cane sugar %) clones is presented in Table 2. Interestingly enough all these clones, excepting NG77-66, were superior to the population mean for stalk yield also. Depending upon the cross combinations and synchronization in flowering time of the parents the selected clones could be utilized in future breeding programmes for sugarcane improvement in the country.

Short Communication

**SOME OBSERVATIONS ON THE INCIDENCE OF
QUICK WILT IN THE GERMPLASM COLLECTION OF
GENUS *PIPER***

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Root rot or quick wilt disease of black pepper caused by *Phytophthora palmivora* is a serious problem faced by cultivators in Kerala. Systemic and contact fungicides such as metalaxyl and Bordeaux mixture are not always effective in controlling the disease under field conditions. Therefore, search for genes tolerant or resistant to the disease among the wild and cultivated species in western ghat areas is given a high priority. During 1987-1989, over 400 collections of cultivated and wild *Piper* species have been made. Out of the above collections 233 surviving ones belong to *Piper nigrum* and a few to the closely related other *Piper* species from the forest areas in Kerala, Tamil Nadu and Karnataka. The collections were maintained in pots and also under rapid multiplication in partial shade on sandy loam soil in Vellanikkara, Trichur during 1989. Plant protection measures were taken regularly, to prevent loss.

During June and July, very high incidence of Quick wilt problem is observed because of favourable weather conditions at Vellanikkara and most of the germplasm material, both in pots and under rapid multiplication on ground were uniformly infected. The infection was extremely severe during 2nd and 3rd week of July when most of the highly infected lines died. However, a few collections were found to survive under both the condition and observations were taken on the basis of intensity of disease on the stem and leaves and also on necrosis on a 0-5 scale both in potted plants and those under rapid multiplication to identify tolerant/resistant types. On the basis of average values frequency class distribution was done: 1-1.5 (very low), 1.6-2.1 (low), 2.2-2.7 (medium low), 2.8-3.3 (medium) 3.4-3.9 (medium high), 4.0-4.5 (high) and above 4.6 (very high).

Based on the observations, 9 collections were scored having very low incidence of the disease, 16 low and 18 medium. The individuals of 1st category were usually without any symptoms except for mild yellowing symptoms on the leaves. High or very high disease scoring collections died

within few days. Out of the collections with very low disease incidence, 6 were cultivated types *P. nigrum*, 2 wild *P. nigrum*, and 1 wild *P. trichostachyon*. Under the category of low incidence, 13 were cultivated *P. nigrum* 1 wild *nigrum* and 2 were wild unidentified species which seem to be variant forms of *P. nigrum* from forest areas situated above 90 m in Western ghats.

The observations presented are of interest as the incidence was very severe inspite of drenching with Bordeaux mixture and spraying with metalaxyl. Those securing low and very low scores will be subjected to inoculation studies to confirm their behaviour. It is also interesting to see that tolerance is found more in the collections from Idukki and Pathanamthitta districts where pepper cultivation has been more ancient.

Table 1. Area-wise range of tolerance to Quick wilt in collections of cultivated and wild *Piper* species

District	Wild		Cultivated	
	Range	No. of Collections	Range	No. of Collections
Idukki	1.0 – 5.1 (very low – very high)	21	1.0 – 5.1 (very low – very high)	58
Kottayam	2.2 – 5.1 (Medium low – very high)	8	–	–
Pathanamthitta	2.8 – 4.5 (Medium – high)	5	2.8 – 5.1 (Low – very high)	31
Palghat (Silent Valley)	1.0 – 5.1 (Very low – very high)	36	–	–
South Kanara	2.6 – 5.1 (Medium low – very high)	15	–	–
North Kanara	2.7 – 5.1 (Medium low – very high)	23	2.8 – 5.1 (Medium – very high)	21
Tirunelveli	1.6 – 5.1 (Low – very high)	12	1.6 – 4.5 (Low – high)	2
Total		120		112

Table 2. Origin of Quick wilt tolerant lines in collections of wild and cultivated *Piper* species

Class	Local name	I.C. Nos.	Species	District	Status
Very Low (1-1.5)	Karimunda	V-3646	<i>P. nigrum</i>	Idukki	Cultivated
	Nadan	V-3657	"	"	"
	—	V-3671	"	"	"
	—	V-3675	"	"	Wild
	Vattamunda	V-3679	"	"	Cultivated
	"	V-3692	"	"	"
	Karinthakara	V-3867	"	Pathanamthitta	"
	—	V-4162	<i>P. trichostachyon</i>	Palghat	Wild
	—	V-3724	<i>P. nigrum</i>	Idukki	"
	—	V-3631	"	"	"
Low (1.6-2.1)	—	V-3643	"	"	Cultivated
	—	V-3648	"	"	"
	—	V-3665	"	"	"
	Kuthiravali	V-3690	"	"	"
	—	V-3702	<i>Piper</i> sp.	"	Wild
	Neelamundi	V-3711	<i>P. nigrum</i>	"	Cultivated
	Vattamundi	V-3713	"	"	"
	Narayakkodi	V-3800	"	Pathanamthitta	"
	Palikkodi	V-3812	"	"	"
	Karivali	V-3865	"	"	"
	—	V-3866	"	"	"
	Cholakkodi	V.3899	"	Kottayam	"
	—	V.4131	<i>Piper</i> sp.	Palghat	Wild
	—	V.4187	<i>P. nigrum</i>	Tirunelveli	Cultivated
	—	V.4211	<i>Piper</i> sp.	"	Wild
	—	V.4216-A	<i>P. nigrum</i>	"	Cultivated

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