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## SAMPLING STRATEGIES FOR DEVELOPING INDIAN SESAME CORE COLLECTION

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Various stratified random sampling strategies were compared for developing a core collection of indigenous sesame *Sesamum indicum* L accessions. Twenty diversity groups (strata) representing 3,129 Indian sesame accessions were used for the study. The Shannon Diversity Index (SDI) pooled over 19 descriptors was used as the measure of the diversity. Simple random sampling alongwith six stratified random sampling strategies were compared for varying sample fractions ranging from 5 to 30%. Stratified random sampling was always superior to simple random sampling. Of the six stratified sampling strategies, a genetic diversity dependent strategy with sampled accessions from various strata directly proportional to the product of the diversity and logarithm of the size of the strata (GL strategy) appeared to be the best strategy. A 10% sample fraction could be determined as the suitable sample fraction, invariably for all sampling strategies, serving both objectives of germplasm management and use.

**Key words :** Sesame, *Sesamum indicum* L. genetic diversity, shannon diversity index, stratified sampling

Large assemblages of plant germplasm have accumulated in genebanks with time and have led to a serious concern among the scientific community as to whether the full range of genetic diversity they contain can be effectively managed and utilized. These collections are often poorly described due to lack of quality information on passport, characterisation and evaluation data. It has been estimated that about 65 per cent of the accessions in world collections have no passport data, 80 per cent are not characterised and only 1 per cent have been extensively evaluated (Peeters and William, 1984). Lack of easy access, resource constraints and the large number of accessions make proper evaluation of germplasm material a difficult task. Developing procedures for creating a collection of manageable and accessible size (a core collection) is among the most important issues in the management and utilization of plant

germplasm collections (Frankel, 1984; Brown, 1989a; Marshall, 1990). The work carried out so far clearly indicates that it is possible to develop a core collection using existing data on the accessions in a collection. The basic issues that are to be addressed for developing a core collection are i) stratification of collection into homogenous (diversity) groups; ii) optimum sample size i.e., number of accessions to be sampled from the whole collection; and iii) the sampling strategies i.e., how to select core entries from groups.

The grouping approaches described and used in most of the core collection studies are mainly hierarchical. Taxonomic, geographical, agro-ecological, morpho-agronomic, biochemical and molecular markers have often been used individually or in combinations for hierarchical grouping of the accessions. Data from genetic markers could also be used in a variety of ways

to create a representative (core) collection (Brown and Schoen, 1994; Bataillon *et al.*, 1996; Gepts, 1995). The issue on optimum sample fraction was addressed by Brown (1989a,b) and a sample size of 10 per cent of the whole collection was suggested based on a theoretical model put forward by Ewens (1972). But in practice, the situations may differ markedly from the assumptions of the model. For sampling within groups, two techniques are mainly employed, i) random sampling and ii) use of principal components score strategy. Brown (1989a,b), Charmet and Balfourier (1995) and Yonezawa *et al.* (1995) proposed stratified random sampling strategy. Different strategies viz., Constant (C), Proportional (P), Logarithmic (L) by Brown (1989b), Genetic diversity dependent (G) by Yonezawa *et al.* (1995), M and H by Schoen and Brown (1995) were proposed for random selection of entries from groups. Principal components score strategy have been used in common bean (Singh *et al.*, 1991), okra (Hamon and van Sloten, 1989; Mahajan *et al.*, 1995), coffee (Hamon *et al.*, 1995) and mungbean (Bisht *et al.*, 1998a).

The diversity in Indian sesame accessions has already been studied for a set of descriptors and the collection has been classified in different groups making combined use of passport information on origin of accessions and morpho-agronomic characterisation data (Bisht *et al.*, 1998b). In the present investigation, estimates of diversity using qualitative and quantitative descriptors were compared for various stratified random sampling allocation strategies and the optimum sample size determined for developing a core collection of Indian sesame accessions.

## MATERIALS AND METHODS

In our earlier investigation, stratification of 3129 indigenous sesame accessions was done making combined use of agro-ecological passport

information and morpho-agronomic characterisation data (Bisht *et al.*, 1998b). The morpho-agronomic characters were used for classifying the entire collection into 7 discrete clusters (main groups). The seven clusters, in combination with agro-ecological passport data, finally resulted in 20 diversity groups (Table 2). These diversity groups were used for comparing various sampling strategies in the present study.

Data on 18 characters, both qualitative and quantitative, were used for estimation of Shannon Diversity Index (Shannon and Weaver, 1963). The quantitative characters were converted into qualitative descriptors making frequency classes as described in Table 1.

### Computation of Population Shannon Diversity Index (SDI)

Consider a population of  $N$  accessions spread over different descriptor states of each of the  $d$  qualitative descriptors. Let there be  $k_i$  ( $i=1,2,3,\dots,d$ ) states for the  $i^{\text{th}}$  descriptor. Denote  $N_{ij}$  for the number of accessions associated with  $j^{\text{th}}$  descriptor state of the  $i^{\text{th}}$  descriptor such that  $\sum_j N_{ij} = N \quad \forall i$ . Then  $P_{ij} = N_{ij}/N$  denote the proportion of accessions belonging to the  $j^{\text{th}}$  descriptor state of the  $i^{\text{th}}$  descriptor. Thus the population Shannon Diversity Index (SDI<sub>*i*</sub>) for the  $i^{\text{th}}$  descriptor is

$$\text{SDI}_i = - \sum_j P_{ij} \log_e P_{ij}$$

and the population diversity index is

$$\begin{aligned} \text{SDI} &= \sum_i \text{SDI}_i \\ &= \sum_i \sum_j P_{ij} \log_e P_{ij}. \end{aligned}$$

### Estimation of Shannon Diversity Index

#### i) Simple Random Sampling Without Replacement (SRSWOR)

A simple random sample of size  $n$  is drawn by SRSWOR from  $N$  accessions. The frequency

Table 1. List of descriptors recorded for the study

|     |                                                                                                                                                                         |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Branching habit (1= un-branched; 2= low; 3= moderate; 4=high (bushy type))                                                                                              |
| 2.  | Stem hairiness (1= glabrous; 2= sparse; 3= hairy; 4= very hairy)                                                                                                        |
| 3.  | Flower colour (1=deep violet/purple; 2=white with deep violet/purple shading; 3= white with light violet/purple shading; 4=white)                                       |
| 4.  | Corolla hairiness (1= glabrous to light hairy; 2= hairy; 3= very hairy)                                                                                                 |
| 5.  | Internode length (1=low; 2=medium; 3=high)                                                                                                                              |
| 6.  | Capsule shape (1= narrow oblong; 2= broad oblong; 3= broad)                                                                                                             |
| 7.  | Density of capsule hair (1=glabrous; 2=sparse, 3=high)                                                                                                                  |
| 8.  | Number of capsule per leaf axil (1=one; 2= two to three)                                                                                                                |
| 9.  | Number of locules per capsule (1=four; 2=four and six; 3= four, six, eight and more than eight)                                                                         |
| 10. | Capsule length (1=small; 2=medium; 3=long)                                                                                                                              |
| 11. | Seed colour (1=white; 2=black; 3=brown; 4= red; 5= grey; 6= others)                                                                                                     |
| 12. | Incidence of Phyllody disease (1= low susceptibility; 2=medium susceptibility; 3=high susceptibility)                                                                   |
| 13. | Days to 50% flowering (number of days to 50% plants having first flower open from date of planting; 1=30-35, 2=36-40, 3=41-45, 4=46-50, 5=51-55, 6=56-60, 7= >60 days)  |
| 14. | Days to 50% maturity (number of days to 50% plants reaching physiological maturity from date of planting; 1=65-75, 2=76-85, 3=86-95, 4=96-105, 5=106-115, 6= >115 days) |
| 15. | Plant height (in cm, Mean of 5 random plants; 1=20-35, 2=36-50, 3=51-65, 4=66-80, 5=81-95, 6= >95)                                                                      |
| 16. | Capsules per plant (mean of 5 plants; 1=1-10, 2=11-20, 3= >20)                                                                                                          |
| 17. | Seeds per capsule (mean number of seeds from 5 capsules each per plant; 1=10-30, 2=31-50, 3=51-70, 4= >70)                                                              |
| 18. | 100-seed weight (g; 1=0.05-0.10, 2=0.11-0.15, 3=0.16-0.20, 4=0.21-0.25, 5=0.26-0.30, 6=0.31-0.35, 7= 0.35)                                                              |

distribution of these  $n$  units over descriptor states for each of the descriptors is computed. Let  $p_{ij}$  ( $i=1,2,3,\dots,d$ ;  $j=1,2,\dots,k_i$ ) denote the sample proportion of accessions for  $j^{\text{th}}$  state of the  $i^{\text{th}}$  descriptor. Then an estimate of SDI is

$$sdi = -\sum_i \sum_j P_{ij} \log_e P_{ij}$$

Due to the complex nature of  $sdi$ , it is difficult to judge its unbiasedness. However,  $sdi$  is a consistent estimate of SDI. For computation of  $E(sdi)$  and  $V(sdi)$ , 100 repeated independent random samples of size  $n$  by SRSWOR were drawn from the population and  $sdi$ , average  $sdi$  and variance among  $sdi$  values were computed. Then mean square error (MSE) of  $sdi$  is

$$MSE(sdi) = V(sdi) + \text{bias}^2(sdi)$$

where  $\text{bias}(sdi) = E(sdi) - SDI$

and then 95% confidence interval (CI) can be computed.

## ii) Stratified Random Sampling

Let the population of  $N$  units be grouped into  $k$  strata with size  $\{N_s\}$   $s = 1, 2, \dots, k$  for the  $s^{\text{th}}$  stratum such that  $\sum_s N_s = N$ . Samples of sizes  $\{n_s\}$  are drawn independently by SRSWOR from the  $s^{\text{th}}$  strata such that  $\sum_s n_s = n$ . Assuming the accessions in a stratum constituting the entire population, SDI is computed for the  $s^{\text{th}}$  stratum. Then  $SDI_{st}$ , the pooled  $SDI_s$  over different strata, is defined as

$$SDI_{st} = \sum_s W_s SDI_s$$

Where  $W_s$  is the weight attached to the  $s^{\text{th}}$  stratum and  $SDI_s$  is the SDI for the  $s^{\text{th}}$  stratum.

The weights  $W_s$  are to be selected such that  $SDI_{st} \cong SDI$ . The weights  $W_s$  are chosen by the researcher on the basis of past experience. In the absence of any idea about the weights, the following three set of weights were considered:

- Equal weights*: Equal weights being attached to each of the  $k$  strata, i.e.,  $W_s = 1/k \forall s$ .
- Proportional Weights*: Weights being proportional to the size of the strata, i.e.,  $W_s \propto N_s \Rightarrow W_s = N_s/N$  for the  $s^{th}$  stratum.
- Proportional to Stratum Diversity* : Weights being proportional to diversity in the  $s^{th}$  stratum., i.e.,

$$W_s \propto SDI_s \Rightarrow W_s = SDI_s / \sum_s SDI_s$$

The set of weights for which  $SDI_{st} \cong SDI$  was considered for estimation of population diversity. Let it be  $W'_s$  for  $s^{th}$  stratum. Let  $(sdi)_{st}$  be the sample diversity index for the  $s^{th}$  stratum, then the estimator of SDI is

$$(sdi)_{st} = \sum_s W'_s (sdi)_{st}$$

The researcher may select another set of weights on the basis of his past experience about the importance to be attached to different strata. In situations where it is not possible to choose  $W_s$ ,  $(sdi)_{st}$  will be an unbiased estimate of  $SDI_{st}$  but a biased estimate of SDI.

### Allocation Strategies

Assuming the sampling fraction (5, 10, 15, 20, 30 %) being fixed in advance, the following six allocation strategies were compared.

**Strategy I (P strategy)**: The number of accessions sampled from different strata are directly proportional to the size of the strata i.e.  $n_s \propto N_s$ ;

**Strategy II (C strategy)**: Equal number of

accessions i.e.,  $n_1 = n_2 = n_3 \dots = n_s = n/k$  are selected from each stratum;

**Strategy III (L strategy)**: The number of accessions sampled from different strata are directly proportional to the logarithm of the size of the strata i.e.,  $n_s \propto \log_e N_s$ ;

**Strategy IV (G strategy)**: The number of accessions sampled from different strata are directly proportional to the diversity in the strata i.e.,  $n_s \propto SDI_s$ ;

**Strategy V (GP strategy)**: The number of accessions sampled from different strata are directly proportional to the product of size and diversity in the strata i.e.,  $n_s \propto N_s SDI_s$ ;

**Strategy VI (GL strategy)**: The accessions from different strata are directly proportional to the product of diversity and logarithm of the size of strata i.e.,  $(SDI)_{st} \log_e N_s$ .

For obtaining the expectation, MSE of  $(sdi)_{st}$  and the corresponding CI the procedure adopted was same as in SRSWOR with bias being given by

$$\text{Bias}((sdi)_{st}) = E((sdi)_{st}) - SDI_{st}$$

### RESULTS NAD DISCUSSION

The population SDI was recorded to be 14.62. The SDI from stratified sampling with weights proportional to (i) size of strata, (ii) equal weights and (iii) diversity in the strata was found to be 11.36, 11.59 and 11.82 respectively. SDI with weights proportional to diversity was the highest but not very close to the population SDI. But in the absence of any knowledge of  $W_s$ , the weights proportional to diversity were used for comparing alternative sampling allocation strategies in stratified sampling.

Shannon diversity indices of different strata are presented in Table 2. It is evident from the

table that diversity in different strata is not uniform. It ranged from 8.58 to 14.43. Diversity was maximum in stratum 6 (14.43) followed by stratum 8 (13.83) and 15 (13.36). It varied from 10 to 12 in the remaining strata except 7, 10 and 20 where the SDI was observed to be 9.43, 9.26 and 8.58, respectively. SDI was comparatively high in small groups as compared to the large ones.

**Table 2. Diversity group size and their Shannon Diversity Indices (SDI)**

| Diversity group | No. of accessions | SDI   |
|-----------------|-------------------|-------|
| 1               | 333               | 11.65 |
| 2               | 59                | 12.00 |
| 3               | 60                | 11.76 |
| 4               | 142               | 12.00 |
| 5               | 50                | 13.82 |
| 6               | 66                | 14.43 |
| 7               | 211               | 9.43  |
| 8               | 65                | 13.83 |
| 9               | 100               | 12.31 |
| 10              | 235               | 9.26  |
| 11              | 470               | 10.81 |
| 12              | 200               | 11.92 |
| 13              | 65                | 10.78 |
| 14              | 37                | 10.07 |
| 15              | 66                | 13.36 |
| 16              | 124               | 10.62 |
| 17              | 395               | 11.65 |
| 18              | 402               | 11.89 |
| 19              | 28                | 11.75 |
| 20              | 22                | 8.58  |

Comparison of different sampling strategies is presented in Table 3. In strictly random sampling, the diversity varied from 68.23 to 93.72 per cent for a sample size of 5 to 30 per cent. The mean square error (MSE) varied from 1.00 to 29.60. The width of the confidence interval

decreased with increase in sample size. There was considerable increase in %SDI for all sampling strategies from 5 to 10 per cent sample fraction. Thereafter, there was no substantial increase in the %SDI with increasing sample size. A comparison of MSE clearly indicates that the genetic diversity dependent strategy particularly IV and VI always performed better in comparison to all other strategies (Table 3). For equal allocation strategy, it was not possible to go beyond 10 per cent sample size. Strategy VI as consistently superior to other strategies with least MSE and a narrow 95 per cent confidence interval for different sample sizes considered. Strategy I with % SDI ranging from 51.68 to 76.36 per cent was poor performer with highest MSE for different sampling fractions.

The sampling strategy to obtain a core sample should maximize the diversity in the sample while attempting to reduce the redundancy of identical genotypes (Frankel and Brown, 1984). Genetic diversity, however, is not randomly distributed over plant populations. It has a structure that can generally be summarised in a hierarchical model (van Hintum, 1995).

In the present study, both agroecological passport data on origin of accessions and clustering technique based on phenetic analysis of individual accessions has been used for stratification of accessions in diversity groups.

A commonly used measure of diversity is the Shannon-Weaver information theoretic expression (Shannon and Weaver, 1963), often known as the Shannon diversity index. The SDI, pooled over different descriptors, has been considered as a measure of diversity. It gives larger values when more descriptor states are present, and other things being equal, it gives larger values when descriptor states are equally common than when some are common and others are rare. However, it is rarely affected by inclusion or

**Table 3. Shannon Diversity Index and its statistical parameters for simple random sampling and other allocation strategies**

| Sample Size (%) | Statistical parameters | Simple random sampling | Stratified sampling allocation strategies |            |             |             |             |             |
|-----------------|------------------------|------------------------|-------------------------------------------|------------|-------------|-------------|-------------|-------------|
|                 |                        |                        | I                                         | II         | III         | IV          | V           | VI          |
| 5%              | SDI                    | 9.66                   | 7.55                                      | 9.60       | 9.59        | 9.62        | 7.83        | 9.87        |
|                 | %SDI*                  | 68.23                  | 51.68                                     | 65.66      | 65.59       | 65.82       | 53.61       | 67.51       |
|                 | MSE                    | 29.60                  | 8.20                                      | 4.90       | 4.94        | 4.78        | 7.62        | 4.12        |
|                 | CI                     | 1.00-20.32             | 1.94-13.16                                | 5.26-13.93 | 5.23-13.94  | 5.33-13.90  | 2.42-13.24  | 5.88-13.86  |
| 10%             | SDI%                   | 11.34                  | 9.66                                      | 10.75      | 10.65       | 10.99       | 9.71        | 11.05       |
|                 | SDI                    | 80.15                  | 66.14                                     | 73.58      | 72.82       | 75.24       | 66.47       | 75.58       |
|                 | MSE                    | 12.86                  | 4.59                                      | 1.12       | 1.35        | 1.02        | 4.37        | 0.95        |
|                 | CI                     | 4.31-18.37             | 5.47-13.86                                | 8.68-12.83 | 8.38-12.93  | 9.02-12.97  | 5.61-13.81  | 9.14-12.96  |
| 15%             | SDI                    | 12.59                  | 10.35                                     | -          | 11.12       | 11.18       | 10.41       | 11.28       |
|                 | %SDI                   | 86.12                  | 70.80                                     | -          | 76.07       | 76.49       | 71.24       | 77.15       |
|                 | MSE                    | 5.88                   | 2.13                                      | -          | 0.47        | 0.39        | 1.96        | 0.29        |
|                 | CI                     | 7.84-17.34             | 7.49-13.21                                | -          | 9.77-12.47  | 9.92-12.41  | 7.66-13.15  | 10.23-12.33 |
| 20%             | SDI                    | 12.88                  | 10.71                                     | -          | 11.38       | 11.37       | 10.79       | 11.58       |
|                 | %SDI                   | 88.12                  | 73.96                                     | -          | 77.90       | 77.83       | 73.81       | 79.21       |
|                 | MSE                    | 3.13                   | 1.21                                      | -          | 0.18        | 0.19        | 1.04        | 0.14        |
|                 | CI                     | 11.15-18.09            | 8.55-12.86                                | -          | 10.55-12.22 | 10.52-12.23 | 8.78-12.79  | 10.85-12.31 |
| 30%             | SDI                    | 13.70                  | 11.16                                     | -          | 11.55       | 11.56       | 11.19       | 11.62       |
|                 | %SDI                   | 93.72                  | 76.36                                     | -          | 79.03       | 79.10       | 76.62       | 79.48       |
|                 | MSE                    | 1.00                   | 0.42                                      | -          | 0.07        | 0.06        | 0.37        | 0.05        |
|                 | CI                     | 11.74-15.66            | 8.82-12.43                                | -          | 11.04-12.06 | 11.08-12.03 | 10.00-12.39 | 11.18-12.06 |

\*SDI expressed as percentage of population SDI

exclusion of rare descriptor states in the sample (Emlen, 1973). This is a desirable attribute in some context, but in a core collection rare descriptor states are of considerable importance, and need to be included with subjective approach, wherever possible.

In stratified sampling, weights are required to be attached to different strata in view of their relative importance over one another based on the degree of diversity in the different strata. All the weights are equal when the strata have equal variability and then stratification is as good as random sampling. But stratification is done when sampling units are heterogeneous with regards to characters of interest. Pooling of results over different strata is done such that the resulting

SDI is approximately equal to the population SDI. In development of SDI for stratified sampling, unweighted estimates are considered. Due consideration for suitable weights is a practical necessity. Therefore, we consider here weights on the basis of closeness of pooled estimates to the population value. Since for weights proportional to diversity, the  $SDI^{st}$  is closer to population SDI, therefore these weights formed the basis of comparison of different sampling strategies in stratified sampling.

In the present study, sampling through stratification based on well identified diverse groups were more efficient over simple random sampling. To overcome the problem of giving undue higher weights to large groups, likely to

contain a higher level of genetic redundancy, Growth and Roelfs (1987) and Brown (1989b) suggested that the number of accessions to be drawn should be proportional to the logarithm of the frequency in each group (L strategy). The C strategy gives each group equal weighting and biases the core in favour of small groups. The P strategy considers a fixed proportion of each group so that the group is represented in the core in proportion to the frequency in the group. Clearly this strategy is biased towards large groups (Brown, 1989b). The P strategy is likely to perform better when diversity is distributed according to the size of groups, that in actual situation does not hold. The C strategy is likely to perform better than the P strategy when diversity is concentrated in smaller groups. In other situations, constant allocation can be inferior to simple random sampling. The genetic diversity dependent (G) strategy proposed by Yonezawa *et al.* (1995) takes into consideration the diversity in different groups irrespective of their sizes and it has been emphasized that this strategy is always better when the diversity in different groups is known. This directed us towards the development of some other intermediate strategies. Therefore, in the present study two more probable diversity dependent strategies, GL and GP, were also considered that may take care both of group sizes and the level of diversity. We find that the GL strategy performed better than the G and GP strategies. The GL strategy is more appropriate when one encounters situations with different levels of diversity and sufficiently large strata sizes while GP is likely to perform better in situations when groups are of small sizes and diversity is unevenly distributed within groups. In the last three strategies, we come across situations when the diversity in certain strata is very large and the corresponding strata size are small enough. Then  $n_s$  is likely to be greater than  $N_s$ . In such situations we take  $n_s = N_s$ . Apart from the above suggested strategies, other sampling strategies might

be applied to develop a core collection but their performance will depend upon the species, the composition and distribution of diversity in collection and the type of characters of interest (Spagnoletti Zeuli and Qualset, 1993).

While comparing various sampling strategies on Durum wheat, Spagnoletti Zeuli and Qualset (1993) found that the three strategies i) random stratified by geographic origin with P strategy, ii) random stratified by geographic origin with L strategy and iii) random stratified with canonical variables produced the desired effects of increasing frequencies from the less representative countries of origin. Diwan *et al.* (1994) proposed random sampling and classified the accessions of annual *Medicago* species-wise and accessions within species country-wise. Sampling within species was done by cluster analysis on agronomic and morphological traits. Basigalup *et al.* (1995) classified accessions of perennial *Medicago* plant introductions according to country of origin and eight sampling strategies were compared. Two methods, combined cluster analysis based on principal components within each geographical group with random selection of entries within each cluster and direct selection of entries within each geographical group were adjudged to be the best strategies for designating the core collection. Charmet and Balfourier (1995) compared Shannon Diversity index averaged over 200 samples generated by computer simulations using various proportions for sampling methods. The clustering method based on agronomic traits with geographic contiguity constraints was better than others. A random sample of 5% of accessions maintained 86 per cent of the diversity while clustering method based on geostatistics gave the best results with 92 per cent of the variation being maintained in a 5 per cent of the core sample.

Considerable increase in %SDI was observed when sample fraction increased from 5 to 10 per cent. No substantial increase was observed beyond

10 per cent sample fraction. Brown (1989a) also proposed an optimum sample size of 10 per cent. Applying Ewens theory, Brown (1989a) showed that the fraction of alleles retained from a population increased rapidly as the sample fraction increased to 0.1, but rather slowly after it surpassed 0.1. Similar was the case in the present study in all the sampling strategies tested. On the basis of the theoretical model, Yonezawa *et al.* (1995) showed that the optimum sample fraction depends upon various genetic and resource parameters, primarily on the degree of genetic redundancy among accessions comprising the whole collection and the amount of resources available for maintenance of the core collection. The optimum sampling fraction was large, with a lower redundancy among accessions or a lower initial allelic diversity within accessions, indicating that a large sample fraction is better in species with a large selfing rate. A 20-30 per cent sample was estimated to be appropriate in situations where accessions in the collection are neither very heavily nor very lightly redundant in terms of diversity.

Based on the above discussion, it is evident that suitable choice of weights, selection of an appropriate sampling allocation strategy along with a optimum sampling fraction is essential for capturing the maximum diversity. In the present study, the weights proportional to diversity in various strata, sampling allocation strategy with sample size directly proportional to the product of diversity and logarithm of the strata size and 10% sample fraction is appropriate for the development of sesame core set and it is likely to serve both the objectives of germplasm management and utilization.

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## SCREENING OF NATURAL DIVERSITY IN KARVANDA (*Carissa* L.): COMMERCIALY POTENTIAL WILD FRUIT IN MAHARASHTRA

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*Carissa* L. is a wild fruit yielding species of much socio-economic value in tribal areas of Maharashtra. Being cross-pollinated in nature, it forms a good source of plant genetic variability and provides useful material for economic exploitation. The present study records range of natural variability in Karvanda (*Carissa* L.) through extensive field surveys in different agro-climatic zones of western Maharashtra. A wide spectrum of variability was observed with respect to number of fruits per cluster (3-17), size ( $9 \times 9$  to 44-43 mm), shape (round to oblong), colour (red to black - exceptionally yellowish-green when ripe), taste (sour to sweet and bitter), pulp colour (white to red), number of seeds per fruit (1-4), TDS contents (10-32%), and weight of 10 seeds (0.19 to 0.71 g). The collected accessions were classified into 16 types based on fruit morphology.

**Key words:** Karaunda, *Carissa*, natural diversity, wild fruit, Maharashtra

Natural variability has so far been studied only for few species of agricultural and horticultural importance. There has been very little attention, literally none, with respect to the wild species of economic potential. Joshi (1995) drew attention to the importance and urgency of research on these lines since the natural biodiversity is declining at an alarming rate.

*Carissa* L. (Karaunda/Karvanda) is a genus of more than 60 species distributed mostly in warm parts of Africa, Australia and Asia (Index Kewensis, 1895 and its supplements). Hooker (1882) described five species of *Carissa* L from the Indian subcontinent with special note that the species in the area are very difficult to define and may probably be reduced to one or two very variable types. Cooke (1903-1908) described four species from Bombay Presidency indicating *C. carandas* L as the most common species distributed throughout the region whereas

*C. inermis* Vahl, *C. spinarum* L, and *C. suavisissima* Bedd. ex Hook. found from southern regions. In addition, African introduced species namely, *C. bispinosa* (L) Merxm. and *C. grandiflora* Bert. ex A. DC. are occasionally cultivated in gardens. Talbot (1911) also recorded occurrence of four species from Bombay Presidency with remarks that all the four species are closely allied, only apparently differing in habit, vestiture of leaves and size of flowers and fruits. Santapau (1960) described *C. conesta* Wt. and *C. congesta* var. *albida* Santapau from Khandala region with comments on confusion of the species identity in Indian floras particularly with reference to *C. congesta* Wt. and *C. carandas* L. Describing the differences, he claimed occurrence of only *C. congesta* Wt. widely and wildly in India. He also recorded infra-specific variability on the basis of fruiting characters, one form with smaller fruits in which the sweetness improves when it is over-

ripe while the other form with larger fruits, deteriorates fast at the stage of over-ripening and develops a taste similar to fermenting sugar.

In India, almost all species of genus *Carissa* are utilized as food. Ripe fruits of indigenous *Carissa carandas*, *C. congesta*, *C. opaca*, *C. paucinervia* and *C. spinarum* are commonly consumed raw or made into jams and jellies whereas unripe fruits are mainly utilized for pickles. Exotic species such as *C. bispinosa*, *C. edulis*, and *C. grandiflora* are occasionally cultivated for edible fruits (Watt, 1908, With India, 1992). Roots, leaves and ripe and unripe fruits of *C. congesta* and *C. spinarum* have ayurvedic importance (Kirtikar and Basu, 1933; Trivedi, 1963, Desai, 1975; Gogte, 1982; Deshpande *et al.*, 1989). Ethnomedicinal and ethnobotanical utility of different species of *Carissa* have been compiled in Dictionary of Indian Folk medicines and Ethnobotany (Jain, 1991).

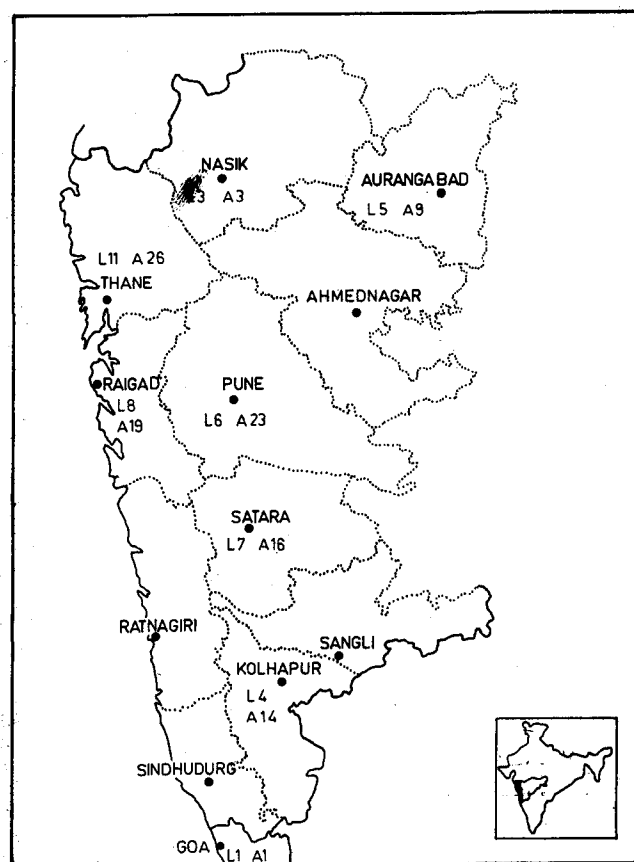
Collection of Karavanda or Karonda fruits from the wild for sale in the nearby market is an age old tradition in the tribal and rural regions of Maharashtra. The species is also important to the tribals as a source of domestic fuel due to its wide occurrence and easy availability plus good burning properties. Cut branches are commonly utilized as dry fence for protecting agricultural fields. This multipurpose species, however, has been rather meagrely studied for natural variability (Dhumal *et al.*, 1993) and for horticultural practices (Jauhari, 1960; Misra and Singh, 1990; Misra and Jaiswal, 1993) and hence is a subject of concern for present work.

Considering the difficulties in species delimitation particularly in fruiting stage, attempts were made to study variability in *Carissa* L irrespective of species identity.

## MATERIALS AND METHODS

During 1993-95, surveying, collecting and evaluating natural diversity in the Karvanda (*Carissa* L) was initiated at ARI, Pune. Germplasm was collected from a wide range of locations from eight districts of western Maharashtra, one district from Marathwada and Goa (Map 1). Fruiting characterization was mainly accounted while selecting and documenting the variability. Random sampling method was followed with a sample size of 2-5 individuals per location. Efforts were also made to evaluate monetary benefits of the species through interviews of tribal collectors, market sellers and wholesale dealers.

A total of one hundred and eleven accessions were collected from forty-five locations within an



Map 1. District-wise locations and accessions of *Carissa* collections from western Maharashtra

altitude range of 100 to 500 meters in fruiting time during April-May. Preliminary characterization and classification was attempted in the laboratory on the basis of exomorphic fruit characters. Determination of TDS contents with hand refractometer helped to correlate sweetness of the fruits recorded in the field.

## RESULTS AND DISCUSSION

Among the locations screened for study of *Carissa* L. variability, Konkan represented the rich population of the species. Pure populations were located at Wyaghreshwar, Mira Dongar, Pachad, Nijampur-Bhorghar in Konkan. In dry eastern regions of Aurangabad populations were scattered. Commercial collection of *Carissa* fruits from wild populations on the other hand was recorded from Mulshi-Maval-Vehla regions of Pune, Karjat-Kashele regions of Raigad and Dolkhamb-Shahapur-Murbad regions of Thane District, besides, collections from small village market also (Fig. 1(a)). No specific selections are made by the collectors during these sales, except for the bitter taste. Unripe fruits are also collected for pickling which fetch good market value. Data on economics at different levels have been compiled in Table 1. Annual turnover per person varies between Rs. 1500-3000 in a fruiting season (hardly of one month). The species seems to be a hardy and disease resistant in general. However, **Sooty mould** was distinctly recorded on population at Wyaghreshwar, Mira Dongar near Pen.

The variability was studied in the field with respect to habit and habitat, height and spread, vegetative characters and reproductive characters. Amongst all, the diversity in exomorphic fruit characters was distinct and dominant (Fig. 1(b)). Very interestingly no specific correlation between fruit morpho-variables and height and spread was noted in the field. Sixteen distinct types could be identified and classified using shape, size, colour,

**Table 1. Socio-economics of *Carissa***

| Sale type                                                            | Approx cost<br>in Rs./kg. | Quantity<br>collected<br>in Kg<br>(one<br>person/<br>day) | Approx.<br>income<br>per<br>person<br>/day |
|----------------------------------------------------------------------|---------------------------|-----------------------------------------------------------|--------------------------------------------|
| 1. At source sale                                                    |                           |                                                           |                                            |
| a. Collection and sale in village market (sold a cupful app. 200 gm) | 10                        | 5-10                                                      | 50-100                                     |
| b. Collection and sale to the wholesale dealer                       | 2 (collector)             | 10-15                                                     | 20-30                                      |
|                                                                      | 6 (dealer)                | in tons                                                   | -                                          |
| 2. Sale in village bazaar or railway or Bus station                  | 10                        | 5-10                                                      | 50-100                                     |
| 3. Sale in big cities                                                | 16-20                     | -                                                         | -                                          |
| 4. Unripe fruits                                                     | 16-20                     | -                                                         | -                                          |

pulp colour, taste, number of seeds per fruit and spinescence as follows :

### Classification of *Carissa* germplasm collection

1. Variety spineless ..... Type I (Acc. coll. 1)
1. Variety with spines
  2. Berry red brown ..... Type II (Acc. coll. 1)
  2. Berry not red brown
    3. Berry yellowish green
    4. Berry round ..... Type III (Acc. Coll. 2)
    4. Berry elongated ..... Type IV (Acc. Coll. 1)
  3. Berry purple black
  5. Berry bitter to taste
  6. Pulp white to pale-pink

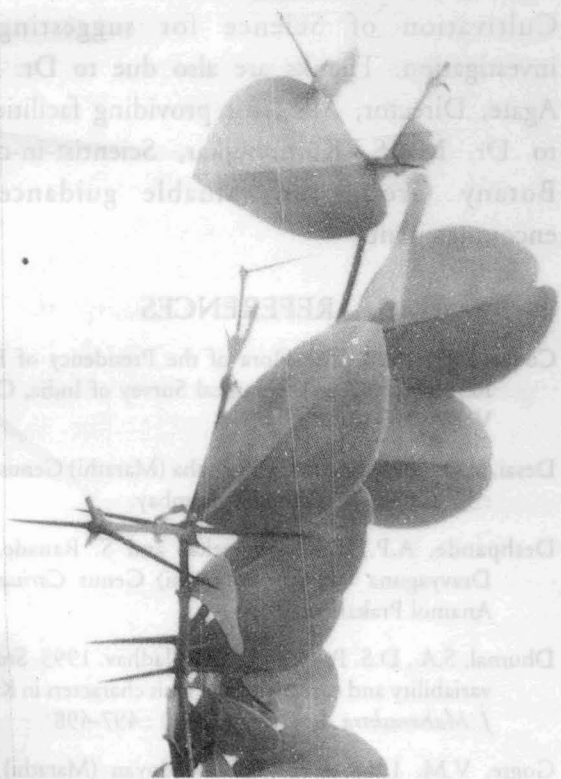
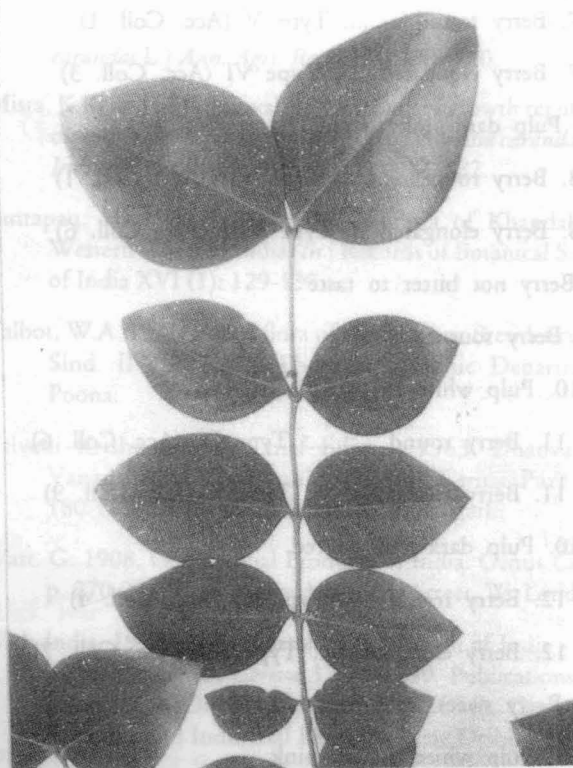
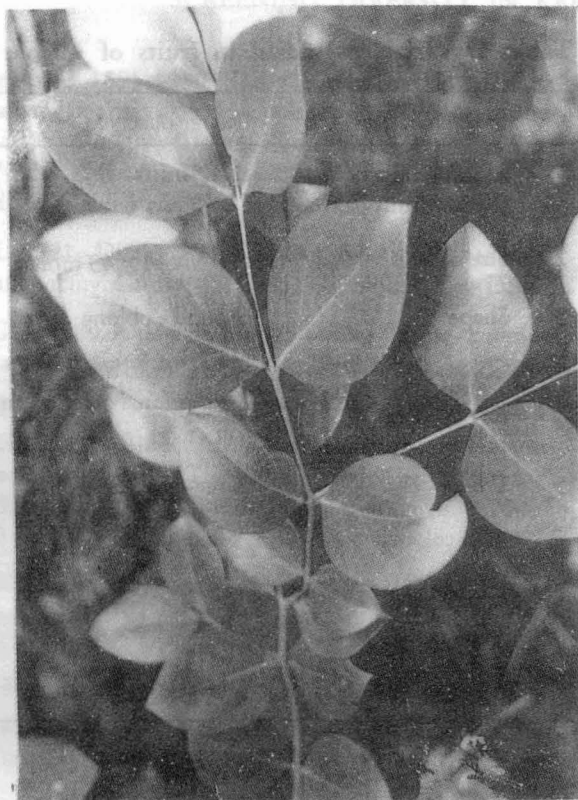


Fig. 1. Karvanda (*Carissa* L.): Showing variability in vegetative and reproductive characters

7. Berry round ..... Type V (Acc. Coll. 1)
7. Berry elongated ..... Type VI (Acc. Coll. 3)
6. Pulp dark-pink to red
8. Berry round ..... Type VII (Acc. Coll. 1)
8. Berry elongated ... Type VIII (Acc. Coll. 6)
5. Berry not bitter to taste
9. Berry sour to taste
10. Pulp white to pale-pink
11. Berry round ..... Type IX (Acc. Coll. 6)
11. Berry elongated ..... Type X (Acc. Coll. 9)
10. Pulp dark-pink to red
12. Berry round ---- Type XI (Acc. Coll. 4)
12. Berry elongated .... Type XII (Acc. Coll. 7)
9. Berry sweet to taste
13. Pulp white to pale-pink
14. Berry round ..... Type XIII (Acc. Coll. 15)
14. Berry elongated .. Type XIV (Acc. Coll. 22)
13. Pulp dark pink to red
15. Berry round ..... Type XV (Acc. Coll. 17)
15. Berry elongated .. Type XVI (Acc. Coll. 10)

It is evident from the key that types with sweet berry, white or red pulp and round and elongated shape (Types XIII to XVI) are common in the region whereas spineless variety (Type I), green ripe-fruited (Type III & IV) are rarely documented in the area. Accessions with distinct extra-ordinary big size, sweet, red or white pulp, spineless type, green fruit-ripening types are worth conserving for the future. The range of variability in fruit characters is given in table 2.

Further evaluation of these accessions on the biochemical standards would give more clear picture of variability in Karvanda (*Carissa* L.).

**Table 2. Variables studied in fruits of *Carissa***

| Fruit character                                | Range observed                                       |
|------------------------------------------------|------------------------------------------------------|
| 1. Fruiting bunch<br>(No. of fruits per bunch) | 3-17 fruits                                          |
| 2. Size of fruit                               | 9 × 9 - 44 × 43 mm                                   |
| 3. Shape                                       | Round - oblong                                       |
| 4. Colour                                      | Red-purple-black<br>(exceptional green when<br>rupe) |
| 5. Taste                                       | Sour-sweet                                           |
| 6. Pulp colour                                 | White-pink-red                                       |
| 7. No. of seeds per fruit                      | 1-4                                                  |
| 8. TDS contents                                | 10-32%                                               |
| 9. Seed weight (10 seeds)                      | 0.19-0.71 g                                          |

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## GENETIC DIVERSITY IN LINSEED

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Two hundred ninety eight accessions of linseed (*Linum usitatissimum* L.) comprising 101 exotic and 197 indigenous collections were studied for genetic divergence for a set of 9 characters. The accessions were grouped into 10 clusters. The genetic diversity was not related to the geographic diversity. Based on divergence and superior clusters mean, crosses among the genotypes from cluster V, VI, VII and IX may result in superior types. The genotypes viz. EC-41646, EC-41495, EC-41767 and IC- 61322 for high oil, EC-236, EC-1413, IC-53262, IC-53291, IC-59012 and IC-60431 for high yield and EC-236, EC-1475, EC-41737 and EAC-41764 for fiber may be used in hybridization programme as superior parents.

**Key words:** Linseed, *Linum usitatissimum*, genetic divergence, germplasm

Linseed (*Linum usitatissimum* L) is an important oilseed crop though it is grown for fibre also. In India, linseed is cultivated primarily for its oil. It occupies fifth place after groundnut, rapeseed and mustard, soybean and sesame. It is grown in about 1200 thousand hectares with seed production of nearly 350 thousand tonnes. The productivity of linseed is not very encouraging. An attempt was made to study the genetic diversity at NBPGR, Regional Station, Akola, Maharashtra.

### MATERIALS AND METHODS

The experimental material consisted of 298 germplasm lines including 101 exotic from, Argentina (68), Australia (21), Belgium (1), Romania (1), France (1), Hungary (1), Japan (2), Poland (1), USA (3) and USSR (2) and 197 indigenous from, Maharashtra (80), Madhya Pradesh (109), Bihar (7) and Andhra Pradesh (1). These accessions were grown in augmented block design, using three checks i.e. C-429, Jawahar 7,

and Jawahar 10 at Experimental Farm, NBPGR, Regional Station, Akola during *rabi* 1996. The rows were 3 meter long and 75 cm apart. Observations were recorded on days to 50 per cent flowering, days to maturity, plant height, number of primary and lateral branches per plant, number of seeds per capsules, yield per plant and oil content. Non-hierarchical euclidean cluster analysis was used for assessing the genetic divergence among 298 genotypes of linseed. The genotypes were grouped into number of clusters as suggested by Spark (1973). The analysis was carried out using SPAR 1 package.

### RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the accessions for 9 characters studied. The range, mean and standard deviation are presented in Table 1. Based on divergence values the accessions were grouped into 10 clusters

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(Table 2). Cluster I has 39 accessions, cluster II 17, cluster III 55, cluster IV 25, cluster V 29, cluster VI 33, cluster VII 42, cluster VIII 44, cluster IX 12 and cluster X had 2 accessions. The clustering pattern in the present study indicated that the genotypes from one source were distributed into different clusters. This suggests the lack of distance build up of geographical diversity. Mishra and Dash, (1997) and Umesh Chandra (1997) have reported that geographical diversity is not necessarily related to genetic divergence. The clustering of genotypes from different eco-geographic locations into one cluster could be attributed to possibly free exchange of breeding materials or even varieties from one place to another (Verma and Mehta, 1976). This may also be due to the fact that unidirectional selection practiced for a particular trait in several places produced similar phenotype which were aggregated in one cluster irrespective of their distant geographic origin (Singh and Gupta, 1968). This is true in these indigenous linseed genotypes. On the other hand, many genotypes originating from one place were scattered over different clusters (Table 2). Such genetic diversity among the genotypes of common geographic origin could be due to factors like heterogeneity, genetic architecture of the populations, past history of selection, developmental traits and degree of general combining ability (Murthy and Arunachalam, 1966).

The average intra and inter cluster distances have been presented in Table 3. Average inter-cluster distance values ranged from 1.845 to 8.300. The maximum distance existed between cluster V and X (8.300). In general, cluster X had more distance from rest of the clusters. Intra-cluster distance was 0 for all the clusters indicating similarity among the clusters. Cluster III contained the maximum number of genotypes (55) followed by cluster VIII, I, VI, V and IV with 44,42,33,29 and 25 respectively.

**Table 1. Range, mean and SD of 9 metric characters in 298 genotypes of linseed**

| Character                     | Range  |        | Mean   | Standard deviation |
|-------------------------------|--------|--------|--------|--------------------|
|                               | Min.   | Max.   |        |                    |
| Days to 50% flowering         | 66.64  | 79.94  | 70.57  | 5.11               |
| Days to maturity              | 102.72 | 114.52 | 107.13 | 5.90               |
| Plant height (cm)             | 23.84  | 47.43  | 38.69  | 7.30               |
| No. of primary branches/plant | 2.70   | 10.15  | 3.10   | 0.98               |
| No. of lateral branches/plant | 5.64   | 23.96  | 12.43  | 4.57               |
| No. of capsules/plant         | 12.76  | 36.00  | 26.72  | 8.23               |
| No. of seeds/capsule          | 4.78   | 7.04   | 5.78   | 1.16               |
| Yield/plant (g)               | 0.45   | 1.65   | 0.94   | 0.40               |
| Oil (%)                       | 38.07  | 44.08  | 42.06  | 2.92               |

**Table 2. Grouping of 298 accessions of linseed in different clusters**

| Cluster | No. of entries | Source                                           |
|---------|----------------|--------------------------------------------------|
| I       | 39             | Australia, Japan, Argentina, Romania, USA, India |
| II      | 17             | Argentina, USA, India                            |
| III     | 55             | Argentina, Australia, USA, India                 |
| IV      | 25             | Argentina, Australia, Belgium, India             |
| V       | 29             | Argentina, Japan, USSR, India                    |
| VI      | 33             | Argentina, India                                 |
| VII     | 42             | Argentina, Australia, Hungary, Poland, India     |
| VIII    | 44             | Argentina, Australia, USSR, India                |
| IX      | 12             | India                                            |
| X       | 2              | Argentina                                        |

Cluster I genotypes (39) had early flowering and maturity, moderate oil content and poor yields. Cluster II comprised 17 genotypes with late flowering and maturity, dwarf plants, low yields and low oil content. Cluster III contained 55 genotypes with early flowering and maturity,

Table 3. Cluster means for nine characters in 298 genotypes of linseed

| Character                     | I      | II     | III    | IV     | V      | VI     | VII    | VIII   | IX     | X      |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Days to 50% flowering         | 66.64  | 79.94  | 68.58  | 77.04  | 67.59  | 68.06  | 70.10  | 74.23  | 07.25  | 75.00  |
| Days to maturity              | 102.72 | 110.53 | 104.89 | 112.40 | 103.17 | 102.88 | 107.21 | 114.52 | 109.67 | 108.00 |
| Plant height (cm)             | 39.02  | 23.84  | 36.06  | 33.94  | 42.92  | 47.43  | 41.92  | 36.73  | 43.27  | 32.50  |
| No. of prim. branches/plant   | 2.73   | 2.70   | 2.85   | 3.03   | 2.74   | 3.99   | 2.98   | 2.96   | 4.47   | 10.15  |
| No. of lateral branches/plant | 12.37  | 5.64   | 12.13  | 9.71   | 13.93  | 12.21  | 14.56  | 11.14  | 23.96  | 10.60  |
| No. of capsules/plant         | 25.41  | 12.76  | 26.21  | 24.05  | 26.69  | 27.04  | 32.78  | 27.14  | 36.60  | 17.65  |
| No. of seeds/capsule          | 4.78   | 4.98   | 6.58   | 7.04   | 6.81   | 5.58   | 4.65   | 5.79   | 5.92   | 5.20   |
| Yield/plant (g)               | 0.76   | 0.45   | 0.88   | 0.70   | 1.65   | 0.93   | 1.10   | 0.85   | 1.11   | 1.00   |
| Oil content (%)               | 40.63  | 39.55  | 42.60  | 38.07  | 42.50  | 43.86  | 44.08  | 41.91  | 43.41  | 42.58  |

Table 4. Intra and inter-cluster distance in 298 genotype of linseed

| Cluster No. | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1           | 0.000 |       |       |       |       |       |       |       |       |       |
| 2           | 4.255 | 0.000 |       |       |       |       |       |       |       |       |
| 3           | 1.845 | 4.184 | 0.000 |       |       |       |       |       |       |       |
| 4           | 3.511 | 2.983 | 2.757 | 0.000 |       |       |       |       |       |       |
| 5           | 2.990 | 5.737 | 2.223 | 4.056 | 0.000 |       |       |       |       |       |
| 6           | 2.233 | 5.305 | 2.204 | 4.038 | 2.614 | 0.000 |       |       |       |       |
| 7           | 2.102 | 5.001 | 2.262 | 3.936 | 2.658 | 1.987 | 0.000 |       |       |       |
| 8           | 2.734 | 3.392 | 2.120 | 1.960 | 3.376 | 3.031 | 2.370 | 0.000 |       |       |
| 9           | 3.976 | 6.785 | 3.668 | 5.002 | 3.630 | 3.190 | 2.917 | 3.951 | 0.000 |       |
| 10          | 8.007 | 8.086 | 7.802 | 7.756 | 8.300 | 6.953 | 7.827 | 7.601 | 7.271 | 0.000 |

moderate yield and oil content. Cluster IV had 25 genotypes having late flowering and maturity, highest number of seeds/capsule (7.04) but low oil content. Cluster V contained the highest yield (1.65 g) and moderate oil content. Cluster VI and VII had tall plants and high oil content. The genotypes of cluster VIII had late maturing and moderate oil content. Cluster IX consisted of 12 genotypes having the highest lateral branches and capsules/plant, tall plants with average yields and oil content. The genotypes in cluster X showed the highest primary branches per plant

(10.15) and moderate oil content.

Obviously, the crosses among the genotypes of cluster V, VI, VII and IX might be useful for obtaining good recombinants and transgressive segregants in segregating generations. The genotypes EC-41646, EC-41495, EC-41767 and IC-61322 in cluster VII showed more than 45% oil content and EC-236, EC-1413, IC-53262, IC-53291, IC-59012 and IC-60431 in cluster V showed good yield per plant. These genotypes are useful and can be utilised as parents in hybridisation. On the other hand, tall plants with

low primary branches e.g. EC-236, EC-1475, EC-41737 and EC-41764 in cluster VII can be utilised as parents for fibre in the hybridization programme.

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## VARIABILITY AND ASSOCIATION ANALYSIS FOR YIELD AND YIELD COMPONENTS IN COWPEA GERMPLASM

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Collection, maintenance and evaluation of germplasm for genetic variability of economically important traits is one of the basic steps for initiating breeding programme for genetic improvement of any crop. Whereas character association will help in simultaneous selection of two or more characters at a time, the present investigation aims to assess the extent of genetic variability and association analysis for yield and yield components in 600 cowpea germplasm comprising indigenous and exotic lines.

**Key words:** Cowpea, *Vigna unguiculata*, variability, germplasm, association analysis

Cowpea (*Vigna unguiculata* (L.) Walp.) is an unique pulse crop with manifold usage such as pulse, green vegetable, green fodder and as cover crop for checking soil erosion. Being a nitrogen fixing legume, its important role as green manure crop can be adjudged by the fact that it can fix nitrogen upto 240 kg per hectare, besides leaving 60-70 kg nitrogen for the succeeding crop (Rachie, 1985). The extent of genetic variability and association among characters studied on 600 cowpea germplasm lines both indigenous and exotics in augmented randomized block design have been summarised. Several promising donor genotypes were identified.

### MATERIALS AND METHODS

Six hundred cowpea germplasm comprising exotic (179), indigenous (257) and breeding stocks (164) were grown in an augmented randomized block design (Federer, 1956) using three checks namely UPC 5286, UPC 5287 and UPC 4200 at the Livestock Research Centre of

G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* (Wet) season of 1994. The germplasm lines were accommodated in 20 blocks having 33 plots, out of which 30 plots had test genotypes and 3 plots were allocated to the check varieties. Each line was assigned to a single row plot of 2 m length, spaced 60 cm apart and plant to plant distance was maintained at 10 cm. Observations were recorded on five randomly selected competitive plants in each plot on plant height (cm), days to 50 per cent flowering, days to 50 per cent maturity, pod length (cm), pods per peduncle, seeds per pod, 100-seed weight (g) and seed yield per plant (g). The average value of five plants for various characteristics were used for statistical analysis. The phenotypic correlation coefficients were estimated according to Beale (1969).

### RESULTS AND DISCUSSION

High coefficient of variation ranging from 20 to 25 per cent was observed for seed yield

(25.37%), plant height (24.56%), 100-seed weight (22.16%) and pods per peduncle (19.90%) indicating that there is enough potential for exploiting high variability present in these characters. Minimum variability recorded for days to 50 per cent maturity (8.68%) followed by seeds per pod (9.72%) indicating that most of the lines have matured almost at the same time with less variation in number of seeds per pod. Days to 50 per cent flowering and pod length showed a medium range (11.86-13.11%) of variation (Table 1). Apte *et al.* (1987) also reported similar findings.

The seed yield was found to be positively correlated with 100-seed weight and pod length. This indicates that the bold seeded genotypes with longer pods containing more number of seeds are high yielding. Positive association of 100-seed weight with pod length and plant height reveals that taller plants, in general, had long pods with bold seeds resulting in higher test weight (Table 2). Negative correlation of 100-seed weight with number of pods per peduncle indicated taller genotypes and longer pods with higher test weight, less number of pods per peduncle.

**Table 1. General mean, standard error, range and coefficient of variation for different characters in cowpea germplasm**

| Character                | Mean $\pm$ SE <sub>m</sub> | Range      | Variance | Coefficient of variation |
|--------------------------|----------------------------|------------|----------|--------------------------|
| Plant height (cm)        | 120.10 $\pm$ 0.02          | 54.8-224.5 | 871.34   | 24.56                    |
| Days to 50% flowering    | 87.01 $\pm$ 0.42           | 60.0-105.0 | 106.57   | 11.86                    |
| Days to 50% maturity     | 116.25 $\pm$ 0.41          | 90.0-135.0 | 101.93   | 8.68                     |
| Pod length (cm)          | 15.17 $\pm$ 0.44           | 9.1-21.8   | 3.97     | 13.11                    |
| Pods per peduncle        | 1.86 $\pm$ 0.01            | 1.0-3.0    | 0.14     | 19.90                    |
| Seeds per pod            | 15.01 $\pm$ 0.06           | 9.3-19.6   | 2.16     | 9.72                     |
| 100-seed weight (g)      | 10.92 $\pm$ 0.09           | 6.7-26.0   | 5.88     | 22.16                    |
| Seed yield per plant (g) | 22.50 $\pm$ 0.23           | 12.3-59.5  | 32.70    | 25.37                    |

**Table 2. Correlation coefficients among quantitative characters in cowpea**

| Character            | 1        | 2        | 3        | 4        | 5        | 6      | 7       | 8     |
|----------------------|----------|----------|----------|----------|----------|--------|---------|-------|
| 1. Plant height      | 1.000    |          |          |          |          |        |         |       |
| 2. Days to flowering | -0.108** | 1.000    |          |          |          |        |         |       |
| 3. Days to maturity  | -0.014   | 0.774**  | 1.000    |          |          |        |         |       |
| 4. Pod length        | 0.117**  | -0.079   | -0.107** | 1.000    |          |        |         |       |
| 5. Pods per peduncle | -0.610** | 0.198**  | 0.227**  | -0.124** | 1.000    |        |         |       |
| 6. Seeds per pod     | 0.038    | -0.026   | -0.004   | 0.047**  | 0.102**  | 1.000  |         |       |
| 7. 100-seed weight   | 0.149**  | -0.173** | -0.145** | 0.424**  | -0.267** | -0.005 | 1.000   |       |
| 8. Seed yield        | 0.066    | -0.045   | -0.034   | 0.232**  | -0.192** | -0.042 | 0.579** | 1.000 |

\*,\*\*Significant at 5 and 1 per cent level of probability respectively

**Table 3. Promising donors for different characteristics**

| Traits           | Promising genotypes                                                                                                                                                  |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Early maturity   | No. 58-2-2, N-990, IT81D-975, IT81D-927-2, IT82D-1069-2, IT82-D-789, K6A-2, V558, TVu589-1, (C × 30)-1-3, MS9020-9-12, EC4180-1, TVu373-2, TVu1612, IT82D-752.       |
| Dwarfness        | H233, V317, IT83D-852, VP-1269, TVu161-1, No.108, TVu1751, TVu1065, TVu53, (C × 17)-14, P446, (C × 23)3-2.                                                           |
| Long pods        | P446, No. 779, IT81D-975, IT81D-1228, TVu620, VP1269, TVu6331, (C × 30)-1-1, (C × 6)-1, K6A-4, H116-1, EC 101936, H244, H903-2-1, (C × 61)-1-1, UPC8705, TVu1947-1-2 |
| More seeds/pod   | VP1269, EC101936, C × 79-2-4, UPC 8988, H903-2-1, TVu3531-1-5-1, (C × 42)-1-2-2, TVu 1947-1-2, TVu1528-1.                                                            |
| High test weight | TVu-6, P5, EC101958-1, IT81D-1228-14, V632, V461-2, TVu493, TVu93, EC6280-1-3-4, C × 30-1, C × 16, MS9020-10-6, (C×60)-4-3, (C × 59)-2, (C × 30)-2-3.                |
| High grain yield | EC101958-1, TVu325-1-1, EC149-1-2, UP2201, (C × 59)-2, EC191059-2-3, TVu-6                                                                                           |

These results are in accordance with the findings of Singh *et al.* (1982). Negative correlation of 100-seed weight with days to 50 per cent flowering and maturity may be due to the fact that in

early flowering genotypes, dry matter accumulation in seed is at a faster rate in comparison to late flowering types. This may be due to high photosynthetic rate in the early stages of reproductive phase of plant growth.

Several lines were identified (Table 3) for early flowering and maturity, pod length, seeds per pod, 100-seed weight and seed yield which could be used as potential donors in hybridization programme for the development of improved cowpea cultivars. Certain line showing indeterminate and profuse branching growth habit with late flowering were also identified for their possible use in developing dual-purpose cowpeas.

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## COMPARATIVE EVALUATION OF INDIGENOUS AND EXOTIC RICE (*Oryza sativa* L.) GERMPLASM FOR QUALITY CHARACTERISTICS

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Comparative evaluation of quality characteristics of 49 exotic and 75 indigenous accessions revealed that, in general, exotic accessions had higher mean hulling, milling and head-rice recovery than the indigenous accessions. Nevertheless, indigenous collection had high variability for head-rice recovery (cv 21.7%). In general, the magnitude and pattern of variation for these characteristics were similar in both the collections. Although indigenous accessions had more variation for kernel size and shape, exotic accessions had higher mean kernel length. There was predominance of long bold kernels in exotic collections. Alkali value and water uptake varied more in exotics. Majority of the exotic accessions (33) were of low to intermediate alkali score (high to intermediate gelatinization temperature) while 36% of the indigenous accessions had high alkali value low gelatinization temperature. In both the collections, kernel linear elongation had similar magnitude of low variability (cv 4.4-4.8%), however, indigenous accessions showed higher mean kernel elongation ( $1.74 \pm 0.01$ ) than the exotics ( $1.66 \pm 0.01$ ). Several potential accessions which could be utilized in the rice quality improvement programme were identified and characteristics of 14 accessions with multiple desirable traits are presented.

Key words: Germplasm, quality, rice, *Oryza sativa* L.

With the growing awareness among the rice consumers and improvement in the standard of living, the demand for quality rice continues to increase. It is not only the basmati rice but also long slender and translucent grains with good cooking quality as well as other non - basmati aromatic rice which have marked potential for export. Hence rice quality improvement accords due priority besides the grain yield in the breeding programme. Therefore, there is a need to evaluate the available genetic resources of indigenous as well as exotic origin for rice quality components to identify potential resource gene(s). The available rice germplasm collected and/or acquired from

diverse sources at the Central Rainfed Upland Rice Research Station has been systematically characterised for quality components in addition to yield, its components and reactions to biotic stresses mainly diseases. In our earlier studies, many valuable accessions for desirable quality parameters have been identified from the indigenous/traditional land races of rainfed rice (Chauhan *et al.* 1990; 1991 and 1995). In the present study, further efforts were made to characterise for quality traits indigenous as well as exotic accessions received from IRRI, Philippines. These exotics are mostly traditional as well as improved rainfed upland cultivars from

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Latin America and West Africa and constitute a very useful gene pool especially for drought tolerance and blast resistance.

## MATERIALS AND METHODS

The experimental materials for the present investigation comprised one hundred and twenty four (49 exotic and 75 indigenous traditional cultivars from rainfed medium and low lands) rice germplasm accessions. They were grown in 3-row plots, 3.5 m long rows in the 1994 wet season. Rows were spaced 20 cm apart. The fertilizers were applied @ 40:8.7:16.6 NPK (kg/ha). The other standard agronomic and plant protection practices were followed to raise a good crop. A composite sample from the middle row was used to record observations on hulling (%), milling (%), head-rice recovery (%), milled rice length (mm), breadth (mm) and L/B ratio, alkali value, amylose content (%), water uptake (ml) volume expansion, cooked kernel length (mm) and kernel linear elongation. Using Satake dehusker and Kett T-2 polisher, 100g representative sample was hulled and milled. Milling was done for 90 seconds. Standard methods were used to compute hulling, milling, head-rice recovery (Govindaswamy and Ghosh, 1969); alkali value (Little *et al.* 1958), amylose content (Juliano, 1971), cooking quality (Beachell and Stansel, 1963) and kernel linear elongation (Azeez and Shafi, 1966).

The range, mean and coefficient of variability were computed separately for indigenous, exotics and pooled data, following standard statistical methods.

## RESULTS AND DISCUSSION

### Kernel colour, size and shape

There was predominance of white colour kernels in both indigenous and exotic accessions. Of the 49 exotics, only 4 were of red kernels and among the indigenous collections, 27 accessions (36%) exhibited red kernels (Fig. 1a).

Two accessions each in both the collections showed white + red kernels. Two indigenous accessions (Bhognobhari, NIC 105697, Dhusari HRC 1125) had purple kernels.

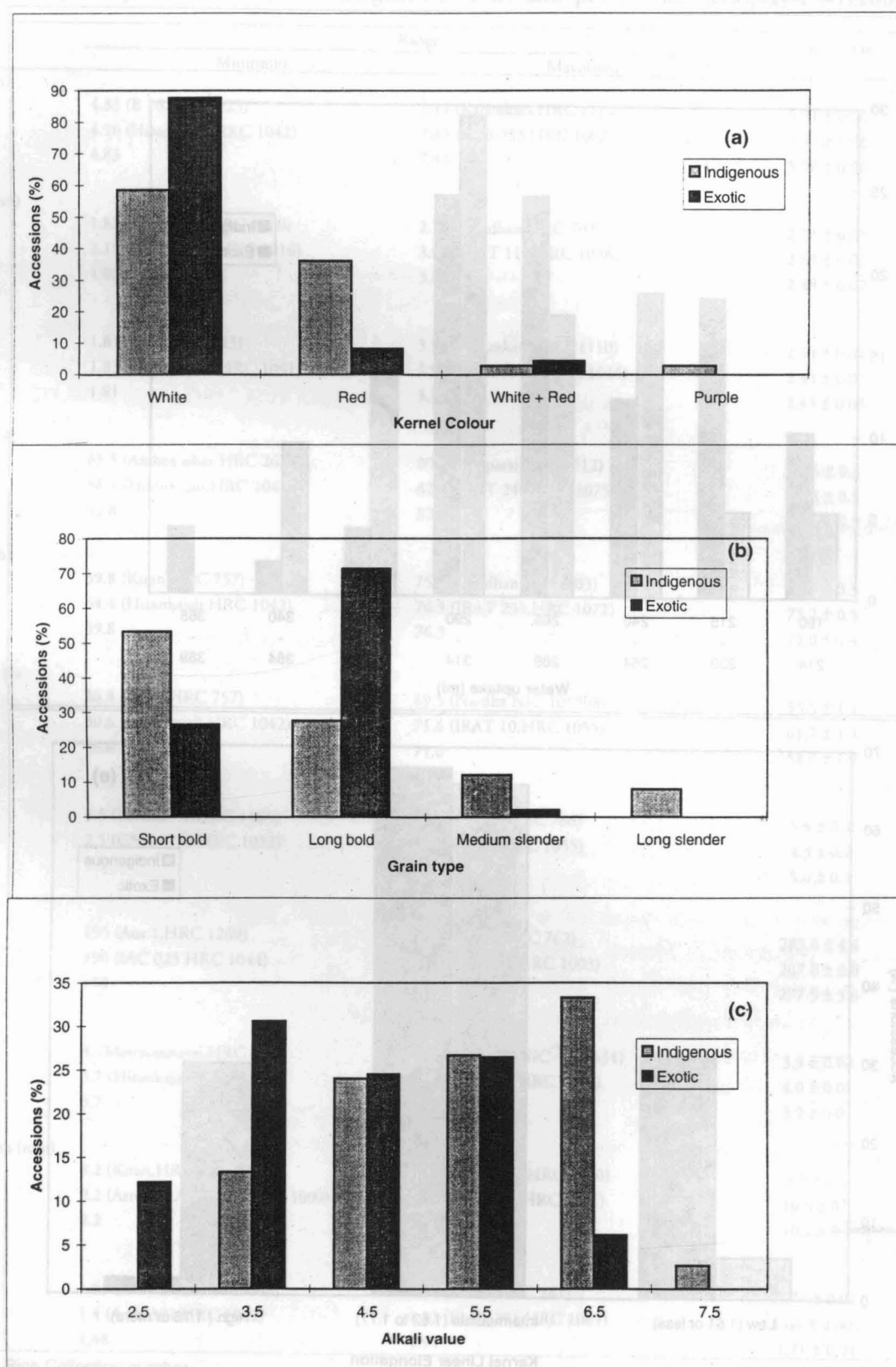
The kernel length varied more in indigenous than in exotic collections. Nevertheless, the mean kernel length was higher ( $6.41 \pm 0.08$  mm) in exotics than that of indigenous collection ( $5.71 \pm 0.06$  mm). The kernel length ranged from 4.83 (B 76, HRC 423) to 7.11 (Kalamkata, HRC 1110) and 4.90 (Hirankajali, HRC 1042) to 7.43 mm (A 08-253, HRC 1002), respectively in indigenous and exotic collections. The exotic accessions exhibited more kernel breadth as those of indigenous collection (Table 1). Accession **Jhillidhan** (HRC 703) and IRAT 115 (ARC 1058) had the highest kernel breadth in the two collections, i.e., 2.77 and 3.07 mm, respectively. The L/B ratio had large range and variability in the indigenous collection as compared to those of exotics (Table 1). The accessions with long bold kernels were predominant in exotics (35, 71.4 %), whereas 40 accessions (53.3%) had short bold kernels in the indigenous collection (Fig 1b). The accessions with long slender kernels were lacking in the exotics and only one accession (CH 988, HRC 677), had medium slender kernels (Fig 1b). The indigenous accessions had higher variability for L/B ratio (cv 16.3%). Only four accessions had long slender kernels (Table 2).

### Chalkiness

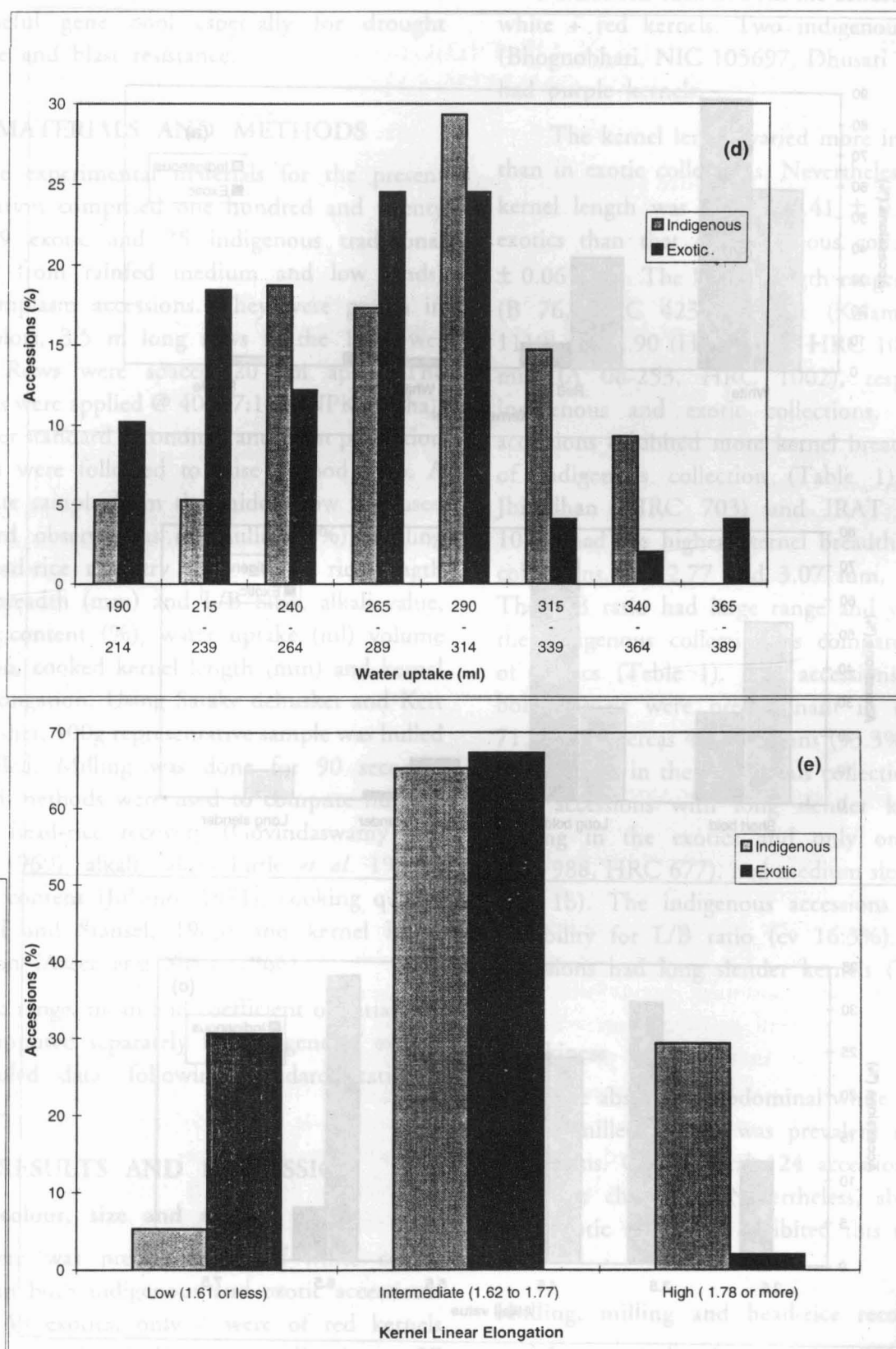
The absence of abdominal white (white jelly) in the milled kernels was prevalent in both the collections. Of the total 124 accessions, 106 did not have chalkiness. Nevertheless, about 10 per cent exotic accessions exhibited this trait.

### Hulling, milling and head-rice recovery

In general, these traits did not vary appreciably. The hulling and milling recovery had



Figs. 1(a-c). Classification of indigenous and exotic germplasm based on (a) Kernel colour; (b) Grain type; (c) Alkali value



Figs. 1(d-e). Classification of indigenous and exotic germplasm based on (d) Water uptake (ml) and (e) Linear elongation

Table 1. Variability in quality attributes of indigenous, exotic and pooled rice germplasm accessions

| Group/Character           | Range                             |                              | Mean $\pm$ SE <sub>m</sub> | cv(%) |
|---------------------------|-----------------------------------|------------------------------|----------------------------|-------|
|                           | Minimum                           | Maximum                      |                            |       |
| Kernel length (mm)        |                                   |                              |                            |       |
| Indigenous                | 4.83 (B 76,HRC 423)               | 7.11 (Kalamkata,HRC 1110)    | 5.71 $\pm$ 0.06            | 9.2   |
| Exotic                    | 4.90 (Hirankajali HRC 1042)       | 7.43 (A 08-253,HRC 1002)     | 6.41 $\pm$ 0.08            | 8.4   |
| Pooled                    | 4.83                              | 7.43                         | 5.98 $\pm$ 0.06            | 10.6  |
| Kernel breadth (mm)       |                                   |                              |                            |       |
| Indigenous                | 1.82 (Kalamkata,HRC 1110)         | 2.77 (Jhilidhan,HRC 703)     | 2.38 $\pm$ 0.03            | 9.2   |
| Exotic                    | 2.15 (CNA 108-8,HRC 1016)         | 3.07 (IRAT 115,HRC 1058)     | 2.63 $\pm$ 0.03            | 9.8   |
| Pooled                    | 1.82                              | 3.07                         | 2.48 $\pm$ 0.02            | 9.7   |
| L:B ratio                 |                                   |                              |                            |       |
| Indigenous                | 1.81 (B 76,HRC 423)               | 3.91 (Kalamkata,HRC 1110)    | 2.44 $\pm$ 0.05            | 16.3  |
| Exotic                    | 1.83 (Harimondir,HRC 1041)        | 2.92 (CNA 108-8,HRC 1016)    | 2.44 $\pm$ 0.03            | 9.8   |
| Pooled                    | 1.81                              | 3.91                         | 2.43 $\pm$ 0.03            | 9.8   |
| Hulling recovery (%)      |                                   |                              |                            |       |
| Indigenous                | 65.5 (Ambemohar,HRC 26)           | 80.0 (Chapasair,HRC 712)     | 75.6 $\pm$ 0.3             | 3.9   |
| Exotic                    | 68.1 (Hirankajali,HRC 1042)       | 82.2 (IRAT 240,HRC 1075)     | 78.8 $\pm$ 0.5             | 4.0   |
| Pooled                    | 65.8                              | 82.2                         | 76.9 $\pm$ 0.3             | 4.3   |
| Milling recovery (%)      |                                   |                              |                            |       |
| Indigenous                | 59.8 (Kiran,HRC 757)              | 75.0 (Jhilidhan,HRC 703)     | 69.8 $\pm$ 0.3             | 4.2   |
| Exotic                    | 64.4 (Hirankajali HRC 1042)       | 76.3 (IRAT 233,HRC 1072)     | 73.2 $\pm$ 0.5             | 4.5   |
| Pooled                    | 59.8                              | 76.3                         | 71.0 $\pm$ 0.4             | 6.1   |
| Head-rice recovery (%)    |                                   |                              |                            |       |
| Indigenous                | 26.8 (Kiran,HRC 757)              | 69.5 (Nardha NIC 105508)     | 55.5 $\pm$ 1.4             | 21.7  |
| Exotic                    | 30.6 (Hirankajali,HRC 1042)       | 71.6 (IRAT 10,HRC 1055)      | 61.7 $\pm$ 1.3             | 14.9  |
| Pooled                    | 26.6                              | 71.6                         | 58.0 $\pm$ 1.0             | 19.7  |
| Alkali value              |                                   |                              |                            |       |
| Indigenous                | 3.5 (Lohana - 1,HRC-1105)         | 7.0 (ADT 33 HRC 766)         | 5.4 $\pm$ 0.1              | 20.2  |
| Exotic                    | 2.5 (CNA 4130 HRC 1022)           | 6.5 (IRT 10,HRC 1055)        | 4.3 $\pm$ 0.2              | 26.3  |
| Pooled                    | 2.5                               | 7.0                          | 5.0 $\pm$ 0.1              | 24.6  |
| Water uptake (ml)         |                                   |                              |                            |       |
| Indigenous                | 195 (Aus 1,HRC 1269)              | 350 (Bhagya,HRC 762)         | 283.4 $\pm$ 4.4            | 13.3  |
| Exotic                    | 190 (IAC 025 HRC 1044)            | 370 (A 08-391 HRC 1003)      | 267.8 $\pm$ 6.0            | 15.7  |
| Pooled                    | 190                               | 370                          | 277.5 $\pm$ 3.6            | 14.5  |
| Volume expansion          |                                   |                              |                            |       |
| Indigenous                | 3. (Mettasannavri,HRC 425)        | 4.0 (Chaingora NIC** 105534) | 3.9 $\pm$ 0.02             | 3.8   |
| Exotic                    | 3.7 (Hirankajali,HRC 1042)        | 4.2 (IRAT 144,HRC 1061)      | 4.0 $\pm$ 0.01             | 1.9   |
| Pooled                    | 3.7                               | 4.2                          | 3.9 $\pm$ 0.01             | 3.5   |
| Cooked kernel length (mm) |                                   |                              |                            |       |
| Indigenous                | 8.2 (Kiran,HRC 757)               | 11.8 (Kalamkata,HRC 1110)    | 9.9 $\pm$ 0.1              | 7.9   |
| Exotic                    | 9.2 (Arroz de Aldeia Ca HRC 1009) | 11.6 (63-83 (A),HRC 1001)    | 10.6 $\pm$ 0.1             | 6.9   |
| Pooled                    | 8.2                               | 11.8                         | 10.2 $\pm$ 0.1             | 8.3   |
| Kernel elongation         |                                   |                              |                            |       |
| Indigenous                | 1.55 (Sathi 34-36,HRC 648)        | 1.94 (Martto,HRC 741)        | 1.74 $\pm$ 0.01            | 4.8   |
| Exotic                    | 1.4 (A 08-391,HRC 1002)           | 1.82 (IRAT 291,HRC 1081)     | 1.66 $\pm$ 0.001           | 4.4   |
| Pooled                    | 1.48                              | 1.94                         | 1.71 $\pm$ 0.01            | 5.1   |

\*HRC : Hazaribag Rice Collection number

\*\*NIC : National Indigenous Collection number.

Table 2. Promising accessions of rice for different quality traits

| Character                                                       | Assession                                                                                                           |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Hulling recovery (= 81%)                                        | A 08-253 (HRC 1002), Arroz Dos Indios (HRC 1010), CNA 4124 (HRC 1019), IRAT 10 (HRC 1055), IRAT 233 (HRC 1072)      |
| Milling recovery (= 75 %)                                       | CNA 4744 (HRC 1027), IAC 025 (HRC 1044), IRAT 134 A (HRC 1060), IRAT 212 (HRC 1070), IRAT 190 (HRC 1066)            |
| Long slender kernels<br>(Kernel length = 6.1; L/B ratio = 3.0)  | Jhingasar (HRC 1109)                                                                                                |
| Intermediate amylose content<br>(20-25%) and alkali value (4-5) | Panidubki (HRC 738), Dahia (HRC 741 A), Saberi (HRC 765), Mughadi (HRC 1128), Badshabhog (NIC 105510),              |
| Water uptake (= 345 ml)                                         | Govind (HRC 752), Bhagya (HRC 762), Arroz De Producto (HRC 1008), Arroz Dos Indios (HRC 1010), CNA 4124 (HRC 1018), |
| Volume expansion (4.2)                                          | Arroz Dos Indios (HRC 1010), CNA 4124 (HRC 1019), IRAT 112 A (HRC 1057), IRAT 144 (HRC 1061)                        |
| Kernel elongation (= 1.84)                                      | Metassannavri (HRC 425), Laldhan (HRC 737), Lohana-1 (HRC 1105), Ladusar (HRC 1117), Bismaia (HRC 1127),            |

Based on milled kernel dimensions

low variability whereas, head-rice recovery varied more. In previous studies, similar trend of variation was observed (Chauhan *et al.*, 1991; Malik *et al.*, 1994). Similar pattern of variability was observed in both the collections (Table 1). Indigenous accessions had more variation for head-rice recovery than that of exotics. Nevertheless, mean head-rice recovery was higher ( $61.7 \pm 1.3$ ) in the exotics. Indigenous accession, Nardha (NIC 105008) and IRAT 10 (HRC 1055) an exotic had the maximum head-rice yield of 69.5 and 71.6 per cent, respectively. Hence efforts should be made to transfer this trait from exotics to the genotypic background of indigenous cultivars, since high head-rice recovery decides the market acceptability of a cultivar. Several accessions with high hulling, milling out-turn and head-rice recovery were identified (Table 2).

### Alkali value

Alkali value gives an idea of gelatinisation temperature of the starch and hence a good indicator of cooking quality of a variety. Most preferred rice varieties are the ones with intermediate gelatinisation temperature (alkali value

of 4-5). Alkali value varied from 3.5 (Lohana 1, HRC 1105) to 7.0 (ADT 33, HRC 766) in the indigenous collections. The exotics had a range of 2.5 (CNA 4130, HRC 1022) to 6.5 (IRAT 10, JRC 1055) and the latter had higher variation for alkali value (cv 26.3%) than the former (cv 20.2%). In general this trait had higher variation than the rest of the traits. (Table 1). Chauhan *et al.* (1991, 1995) have also recorded high variability for this character. The accessions with low alkali value (4.0) were more in the exotics (42.8%) as compared to the indigenous ones (13.3%). Twenty seven of the 75 indigenous accessions were showing higher alkali value (= 6.0) as compared to only 3 exotic accessions (IRAT 10, IRAT 190 and IRAT 212). Nevertheless, irrespective of the group, majority of the accessions had intermediate alkali value (Fig. 1c).

### Amylose content

Only indigenous accessions were evaluated for amylose content which ranged from 14.3 (Govind, HRC 752) to 26.1% (Aditya, HRC 756) with an overall mean of  $21 \pm 0.2$  and showing low variability (cv 8.8%)

Table 3. Characteristics of some promising rice accessions

| Accession        | HRC/NIC<br>(No.) | Hulling<br>recovery<br>(%) | Milling<br>recovery<br>(%) | Head<br>rice (%) | Kernel<br>length<br>(mm) | L/B ratio   | Alkali<br>value | Water<br>uptake<br>(ml) | Kernel<br>elongation | Leaf blast<br>score |
|------------------|------------------|----------------------------|----------------------------|------------------|--------------------------|-------------|-----------------|-------------------------|----------------------|---------------------|
| Laldhan          | 737              | 77.1                       | 72.9                       | 64.6             | 5.27                     | 2.12        | <u>5.5</u>      | <u>320</u>              | <u>1.93</u>          | -                   |
| Panidubki        | 738              | 79.7                       | 73.1                       | 68.9             | 5.85                     | 2.22        | <u>5.5</u>      | <u>300</u>              | 1.71                 | -                   |
| Govind           | 752              | 71.4                       | 63.0                       | 39.0             | <u>6.15</u>              | 2.93        | 7.0             | <u>345</u>              | 1.63                 | <u>4</u>            |
| Saberi           | 765              | 77.5                       | 70.0                       | 66.0             | <u>6.16</u>              | 2.87        | <u>5.5</u>      | 260                     | 1.69                 | <u>5</u>            |
| Arroz-dos Indios | 1010             | <u>81.0</u>                | <u>75.8</u>                | <u>70.5</u>      | <u>6.99</u>              | 2.61        | 3.5             | <u>350</u>              | 1.66                 | 0                   |
| CNA 4124         | 1019             | <u>81.0</u>                | <u>75.4</u>                | 69.0             | <u>6.65</u>              | 2.64        | 4.5             | <u>310</u>              | <u>1.74</u>          | <u>3</u>            |
| CNA 4125         | 1020             | <u>81.4</u>                | <u>76.0</u>                | 67.0             | <u>6.59</u>              | 2.58        | 4.5             | 255                     | 1.73                 | <u>2</u>            |
| CNA 4744         | 1027             | <u>81.8</u>                | <u>76.1</u>                | <u>71.1</u>      | <u>6.74</u>              | 2.52        | 5.5             | 200                     | 1.60                 | <u>5</u>            |
| IRAT 115         | 1058             | 80.0                       | 74.4                       | <u>71.4</u>      | <u>6.17</u>              | 2.01        | 2.5             | 220                     | 1.65                 | <u>3</u>            |
| IRAT 240         | 1075             | <u>82.2</u>                | <u>76.2</u>                | 68.6             | <u>6.68</u>              | 2.67        | 4.5             | 250                     | <u>1.74</u>          | <u>4</u>            |
| Khirasar         | 1124             | 79.8                       | 73.8                       | 64.3             | <u>6.56</u>              | <u>3.00</u> | 6.5             | <u>305</u>              | 1.68                 | 9                   |
| Bismania         | 1127             | 75.0                       | 68.7                       | 58.9             | 5.25                     | 2.22        | <u>5.5</u>      | <u>305</u>              | <u>1.90</u>          | -                   |
| Mughadi          | 1128             | 73.4                       | 68.6                       | 53.2             | <u>6.12</u>              | 2.66        | <u>5.5</u>      | <u>300</u>              | 1.70                 | 7                   |
| Kalamdan NIC     | 105814           | 76.7                       | 70.5                       | 56.6             | <u>6.63</u>              | <u>3.07</u> | <u>5.5</u>      | 290                     | 1.69                 | -                   |

Underlined values indicate the desirable traits(s)

### Water uptake and volume expansion

This character relates to fluffiness of the cooked rice. A moderate level of variability was registered (cv 13.3-15.7%) for water uptake. In the indigenous collection Bhagya (HRC 762) had the highest water uptake (350ml), about 24% of the accessions showed water uptake of 315ml or more whereas only 10% the exotics were grouped in this class (Fig 1d). The mean water uptake was slightly higher in the indigenous collection as compared to the exotics (Table 1) Volume expansion did not show appreciable variability and exhibited narrow range in both the groups (Table 1). The accession Arroz Dos Indios (HRC 1010), CNA 4124 (HRC 1019), IRAT 112 A (HC 1057) and IRAT 144 (HRC 1061) had the highest volume expansion (4.2).

### Kernel linear elongation

This is the most prized cooking quality

character. Varieties with high kernel elongation fetch good market price. Besides other quality traits, *basmati* rice are very well known for this character. Although mean cooked kernel length of the exotics was higher than that of the indigenous collection but variability was marginally higher in the latter (Table 1). The indigenous collection showed large range (1.55-1.99) with higher mean kernel elongation ( $1.74 \pm 0.01$ ). The accession Marto (HRC 741) among the indigenous and IRAT 291 (HRC 1081) among the exotics had the highest kernel elongation of 1.94 and 1.82, respectively. Only one exotic (IRAT 291) exhibited high kernel elongation while 22 accessions (29.3%) of the indigenous group had high value (1.78) for this trait (Fig. 1e). Five accessions had a fairly high (1.84) kernel elongation (Table 2). This trait had low variation (cv 4.4-4.8). In our previous studies also (Chauhan *et. al.*, 1990, 1991 and 1995) low variability for this character was observed.

Quality characteristics of the accessions in both the collections revealed that exotics could be the good sources for improving hulling, milling and head-rice recovery, water uptake and volume expansion (Table 2). The indigenous collection had potential resource gene(s) for long slender grains, intermediate alkali value and kernel linear elongation (Table 2). Fourteen accessions having multiple desirable quality characters were identified (Table 3) of which Arroz dos Indios, CNA 4124, CNA 4125 and IRAT 115, in addition to good quality also possessed high level of blast resistance, a major disease of rainfed uplands. Hence these should be utilised in the rice quality improvement programme to improve simultaneously more than one trait.

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## EVALUATION OF SOME CULTIVARS OF *Capsicum annuum* IN SAURASHTRA REGION WITH SPECIAL REFERENCE TO FRUIT SHAPE AND CAPSAICIN CONTENT

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A survey of red pepper (*Capsicum annuum* L) cultivation at different centres of Saurashtra region was made. Based upon the shape and size of fruits and their capsaicin contents, twenty populations were studied and these were classified into three channels named as A, B and C. A new cultivar named 'Khumkhiya' was also recorded and was placed under channel D and named as D 70.

**Key words:** Red pepper, *Capsicum*, fruit shape, capsaicin, evaluation

Red pepper (*Capsicum annuum*), a native of tropical America and West Indies (Hill, 1952) was introduced into India by the Portugese in the Seventeenth century (Mathew *et al.*, 1971). *C. annuum* commonly known as red pepper or chillies are mainly cultivated for fruits which are used as vegetable for culinary purposes, in medicine as a stimulant and as a source of oleoresin (Mathew *et al.*, 1971). A large number of varieties of *C. annuum* are under cultivation in India and perhaps these have developed by hybridization, climatic variations and long period of cultivation. The fruits contain an active pungent principle substance, an alkaloid known as Capsaicin C<sub>18</sub>H<sub>27</sub>O<sub>3</sub>N (Ananthasamy *et al.*, 1960). In Saurashtra, chillies are cultivated during the period of August to February and local markets are flooded with different types of ripe fruits. Based on the shape of fruits, these types are known as gholar, reshama patta, double patta, lawingia and deshi. So far, systematic studies in the variation of fruits shape in various cultivars have not been made. Present investigation has, therefore, been

undertaken to study the intraspecific variation with respect to fruit shape, size, colour and capsaicin contents.

### MATERIALS AND METHODS

The seeds of *C. annuum* were collected from 20 recognised places and were used for the present study at Vegetable Research Centre, Gujarat Agricultural University, Junagarh Campus. Plants were raised from seeds in plots of one square meter during August. The saplings were transplanted into plots of 4.5 × 2.4 m<sup>2</sup> in the month of October. Forty plants were maintained in each plot at equal distance in four rows (plant density was 3.7/sq.m.). The plots were regularly irrigated and were kept weed free throughout the period of study. Morphological characters, like shape, size and colour of fruits were recorded. Chromosome number was verified in the root tips of the seedlings grown on wet filter paper in petriplates by the smear method (Sass, 1958).

The quantitative estimation of capsaicin in the dry fruits was done by colorimetric procedure after Bajaj and Kaur (1979). 0.5 g dried power was extracted with acetone. This was passed through basic alumina column. A mixture of acetone, methanol and distilled water (75:25:2) was added to the extract. From this mixture, 10 ml of aliquot was evaporated to dryness and 0.5 ml of folin-ciocalten reagent was added to develop colour. One ml saturated calcium carbonate solution was added and the final volume was made to 10 ml by addition of distilled water. The optical density of the blue coloured solution which developed after one hour was measured by spectrophotometer at 780 nm. Quantity of capsaicin was calculated by a standard curve prepared by using pure capsaicin (BDH).

## RESULTS AND DISCUSSION

**I. Fruit Morphology :** On the basis of Anderson's (1949) scattered diagram method, all the 20 populations cultivated were found different from each other. These populations showed variations in fruit shape, size and colour (Table 1), however, the chromosome number of all these populations was  $2n = 24$ . Since the entire Saurashtra region has uniform semi-arid climate and there is not much variation in the soil under cultivation, the twenty populations have been recognized as varieties. Based on the fruit shape, size and colour, these populations are classified into following three channels and their main morphological features are given in Table 1.

1. Channel A : Fruit broad, short and bell shaped

2. Channel B : Fruits long, broad at upper end, tapering below and become flat and conical on drying.

3. Channel C : Fruits linear and cylindrical and they retain their shape even after drying

**II. Capsaicin :** The quantity of capsaicin in

the fruits at different stages of development in various cultivars is shown in Table 2.

It is evident from the data in Table 2, that the quantity of capsaicin was the lowest in young green fruits, which increased considerably in mature green fruits but again declined in mature red fruits. The plausible reason for the decrease in capsaicin content from green mature fruits to red fruits may be due to the conversion of pigment carotenoid into red pigment called capsanthin which has identical chemical structure with capsaicin (Mathew *et al.*, 1971). It is also evident that the cultivars are of mild, medium hot and hot fruit varieties. The cultivars of Channel A are of mild type with 0.12-0.52 mg/g capsaicin in mature green fruits. The cultivars of Channel B are medium hot with 0.15-0.57 mg/g capsaicin in mature green fruits and Channel C consisted of hot type of varieties with 0.32-0.73 mg/g capsaicin in their mature green fruits.

The quantity of capsaicin in different parts of a fruit in various cultivars of different Channels also showed considerable variation (Table 3). The peduncle of fruits of different varieties consisted of lowest quantity of capsaicin (0.001-0.002 mg/g), while placenta consisted of maximum capsaicin (0.41-0.67 mg/g) in all the cultivars. On the other hand, the quantity of capsaicin in seeds was mild (0.12-0.22 mg/g) and in pericarp, it was moderate (0.22-0.45 mg/g).

It was interesting to note that most of the mild chillies (Channel A) were low yielding varieties. Similarly, the medium chillies (Channel B) were also low yielding ones, but sometimes there were medium to high yielding type which exhibited higher capsaicin contents. On the other hand, the hot chillies (Channel C) were high yielding and rarely low or medium yielder also with lower or moderate capsaicin contents in their fruits.

Table 1. Morphological features of the fruits of different varieties of *C. annuum*

| S.No.     | Cultivars | Fruit Characters        |                  |               |                                  |                              |
|-----------|-----------|-------------------------|------------------|---------------|----------------------------------|------------------------------|
|           |           | Shape                   | Size (cm)        |               | Colour                           | Other characters             |
| Channel A |           |                         |                  |               |                                  |                              |
| 1         | A 13      | Very broad bell shaped  | 4-5<br>3.4-4     | long<br>broad | Bright red                       | Smooth walled                |
|           | A 35      | Broad bell shaped       | 4-5<br>3-3.5     | long<br>broad | Pale green<br>bright red         | Shining                      |
| 3.        | A 37      | Bell shaped             | 4-4.5<br>2-3     | long<br>broad | Shining bright red<br>bright red | Wrinkled, pointed<br>shining |
| 4.        | A 54      | Long                    | 2-3<br>1.2-2.5   | long<br>broad | Pale green<br>orange             | Shining                      |
| Channel B |           |                         |                  |               |                                  |                              |
| 5.        | B 17      | Long                    | 3-4<br>1.5-2     | long<br>broad | Medium green<br>dark red         | Flat, blunt                  |
| 6.        | B 23      | Long                    | 8-9<br>2.5-3     | long<br>broad | Light green<br>light red         | Pointed wrinkled             |
| 7.        | B 30      | Tapering below<br>below | 6-7<br>1.5-2.5   | long<br>broad | Medium green<br>dark red         | Thick, pointed               |
| 8.        | B 32      | Long                    | 6-8<br>1.5-2.5   | long<br>broad | Medium green<br>bright red       | Smooth                       |
| 9.        | B 44      | Very long               | 13-14<br>2.5-3.5 | long<br>broad | Dark green<br>bright red         | Pointed shining              |
| 10.       | B 48      | Long                    | 5-5.5<br>1.5-2   | long<br>broad | Medium green<br>light red        | Wrinkled                     |
| 11.       | B 59      | Very long               | 13-15<br>3.5-4   | long<br>broad | Pale green<br>bright red         | Wrinkled blunt, shining      |
| Channel C |           |                         |                  |               |                                  |                              |
| 12.       | C 33      | Curved pointed          | 7-8<br>2-2.5     | long<br>broad | Light green<br>bright red        | Thick                        |
| 13.       | C 37      | Pointed                 | 7-9<br>2.5-2     | long<br>broad | Pale green<br>bright red         |                              |
| 14.       | C 43      | Curved blunt            | 5-6<br>2-5.3     | long<br>broad | Pale green<br>bright red         |                              |
| 15.       | C 50      | Thin                    | 5-7<br>3-3.5     | long<br>broad | Dark green<br>dark red           | Rough, wrinkled shining      |
| 16.       | C 32      | Curved                  | 7-8<br>2.5-3     | long<br>broad | Medium green shining<br>dark red |                              |
| 17.       | C 64      | Thin pointed            | 5-6<br>1.5-2     | long<br>broad | Medium green<br>orange           | Wrinkled                     |
| 18.       | C 67      | Thin, pointed, curved   | 7.5-8<br>2.5-3.5 | long<br>broad | Dark green<br>light red          | Wrinkled                     |
| 19.       | C 71      | Pointed, thick<br>thick | 8-9<br>3.0-3.5   | long<br>broad | Bright red                       | Shining                      |
| 20.       | C 73      | Pointed                 | 6-7.5<br>1.5-3   | long<br>broad | Medium green<br>dark red         | Shining                      |
| Channel D |           |                         |                  |               |                                  |                              |
| 21.       | D 70      | Erect tapering below    | 4-5<br>1-2.5     | long<br>broad | Orange yellow                    | Shining, smooth walled       |

Table 2. Capsaicin content of fruits at different stages of development in various cultivars of *Capsicum annuum*

| S.No.     | Cultivars | Capsaicin (mg/g)* |              |             |
|-----------|-----------|-------------------|--------------|-------------|
|           |           | Young green       | Mature green | Mature red  |
| Channel A |           |                   |              |             |
| 1.        | A 13      | 0.05 ± 0.00       | 0.12 ± 0.02  | 0.11 ± 0.03 |
| 2.        | A 35      | 0.15 ± 0.01       | 0.33 ± 0.03  | 0.30 ± 0.04 |
| 3.        | A 37      | 0.18 ± 0.02       | 0.35 ± 0.02  | 0.33 ± 0.02 |
| 4.        | A 54      | 0.31 ± 0.02       | 0.52 ± 0.02  | 0.50 ± 0.06 |
| Channel B |           |                   |              |             |
| 5.        | B 17      | 0.10 ± 0.00       | 0.15 ± 0.02  | 0.14 ± 0.07 |
| 6.        | B 23      | 0.13 ± 0.01       | 0.21 ± 0.03  | 0.19 ± 0.02 |
| 7.        | B 30      | 0.14 ± 0.02       | 0.28 ± 0.02  | 0.26 ± 0.02 |
| 8.        | B 32      | 0.18 ± 0.01       | 0.30 ± 0.06  | 0.28 ± 0.03 |
| 9.        | B 44      | 0.22 ± 0.01       | 0.42 ± 0.07  | 0.40 ± 0.04 |
| 10.       | B 48      | 0.24 ± 0.02       | 0.45 ± 0.05  | 0.41 ± 0.05 |
| 11.       | B 50      | 0.38 ± 0.04       | 0.57 ± 0.08  | 0.54 ± 0.06 |
| Channel C |           |                   |              |             |
| 12.       | C 33      | 0.16 ± 0.01       | 0.32 ± 0.02  | 0.30 ± 0.02 |
| 13.       | C 37      | 0.18 ± 0.01       | 0.34 ± 0.02  | 0.32 ± 0.03 |
| 14.       | C 43      | 0.20 ± 0.01       | 0.42 ± 0.03  | 0.40 ± 0.03 |
| 15.       | C 50      | 0.25 ± 0.02       | 0.48 ± 0.04  | 0.45 ± 0.04 |
| 16.       | C 52      | 0.31 ± 0.02       | 0.50 ± 0.06  | 0.47 ± 0.05 |
| 17.       | C 64      | 0.35 ± 0.03       | 0.62 ± 0.07  | 0.59 ± 0.06 |
| 18.       | C 67      | 0.40 ± 0.04       | 0.65 ± 0.08  | 0.61 ± 0.03 |
| 19.       | C 71      | 0.45 ± 0.03       | 0.71 ± 0.09  | 0.65 ± 0.03 |
| 20.       | C 73      | 0.47 ± 0.04       | 0.72 ± 0.06  | 0.67 ± 0.04 |
| Channel D |           |                   |              |             |
| 21.       | D 70      | 0.48 ± 0.03       | 0.70 ± 0.04  | 0.68 ± 0.04 |

\*Mean of data from 5 replicates  
± Standard deviation

Table 3. Quantity of capsaicin in different parts of mature green fruits of various cultivars of *Capsicum annuum*

| S.No.     | Cultivars | Capsaicin (mg/g) |          |          |        |
|-----------|-----------|------------------|----------|----------|--------|
|           |           | Peduncle         | Pericarp | Placenta | Seeds  |
| Channel A |           |                  |          |          |        |
| 1.        | A 13      | 0.001            | 0.22     | 0.41     | 0.12   |
| 2.        | A 35      | 0.002            | 0.24     | 0.45     | 0.14   |
| 3.        | A 37      | 0.001            | 0.21     | 0.44     | 0.13   |
| 4.        | A 54      | 0.001            | 0.25     | 0.42     | 0.11   |
| Channel B |           |                  |          |          |        |
| 5.        | B 17      | 0.002            | 0.26     | 0.45     | 0.13   |
| 6.        | B 23      | 0.001            | 0.26     | 0.46     | 0.16   |
| 7.        | B 30      | 0.002            | 0.28     | 0.46     | 0.15   |
| 8.        | B 32      | 0.002            | 0.27     | 0.47     | 0.14   |
| 9.        | B 44      | 0.001            | 0.29     | 0.48     | 0.16   |
| 10.       | B 48      | 0.001            | 0.30     | 0.50     | 0.17   |
| 11.       | B 59      | 0.002            | 0.31     | 0.52     | 0.17   |
| Channel C |           |                  |          |          |        |
| 12.       | C 33      | 0.001            | 0.32     | 0.46     | 0.18   |
| 13.       | C 37      | 0.001            | 0.35     | 0.52     | 0.19   |
| 14.       | C 43      | 0.001            | 0.33     | 0.53     | 0.18   |
| 15.       | C 50      | 0.001            | 0.36     | 0.54     | 0.19   |
| 16.       | C 52      | 0.002            | 0.34     | 0.55     | 0.20   |
| 17.       | C 64      | 0.002            | 0.38     | 0.57     | 0.20   |
| 18.       | C 67      | 0.002            | 0.40     | 0.58     | 0.20   |
| 19.       | C 71      | 0.002            | 0.41     | 0.62     | 0.21   |
| 20.       | C 73      | 0.002            | 0.45     | 0.67     | 0.22   |
| Channel D |           |                  |          |          |        |
| 21.       | D 70      | 0.002            | 0.46     | 0.69     | 0.23   |
|           |           | ± 0.0            | ± 0.08   | ± 0.06   | ± 0.02 |

\*Mean data from 5 replicates

III. **New Cultivar** : A new cultivar with morphological features different to those of variations in Channels A, B and C, particularly in fruit shape was noticed in the fields of Saurashtra region. The plants of this cultivar were about 15 cm long, dark green, non-bushy. Leaves were long with acute apex. Fruits were broad, medium sized (4-5 cm long), shining, smooth walled, tapering

and orange yellow in colour. The fruits were erect and not pendant as in the cultivars of other three Channels (Table 1). The chromosome number of this cultivar was, however, the same ( $2n = 24$ ).

Mature green fruits of this cultivar consisted of high capsaicin contents (0.70 mg/g) which declines slightly in mature red fruits (0.68 mg/g). Thus, this cultivar is also of hot type as is the case with those of Channel C (Table 2). In mature green fruits, the quantity of capsaicin was the highest in the placenta (0.69 mg/g), followed by pericarp, seeds and peduncle (Table 3). Thus, on the basis of erect fruit type and higher capsaicin content, this cultivar 'Khumkhiya' has been placed in Channel D and named as D 70.

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## CLASSIFICATION OF URIDBEAN GERMPLASM FROM DIVERSITY ZONES OF UTTAR PRADESH

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The landraces in Uridbean (*Vigna mungo* L.) were collected from diversity rich zones in Uttar Pradesh, India. The collections were characterized for visual traits and quantitative characters. The ordination of genotypes were done by principal component analysis. The classification gave 13 clusters and many resistant genotypes for viral diseases were identified. The genetic donors for yield, pod and flowering traits were isolated along with green seeded erect types which are not found frequently.

**Key words :** Uridbean, landraces, germplasm, classification

Uridbean [*Vigna mungo* (L.)] Hepper is an important pulse crop of Indian subcontinent. India being one of the important centre of diversity, a thrust for germplasm collection, evaluation and conservation is a desired necessity to keep pace with increasing population. Allard (1960) and Harlan (1956) also speculated the problem of germplasm conservation, while discussing natural variability of plants and pointed out that centre of diversity are in constant process of genetic erosion. Unfortunately, the progress in breeding often by selection and purification of genetically mixed landraces inevitably led to more uniformity and less genetic variability within the variety that was presented in the original landrace. Keeping this view in mind, explorations were conducted in the districts of Uttar Pradesh namely, Hardoi, Barabanki, Bareilly, Sitapur and eight districts in Kumaon and Garhwal which were reported to be rich in diversity for local types in this crops (Paroda and Arora, 1991). For estimation of diversity within the germplasm, the classification of germplasm accessions into homogenous groups

is utmost desirable practice using multivariate parameters instead of using univariate methods. It was presumed that the genotypes originated from distantly separated regions of the world are likely to be different in their genetic make up. However, several scientists for different crop species have supported no parallelism in geographical distribution and genetic diversity (Malhotra and Singh, 1971). The collected 150 accessions of uridbean were subjected to principal component analysis (PCA) for classification in the present study.

### MATERIALS AND METHODS

One hundred fifty accessions collected from diversity zones of Uttar Pradesh were sown in the month of July at Crop Research Station, Pantnagar in augmented design with four checks namely Narendra Urid-1, Pant Urid-35, Type-9, and Pant Urid-19 after every 10 plots of new accessions. Each plot of accession as well as checks consisted of 2 rows of 4m length. The row spacing was 30 cm and plant spacing was kept

10 cm. All accessions were assigned in 15 blocks with 4 repeated checks in every block. The trial was protected for insect/pest. Observations for various characters viz., plant height (cm), days to 50 per cent flowering, days to maturity, pods per plant, pod length (cm), seeds per pod, 100 seed weight (g) and yield kg/ha were subjected to statistical analysis. The analysis of variance was performed in augmented design using method given by Federer (1961) and elaborated by Federer and Raghav Rao (1975). The genotypic means were adjusted for the block effects as measured by the check plots. The total number of block were determined by relationship

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

where, b = number of blocks

c = number of checks

The adjustment factor  $r_j = (1/C) (B_j - M) =$  Mean of jth block minus grand mean. The adjusted yields were calculated by subtracting  $r_j$  from actual observations.

$$y_i = y_{ij} - r_j$$

where,

$Y_{ij}$  = yield of  $i^{\text{th}}$  variety occurring in jth block.

Further classificatory analysis was done on these adjusted values of variables.

For extracting the principal components correlation matrix was obtained by adjusted means of variable as matrix. The matrix of r non zero eigen values was utilized to extract r principal components. Thus from a matrix of 6 non-zero eigen values, the 6 principal components (PCP) were extracted.

Here the 1st PCP represented largest variance of random linear combination of variables represented in data matrix. The other PCPs were orthogonal axis of 1st PCP. The measure of degree of fit or fraction of total variance explained

by 6 principal components were obtained as fraction of non zero eigen values and total R eigen values.

The genetic divergence among genotypes was studied using non hierarchical euclidian, cluster analysis model described by Beale (1969) and elaborated by Spark (1973). The PCPs obtained from original variables were utilized for this analysis. The assumption for this method was that the euclidian distances 'D' separating 'n' points in a 'P' dimensional space are proportional to the dissimilarities between the objects and secondly, that no object can belong simultaneously to two clusters.

## RESULTS AND DISCUSSION

The analysis of variance performed for augmented designs revealed sufficient differences among checks. The results for mean and range in various characters has been given in Table 1. The range of characters is indicative of high amount of variability as the plant height ranged from 28 to 80 days and maturity ranged from 58 days to 116 days. The pods per plant showed tremendous variability with minimum of 9.9 up to 116.6 pods. The pod length varied from 2.9 to 7.12 and seed weight from 1.32 to 4.72 g. The maximum yield was obtained in accession ShU 96133 which was a local collection from district Nainital. The earliest accession in flowering and maturity was ShU 9547. Accession ShU 9534 (from Hardoi) was having the highest number of pods and found resistant to both yellow mosaic and leaf crinkle virus.

Such landraces with useful traits impart a possibility of direct utilization. The values of eigen vectors, roots and variation explained is given in Table 2. The maximum value of eigen roots 2.89 was obtained by 1st eigen vector followed by 1.85, 1.08, 0.833, 0.69, 0.42, 0.18, 0.33 by other corresponding seven vectors. The different vectors

**Table 1. Mean and range of various quantitative characters in uridbean germplasm**

| Particulars                 | Characters             |                             |                     |                      |                     |                     |                        |                    |
|-----------------------------|------------------------|-----------------------------|---------------------|----------------------|---------------------|---------------------|------------------------|--------------------|
|                             | Plant height<br>(cm)   | Days to<br>50%<br>flowering | Days to<br>maturity | Pods/plant           | Pod length<br>(c.)  | Seed/pod            | 100 seed<br>weight (g) | Yield<br>(kg/ha)   |
| Accessions                  | 90.83<br>(125.5-183.8) | 54.93<br>(18.4-79.7)        | 86.37<br>(58- 116)  | 30.20<br>(9.9-116.6) | 4.22<br>(2.90-7.12) | 6.67<br>(3.42-7.61) | 3.24<br>(1.32-4.72)    | 1057<br>(709-2839) |
| Check 1<br>(Narendra Urd 1) | 191.5                  | 42.93                       | 75.53               | 44.87                | 4.567               | 6.507               | 3.175                  | 2301               |
| Check 2 (PU-35)             | 112.3                  | 42.73                       | 74.67               | 42.93                | 4.567               | 6.780               | 3.039                  | 1602               |
| Check (T-9)                 | 93.87                  | 43.20                       | 76.00               | 35.53                | 4.380               | 6.820               | 3.197                  | 1371               |
| Check-4 (PU-19)             | 101.6                  | 43.93                       | 75.00               | 39.07                | 4.300               | 6.593               | 2.984                  | 1709               |
| CV %                        | 16.13                  | 3.773                       | 4.164               | 26.80                | 5.263               | 6.321               | 8.858                  | 18.63              |

(Range in parenthesis)

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

| Particulars              | Characters           |                             |                     |            |                    |          |                        |                  |
|--------------------------|----------------------|-----------------------------|---------------------|------------|--------------------|----------|------------------------|------------------|
|                          | Plant<br>height (cm) | Days to<br>50%<br>flowering | Days to<br>maturity | Pods/plant | Pod length<br>(cm) | Seed/pod | 100 seed<br>weight (g) | Yield<br>(kg/ha) |
| Plant height (cm)        | 0.38                 | 0.40                        | -0.14               | -.23       | -0.16              | 0.51     | 0.56                   | -0.027           |
| Days to 50%<br>flowering | -0.35                | 0.57                        | -0.039              | 0.050      | 0.19               | -0.026   | -0.048                 | 0.71             |
| Days to maturity         | -0.33                | 0.58                        | -0.02               | 0.07       | 0.21               | -0.032   | -0.09                  | 0.69             |
| Pods/plant               | 0.42                 | 0.28                        | 0.10                | 0.06       | -0.14              | -0.80    | 0.23                   | 0.002            |
| Pod length (cm)          | 0.35                 | -0.08                       | -0.21               | -0.30      | 0.84               | -0.065   | -0.064                 | 0.01             |
| Seeds/Pod                | 0.15                 | -0.016                      | -0.68               | 0.70       | 0.01               | 0.04     | -0.003                 | 0.003            |
| 100 seed weight (g)      | 0.22                 | 0.009                       | 0.66                | 0.57       | 0.31               | 0.23     | 0.13                   | 0.03             |
| Yield (kg/ha)            | 0.48                 | 0.28                        | 0.06                | -0.04      | -0.22              | 0.18     | -0.76                  | 0.03             |
| Eigen roots              | 2.89                 | 1.85                        | 1.08                | 0.833      | 0.69               | 0.42     | 0.18                   | 0.033            |
| Variation (%)            | 36.13                | 23.20                       | 13.54               | 10.42      | 8.63               | 5.36     | 2.27                   | 0.41             |

associated with various characters have shown positive and negative values as contribution obtained for vectors. The contribution of positive and negative values is based on relative proportion of multivariates in the formation of orthogonal vectors as the observable variates are presented as a function of smaller number of latent vectors so that few orthogonal variates are obtained (Morrison, 1976).

The maximum variation of 36.13 per cent was explained by 1st vector and rest of the variation 23.20, 13.54, 10.42, 8.63, 5.36, 2.27 and 0.41 were explained by other seven vectors. The maximum variation contributed for first vector is from characters plant height, pods per plant and yield kg/ha. The first six principal components explained 97.31 per cent variation which were utilised for clustering purpose.

Table 3. Average inter and intra cluster distances in uridbean germplasm

| Cluster No. | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      | 11      | 12      | 13      |
|-------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1.          | (1.106) |         |         |         |         |         |         |         |         |         |         |         |         |
| 2.          | 1.791   | (1.212) |         |         |         |         |         |         |         |         |         |         |         |
| 3.          | 1.687   | 1.50    | (1.239) |         |         |         |         |         |         |         |         |         |         |
| 4.          | 3.379   | 3.085   | 2.541   | (1.566) |         |         |         |         |         |         |         |         |         |
| 5.          | 2.283   | 2.601   | 2.467   | 1.939   | (1.023) |         |         |         |         |         |         |         |         |
| 6.          | 3.156   | 2.601   | 2.966   | 3.995   | 3.143   | (1.030) |         |         |         |         |         |         |         |
| 7.          | 2.742   | 2.238   | 3.057   | 3.17    | 1.916   | 2.158   | (1.340) |         |         |         |         |         |         |
| 8.          | 5.493   | 4.010   | 4.716   | 4.068   | 4.962   | 5.367   | 4.500   | (1.976) |         |         |         |         |         |
| 9.          | 4.402   | 3.976   | 3.946   | 4.436   | 4.220   | 4.635   | 4.506   | 6.166   | (1.412) |         |         |         |         |
| 10.         | 3.140   | 3.117   | 2.409   | 2.545   | 2.261   | 2.389   | 2.906   | 5.582   | 4.014   | (1.307) |         |         |         |
| 11.         | 2.880   | 2.249   | 2.350   | 3.154   | 2.529   | 1.443   | 2.150   | 5.037   | 3.313   | 1.654   | (1.078) |         |         |
| 12.         | 2.487   | 2.376   | 2.902   | 3.011   | 1.865   | 3.526   | 2.102   | 4.883   | 3.160   | 3.333   | 2.683   | (1.193) |         |
| 13.         | 12.409  | 12.409  | 12.303  | 12.465  | 12.353  | 12.302  | 12.398  | 13.137  | 12.876  | 12.469  | 12.347  | 12.000  | (0.000) |

(Values in parenthesis are intra cluster distance)

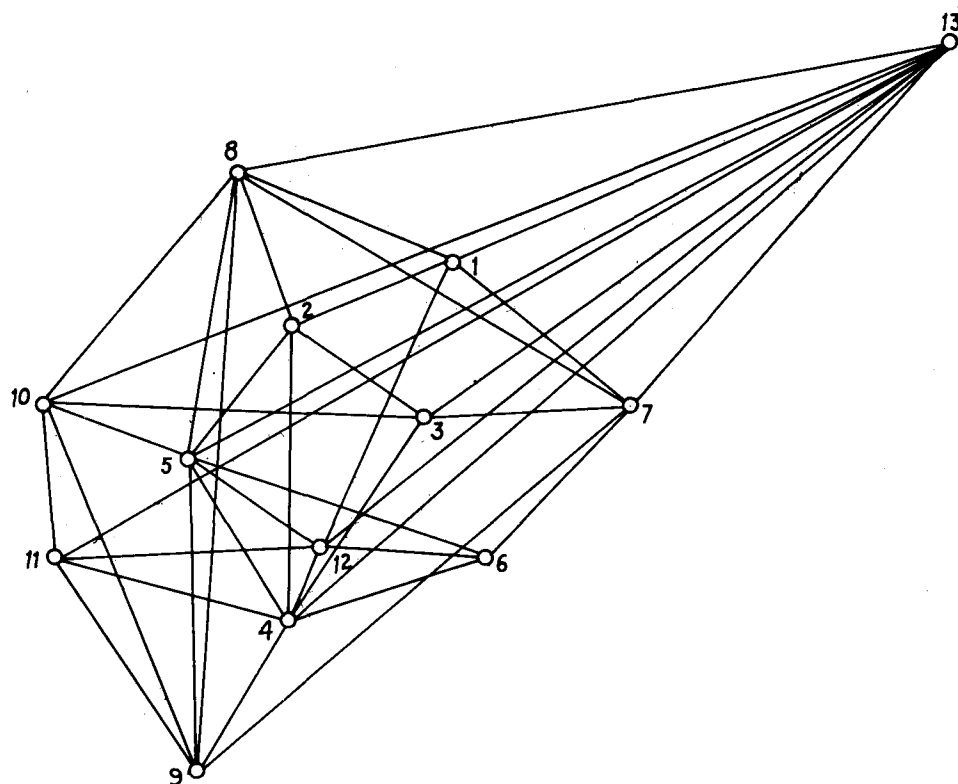


Fig. 1. Cluster diagram showing relative inter cluster distances among uridbean germplasm

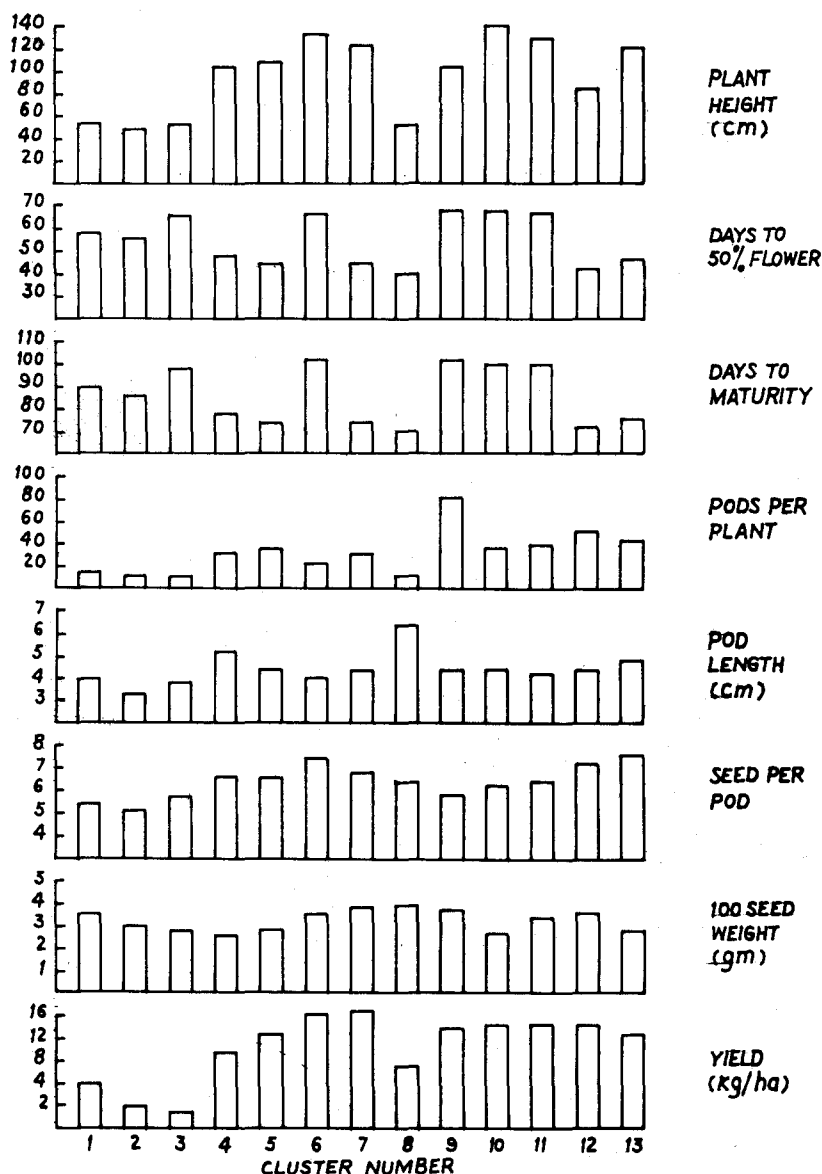


Fig. 2. Cluster mean different characters in urid bean germplasm

The cluster analysis grouped 154 accessions into 13 clusters which was found appropriate as determined by F test. The non-hierarchical clustering procedures followed, allows solution to large data problems because it is not necessary to calculate and store the similarity matrix everytime. The inter and intra cluster distance between and within clusters have been given in Table 3.

The maximum intra cluster distance 1.976 was found in cluster No. 8 and minimum in

cluster No. 6. This distance is indicative of relative divergence among similar genotypes within a group. The maximum inter cluster distance was between cluster Nos. 13 and 10. These clusters had accessions collected from various different localities. The arrangement of accessions in between clusters was found independent of their locality of collections indicating that pattern of diversity in urdbean is not location specific.

The cluster means as depicted in Fig. 2 revealed that within clusters the accessions with

distinct characters, clustered together making a particular cluster distinct. The tallest accession were recorded in cluster No. 10 which had highest mean of 139.27 cm, cluster No. 8 had early flowering and maturity types. The maximum number of pods with mean value of 44 per plant were obtained in cluster No. 13 which is a single entry cluster with accession ShU-9641 collected from Shergarh in district Bareilly. This cluster also had maximum number of seeds per pod. The entry was typically distinct and exclusive. This cluster was in maximum diverse end (Fig. 1). Although such classificatory studies in urbean are scanty, in other crops like wheat Wrigley *et al.* (1982) have done such studies.

The presentation in the Fig. 2 allowed convenient selection of superior cluters for different traits and their accessions within these clusters. The promising accessions identified as genetic donors have been given in Table 4, which can be utilized in breeding programmes.

**Table 4. Identified genetic donors for various characters in uridbean germplasm**

| Character                | Entry Name                                       |
|--------------------------|--------------------------------------------------|
| 1. Plant Height (cm)     | ShU 9511, ShU 9512, ShU 9537, ShU 9539, ShU 9606 |
| 2. Days to 50% flowering | ShU 9636, ShU 9603, ShU 9610                     |
| 3. Days to maturity      | ShU 9636, ShU 9603, ShU 96104                    |
| 4. Pods/Plant            | ShU 9636                                         |
| 5. Pod Length (cm)       | ShU 96104, ShU 9603, ShU 9634                    |
| 6. Seed/Pod              | ShU 9641                                         |
| 7. 100 Seed Weight (g)   | ShU 9536, ShU 9603, ShU 96104                    |

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## VARIABILITY IN ASCORBIC ACID CONTENT OF SOME *Lycopersicon* SPECIES

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Evaluation and analysis of 19 exotic germplasm of tomato comprising of *L. esculentum*, *L. peruvianum* and *L. pimpinellifolium* for ascorbic acid and fruit attributes indicated an appreciable range of variation. *L. peruvianum*, a non-edible green fruited species averaged the highest (60.97 mg/100 g of fresh weight) than other species analysed for ascorbic acid content. The average fruit length, fruit width and fruit weight of *L. esculentum* was more as compared to other two species. Variability in fruit attributed was low in *L. pimpinellifolium*

Key words : Tomato, *Lycopersicon* spp., variability, ascorbic acid

People can not produce ascorbic acid within their bodies, it must be consumed as part of a balanced diet. Nearly 90 per cent of this ascorbic acid is obtained from vegetables and fruits. Vegetables are an important dietary source of ascorbic acid, though there are a marked differences in the ascorbic acid content of different vegetables and even within the same species (Inove *et al*, 1998). Wills *et al*. (1996) reported that tomatoes possessed about 20 mg of ascorbic acid per 100 g of fresh weight. Some of the wild and semi cultivated forms had ascorbic acid values considerably higher than cultivated varieties. Since a wide variety of exotic germplasm were grown in the field at NBPGR Regional Station for characterization and evaluation, particular attention was paid to record differences among these species (*L. esculentum*, *L. peruvianum*, *L.pimpinellifolium*) in ascorbic acid content to use in future tomato improvement programs.

### MATERIALS AND METHODS

A total of 188 exotic accessions of tomato germplasm (*Lycopersicon* spp) was transplanted for

characterization, multiplication and evaluation at the NBPGR Regional Station, Hyderabad during Rabi season 1997-98 in an augmented design at a spacing of 60 × 60 cm, with local checks after every 10 accessions. About 19 exotic accessions comprising three species were analysed for ascorbic acid content by volumetric method by extracting 5 g sample in 4 per cent oxalic acid and by using 2, 6 - dichlorophenol indophenol dye. The amount of ascorbic acid was estimated by  $\frac{0.5}{V_r \text{ ml}} \times \frac{V_2}{5 \text{ ml Wt.}} \times \frac{100}{O_{\text{sample}}} \times 100$ . The fruit length, width were determined by digital caliper and fruit weight was determined by electronic balance. The data were recorded as per IPGRI descriptor (1996) on 10 randomly selected fruits taken from 5 different plants.

### RESULTS AND DISCUSSION

The *L. peruvianum*, a non edible green fruited species averaged the highest (60.97 mg/100g) of other types examined for ascorbic acid content. Representatives of this species were EC 211582,

Table 1. Variability in Vitamin C content and fruit attributes of *Lycopersicon* species

| <i>L. peruvianum</i>       |                       |                   |                  |                  |
|----------------------------|-----------------------|-------------------|------------------|------------------|
| Acc. No.                   | Asco. acid (mg/100 g) | Fruit length (mm) | Fruit width (mm) | Fruit weight (g) |
| EC 211582                  | 59.77                 | 13.966            | 13.75            | 0.8              |
| EC251668                   | 62.8                  | 13.822            | 13.648           | 0.886            |
| EC169966                   | 32.5                  | 13.892            | 14.904           | 0.6              |
| EC267727                   | 70                    | 10.55             | 11.06            | 0.478            |
| EC274122                   | 87.5                  | 8.3               | 8.31             | 0.22             |
| EC274046                   | 34.2                  | 8.7               | 8.526            | 0.2401           |
| EC251661                   | 80                    | 8.5               | 8.835            | 0.4055           |
| Average                    | 60.9671429            | 11.1042857        | 11.2904286       | 0.51851429       |
| Range                      | 32.5-87.5             | 8.3-13.966        | 8.31-14.904      | 0.22-0.886       |
| Sed $\pm$                  | 21.1324606            | 2.71050043        | 2.80691942       | 0.25883032       |
| C.V                        | 34.662                | 24.419            | 24.86            | 49.91            |
| <i>L. esculentum</i>       |                       |                   |                  |                  |
| Acc.No.                    | Ascor.acid (mg/100 g) | Fruit length (mm) | Fruit width (mm) | Fruit weight (g) |
| EC162508                   | 45                    | 28.68             | 23.38            | 15               |
| EC251680                   | 25                    | 42.235            | 37.415           | 12.88            |
| EC338734                   | 27.5                  | 40.21             | 46.794           | 44.9             |
| EC163894                   | 25                    | 31.068            | 40.714           | 20               |
| EC144681                   | 40                    | 32.28             | 40.01            | 36               |
| EC164660                   | 25                    | 40.127            | 48.13            | 40               |
| EC163594                   | 23.68                 | 39.1              | 47.92            | 40.5             |
| EC338717                   | 36.84                 | 35.51             | 32.508           | 18               |
| EC310301                   | 35.07                 | 51.22             | 39.804           | 14               |
| EC315457-1                 | 35                    | 30.815            | 34               | 16               |
| Average                    | 31.809                | 37.1245           | 39.0675          | 25.7             |
| Range                      | 23.68-45              | 28.68-51.22       | 23.38-48.13      | 12.88-44.93      |
| Sed $\pm$                  | 7.53479403            | 6.84035899        | 7.75937551       | 12.9093186       |
| C.V                        | 23.67                 | 18.43             | 19.86            | 3.89             |
| <i>L. pimpinellifolium</i> |                       |                   |                  |                  |
| Acc.No.                    | Ascor.acid (mg/100g)  | Fruit length (mm) | Fruit width (mm) | Fruit weight (g) |
| EC315464                   | 29.885                | 20.13             | 25.62            | 3.08             |
| EC313478                   | 32.2                  | 20                | 24.8             | 3                |
| Average                    | 31.0425               | 20.065            | 25.21            | 3.04             |
| Range                      | 29.89-32.2            | 20-20.13          | 24.8-25.62       | 3-3.08           |
| Sed $\pm$                  | 1.639522              | 0.09192388        | 0.57982756       | 0.05656854       |
| C.V                        | 5.28                  | 4.98              | 3.97             | 1.84             |

EC 251668, EC 169966, EC 267727, EC 274122, EC 274046 and EC 251661. Reynard and Kanapaux (1943) has also reported that small sized tomatoes account for high ascorbic acid content per unit of weight. The representatives of *L. esculentum* group were EC 162509, EC 251680, EC 338734, EC 163894, EC 144681, EC 164660, EC 163594, EC 338717, EC 310301 and EC 315457-1 and *L. pimpinellifolium* was represented by EC 315464 and EC 313478.

A significant difference in ascorbic acid content between *L. peruvianum* with other two species and a non significant difference between *L. esculentum* and *L. pimpinellifolium* for ascorbic acid content were recorded. Among *L. peruvianum* EC 274122 (87.5), EC 251661 (80), EC 267727 (70), EC 251668 (62.8) and EC 211582 (59.77) possessed more ascorbic acid content. EC 162508 (45), EC 144681 (40), EC 338717 (36.84), EC 31031 (35.07), EC 315457-1 (35) had more ascorbic acid content than other accessions in *L. esculentum* group. The range of ascorbic acid content recorded for *L. esculentum*, *L. peruvianum* and *L. pimpinellifolium* was 23.68-45 mg; 32.5-87.5 mg and 29.85-32.2 mg per 100 g fresh weight respectively. Variability for this attribute was more in *L. peruvianum* followed by *L. esculentum* than *L. pimpinellifolium*.

*L. esculentum* averaged the highest fruit length (37.12 mm) than other two species and the least fruit length (11.10 mm) was recorded in *L. peruvianum*. The range of fruits length for *L. esculentum*, *L. peruvianum*, *L. pimpinellifolium* was 28.68- 51.20, 8.3-13.97 and 20.13-20.00 mm respectively. Significant differences were recorded for fruit length between *L. esculentum* with *L. peruvianum* and *L. pimpinellifolium*. Among *L. esculentum* EC 310301 (51.22 mm), EC 251680 (42.235), EC 338734 (40.21), EC 164660 (40.127), EC 163594 (39.1 mm) of *L. esculentum*

got more length than other accessions. The average length of *L. pimpinellifolium* and *L. peruvianum* was 20.1 mm and 11.1 mm respectively. The variability for this attribute was less in *L. pimpinellifolium*.

Among these three species studied, *L. esculentum* recorded maximum average fruit width (39.07 mm). EC 164660 (48.13 mm), EC 163594 (47.92 mm), EC 338734 (46.794 mm), EC 163894 (40.7 mm), EC 144681 (40.01 mm), EC 310301 (35.07mm) of *L. esculentum* had more fruit width among the accessions analysed for ascorbic acid content. The average width of *L. peruvianum* and *L. pimpinellifolium* was 11.29 and 25.21 mm respectively. The range of fruit width recorded for *L. esculentum*, *L. peruvianum* and *L. pimpinellifolium* was 23.38-48.1; 8.31-14.9 and 24.8-25.624 mm respectively. The variability for this attribute was less in *L. pimpinellifolium*.

Maximum average fruit weight (25.7 g) was recorded in *L. esculentum* among these three species. The range for this attribute was 12.88 - 44.9 g; 0.22-0.886 g and 3-3.08 g in *L. esculentum*, *L. peruvianum* and *L. pimpinellifolium* respectively. EC 338734 (44.9 g), EC 163594 (40.5g), EC 164660 (40 g), EC 144681 (36 g) belongs to *L. esculentum* got more fruit weight. The variability for this attribute was also less in *L. pimpinellifolium*.

From the above results, it can be concluded that *L. peruvianum*, a non edible green fruited species averaged the highest (60.97mg/100 g of fresh weight) in comparison to other species analysed for ascorbic acid content. The average fruit length, fruit width and fruit weight of *L. esculentum* was more compared to other two species. Variability in fruit attributes were low in *L. pimpinellifolium*.

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## GENETIC DIVERGENCE IN CHICKPEA

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A wide range of genetic divergence was noted in 25 genotypes of Chickpea for six yield related traits. These strains were grouped into 7 clusters. The cultivars within a cluster showed smaller  $D^2$  values than those belonging to two different clusters. 100-seed weight and seed yield per plant were chiefly responsible for genetic divergence. Based on inter-cluster distances, crossing of cluster IV genotypes with V, VI and VII was suggested to get maximum heterotic effect in  $F_1$  and a broad spectrum of variability in the segregating generations to isolate superior individuals for yield and its components.

**Key words :** Chickpea, genetic divergence, phenotypic diversity.

Chickpea (*Cicer arietinum* L.) is one of the important pulse crop under cultivation in India since ancient times. It is one of the main source of protein and certain essential amino acids to largely vegetarian diet. Much of the area under Chickpea crop is concentrated in states of Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, Bihar, West Bengal and Maharashtra.

These regions have wide agro-climatic variations/agricultural situations. Information on the nature and degree of genetic variability present in chickpea lines would help in the understanding of evolutionary mechanism involved in intra-specific divergence and choice of desirable parents for evolving superior varieties. The present investigation was, therefore, aimed at assessing the genetic divergence among 25 strains of Chickpea using Mahalanobis  $D^2$  for future breeding programme that could lead to the isolation of desired segregants in the succeeding generations.

## MATERIALS AND METHODS

Twenty five chickpea lines of which C-235 (small seeded) and HPG-17 (bold seeded) formed recommended varieties, were evaluated in four rabi seasons w.e.f. 1991 to 1994. The experiment was laid out in RBD with two replications in the last week of October every year at the Experimental Farm of Himachal Pradesh Krishi Vishvavidyalaya, Research Sub Station, Berthin (600 m amsl). Each plot consisted of 4 rows of 4 m length with 30 cm and 10 cm spacings between and within row, respectively. Observations were recorded on ten randomly selected plants from each entry excluding the border rows in each replication for six quantitative traits viz; days to 50 per cent flowering, days to maturity, plant height (cm), pods per plant, 100-seed weight (g) and seed yield per plant (g). Mahalanobis's (1936)  $D^2$  statistic was used to assess genetic divergence on four season's pooled data. Genotypes were

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Table 1. Pedegree, disease reaction, agronomic score and source of the lines

| Sr. No. | Lines/cultivars | Disease reactions |          | Agronomic score | Source                                                                                                                        |
|---------|-----------------|-------------------|----------|-----------------|-------------------------------------------------------------------------------------------------------------------------------|
|         |                 | Ascochyta blight  | Root rot |                 |                                                                                                                               |
| 1.      | ICCX 810800     | R                 | T        | Very good       | Received from ICRISAT as developed lines for future breeding programme and evaluation as such                                 |
| 2.      | ICCX 810737     | T                 | T        | Good            |                                                                                                                               |
| 3.      | ICCX 90201      | T                 | T        | -do-            |                                                                                                                               |
| 4.      | HPG-8           | S                 | S        | -do-            | Developed from breeding material received from ICRISAT in F <sub>2</sub> generation through selection in advanced generations |
| 5.      | HPG-14          | S                 | MS       | -do-            |                                                                                                                               |
| 6.      | HPG-25          | T                 | MS       | -do-            |                                                                                                                               |
| 7.      | HPG-34          | S                 | T        | -do-            |                                                                                                                               |
| 8.      | HPG-35          | S                 | MS       | -do-            |                                                                                                                               |
| 9.      | HPG-41          | T                 | MS       | -do-            |                                                                                                                               |
| 10.     | HPG-72          | S                 | MS       | -do-            |                                                                                                                               |
| 11.     | H75-35          | S                 | T        | -do-            |                                                                                                                               |
| 12.     | H76-102         | T                 | MS       | -do-            |                                                                                                                               |
| 13.     | H86-100         | T                 | T        | -do-            |                                                                                                                               |
| 14.     | H86-21          | T                 | T        | -do-            |                                                                                                                               |
| 15.     | HPG-5           | S                 | T        | -do-            |                                                                                                                               |
| 16.     | HPG-17          | T                 | T        | -do-            |                                                                                                                               |
| 17.     | HPG-4           | S                 | S        | Very good       |                                                                                                                               |
| 18.     | HPG-27          | S                 | T        | Good            | Developed through pure line selection from HAUC-1                                                                             |
| 19.     | HPG-28          | S                 | S        | -do-            |                                                                                                                               |
| 20.     | HPG-33          | S                 | T        | -do-            |                                                                                                                               |
| 21.     | HPG-36          | S                 | MS       | -do-            |                                                                                                                               |
| 22.     | HPG-39          | T                 | T        | -do-            |                                                                                                                               |
| 23.     | HPG-40          | T                 | T        | -do-            |                                                                                                                               |
| 24.     | HPG-81          | S                 | T        | -do-            |                                                                                                                               |
| 25.     | C-235           | S                 | S        | Good            |                                                                                                                               |
|         |                 |                   |          |                 |                                                                                                                               |
|         |                 |                   |          |                 |                                                                                                                               |

R = Resistant, T = Tolerant, S = Susceptible, MS = Mildly susceptible

grouped into different clusters according to Tocher's method (Rao, 1952). Pedigree, disease reaction, agronomic score and source of the lines are appended in Table 1.

## RESULTS AND DISCUSSION

Analysis of variance revealed the presence of genetic variability for all the six traits studied. Significant values of  $X^2$  in pooled analysis ( $X^2_{144} = 1682.36$ , Wilk's criterion) showed that the lines differed among themselves. Based on  $D^2$  values of pooled data, 25 genotypes were grouped into seven clusters (Table 2). Among these,

Table 2. Clustering pattern based on  $D^2$ -statistic in chickpea

| Cluster | No. of genotypes | Genotypes                                                     |
|---------|------------------|---------------------------------------------------------------|
| I       | 2                | ICC × 810800, ICC × 810737                                    |
| II      | 9                | HPG4, HPG14, HPG25, HPG33, GPG34, HPG39, HPG4, HPG72, H76-102 |
| III     | 3                | HPG8, HPG27, ICCV 90201                                       |
| IV      | 5                | HPG17, HPG28, H75-35, H86-21, H86-100                         |
| V       | 3                | C-235, HPG38, HPG41                                           |
| VI      | 2                | HPG35, HPG81                                                  |
| VII     | 1                | HPG5                                                          |

cluster-II consisted of nine followed by cluster-IV (five), cluster III and V with three each and cluster I and VI with two genotypes. The cluster VII represented only one genotype. The inter and intra cluster distances is presented in Table 3.

A perusal of Table 3 indicates that maximum inter cluster distance was observed between cluster IV and V followed by IV and VI, IV and VII, II and V and I and V, suggesting wide diversity between these groups. Contrary to it, least inter cluster distance between VI and VII clusters indicated the close relationship. Maximum intracluster distance was observed for cluster II, followed by cluster IV depicting diversity among the lines. Cluster VII gave zero intracluster distance, since it was represented by a single genotype.

Further, it appeared that the  $D^2$  values for 248 pairs of genotypes were appreciably higher for 100-seed weight than for any other character. This fact was further substantiated by actual contribution of each character based on 300 pairs of 25 genotypes exist. 100-seed weight alone contributed 82.6 per cent and was followed by seed yield per plant by 8.3 per cent. The cluster means of genotypes for seven clusters as presented in Table 4 reveal that only 100-seed weight and seed yield per plant contributed maximum to divergence. The mean values of these characters

Table 3. Intra and inter-cluster distance (D) values in chickpea

| Character | I    | II     | III    | IV     | V       | VI      | VII     |
|-----------|------|--------|--------|--------|---------|---------|---------|
| I         | 3.42 | 206.14 | 150.98 | 558.73 | 683.19  | 322.06  | 193.55  |
| II        |      | 61.11  | 121.08 | 293.33 | 958.99  | 426.98  | 452.15  |
| III       |      |        | 8.42   | 659.43 | 454.06  | 136.81  | 168.45  |
| IV        |      |        |        | 60.28  | 2099.53 | 1256.87 | 1196.77 |
| V         |      |        |        |        | 41.156  | 155.25  | 203.87  |
| VI        |      |        |        |        |         | 55.50   | 115.19  |
| VII       |      |        |        |        |         |         | 0.00    |

varied widely in different clusters. Cluster IV was distinguished by genotypes having maximum mean values for 100 seed weight, plant height and seed yield per plant whereas, cluster V showed minimum values for 100-seed weight and plant height. The cultivars of cluster VII and II for number of pods per plant and those of clusters V and VII for days to 50 per cent flowering registered the maximum and minimum values.

**Table 4. Cluster means for different characters in chickpea**

| Character | No. of genotypes | Days to 50% flower | Days to maturity | Plant height | Pods/plant | 100-seed weight (g) | Seed yield/plant |
|-----------|------------------|--------------------|------------------|--------------|------------|---------------------|------------------|
| I         | 2                | 135.8              | 190.5            | 55.7         | 60.4       | 20.10               | 9.03             |
| II        | 9                | 139.7              | 191.5            | 65.6         | 55.4       | 21.47               | 11.54            |
| III       | 3                | 138.1              | 190.9            | 58.02        | 56.7       | 21.09               | 9.44             |
| IV        | 5                | 137.0              | 194.3            | 66.3         | 58.3       | 25.74               | 12.73            |
| V         | 3                | 139.9              | 191.6            | 53.7         | 60.1       | 13.65               | 8.83             |
| VI        | 2                | 138.0              | 195.8            | 57.87        | 55.8       | 18.45               | 10.92            |
| VII       | 1                | 122.6              | 191.2            | 56.7         | 62.5       | 15.98               | 8.05             |

The importance of genotypic diversity for selection of parents for successful hybridization programme is quite obvious. Therefore, it was observed from the present study that traits viz; seed weight and seed yield per plant, which contributed maximum to the total divergence,

should form the basis for selection of parents for hybridization among distantly placed clusters, keeping in view their yield potential to obtain a good amount of heterosis. These results are corroborative with the findings of Asawa *et al.* (1981), Singh *et al.* (1982), Jain *et al.* (1981) and Adhikari *et al.* (1983). From the above study, it is suggested that for creating maximum genetic variability, crossing among the genotypes of clusters IV and V, VI and IV, II and V; I and V would be useful. Crosses in the above combinations are expected to provide enough variability to select for high yielding segregants in the segregating generations.

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## CHARACTERIZATION OF CITRONS GROWING IN NORTH EAST INDIA USING HIERARCHICAL CLUSTER ANALYSIS

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Eight different citron biotypes collected from different parts of north east were utilised for hierarchical agglomerative cluster analysis using sixty-five morphological characters. Euclidean distance between the genotypes were measured by re-scaled reversed absolute squared Euclidean similarity coefficient matrix. The cluster analysis of the Euclidean similarity co-efficient matrix was performed by five different methods. Three clusters were formed in all the five methods utilised for dendrogram construction. The first cluster includes the genotypes Seuli (Barapani), Gondharaj (Nowgaon and Agartala collections). The genotypes Haijange (Imphal), Bira Jora (Titabor) and Jora Tenga. (Margherita) falls in the second cluster. The third cluster includes the genotypes Bira Jora (Jorhat and Teok collections). Existence of variability in the morphological characters confirms that north east India is one of the centre of origin of the citrons.

**Key words :** Citron, *Citrus medica*, cluster analysis, germplasm evaluation, numerical taxonomy, origin

The north eastern parts of India which falls under the sub- Himalayan ranges are the principal areas of citrus diversification. Citron (*Citrus medica* L.) is one of the ancient species of this region. It is monoembryonic and available in diverse forms (Scora, 1988). The citron was first introduced into the Mediterranean areas and brought under cultivation (Tolkowsky, 1938). Very little is known about the cross and self fertility in the citron. Limited observations suggest that the citron produces vigorous selfed seedlings and appears to be highly homozygous (Barret and Rhodes, 1976).

The taxonomy of citrus species are very much complicated and confusing (Swingle, 1943, Tanaka, 1954). Based on numerical taxonomy (Barret and Rhodes, 1976), isozyme analysis (Torres *et al.*, 1978), RFLP analysis (Green *et al.*, 1986) and RAPD markers (Sugawara *et al.*, 1995), it has been proposed that citron (*Citrus*

*medica* L.), Pummelo (*Citrus grandis* Osbeck) and mandarin (*Citrus reticulata* L. lanco) are the basic species of citrus. Though north east India is one of the major centre of origin for *Citrus* species, unfortunately very little attention has been given for the genetical characterization of citrus species growing in this area.

Numerical taxonomic analysis (Sneath and Sokal, 1973) utilising morphological characters can generate important information on citrus germplasm variability and can effectively be utilised alongwith the modern biochemical and molecular biological techniques.

Among the techniques available for numerical taxonomic study, hierarchical cluster analysis can readily be used to assess relatedness and distance of any type of sample characterised by any type of descriptors (Peeters and Martinelli, 1989). It may be used to assess the genetic similarity and

dissimilarity in germplasm collection and the technique could also have application for the selection of parental lines for which varying degrees of segregation are sought.

In this paper, genetic relatedness among the eight different citron biotypes utilising hierarchical agglomerative cluster analysis has been reported.

## MATERIALS AND METHODS

Eight different citron genotypes were collected from the different parts of north east India and a list of the collected genotypes are presented in the Table 1. Sixty five morphological characters (Table 2) of the tree, leaves, flowers, fruits (both external and internal characters) and seeds were studied.

Table 1. List of the collected *Citrus* germplasm

| Germplasm     | Place of Collection |
|---------------|---------------------|
| 1. Haijange   | Imphal, Manipur     |
| 2. Jora Tenga | Margherita, Assam   |
| 3. Gondharaj  | Agartala, Tripura   |
| 4. Seuli      | Barapani, Meghalaya |
| 5. Bira Jora  | Jorhat, Assam       |
| 6. Bira Jora  | Teok, Assam         |
| 7. Bira Jora  | Titabor, Assam      |
| 8. Gondharaj  | Nowgaon, Assam      |

Numerical taxonomic studies were carried out using morphological characters. Weightage of the morphological characters were given according to the recommendations of IBPGR (1988). Morphological characters and their status (weightage) used for numerical taxonomic study are given in Table 2. Hierarchical Agglomerative Cluster Analysis were performed and dendrograms were prepared. A brief account of the procedures followed are described below.

## Hierarchical Agglomerative Cluster Analysis:

It is a special class of log-linear model. If a term for the interaction of a set of variables exists, there must be lower-order terms for all possible combinations of these variables. For example, if the term A by B by C is in the model, then the terms A, B, C, A by B, A by C, and B by C must also be in the model.

For performing hierarchical cluster analysis, first Euclidean distance is measured and clusters are made by several methods using corresponding agglomeration schedule. This schedule are being prepared on the basis of Euclidean similarity or dissimilarity distance coefficient matrix. The values of Euclidean dissimilarity matrix were found to be in meaningless scales. Hence, the values were transformed using the following procedure:

- (i) Absolute values were taken for the values of the distances. (This transformation generally used when the sign indicates the direction of the relationship, but only the magnitude of the relationship is of interest).
- (ii) Dissimilarities values were changed to similarity values. (This transformation generally used to reverse the ordering of the distances by negating the values.)
- (iii) The distance values were rescaled to 0 to 1 range.

By transforming the values of the dissimilarity matrix, "Rescaled Reversed Absolute Squared Euclidean Similarity Coefficient Matrix" were prepared. Using this matrix, values the clustering analysis were performed by five methods *viz.*, average linkage (Between groups), average linkage (within group), single linkage, complete linkage and median method.

**Table 2. List of citrus characters and their weightage used for numerical taxonomic study**

**I. TREE**

- i. Tree size : 1. Small 2. Medium 3. Large
- ii. Spines : 1. Absent 2. Few 3. Many
- iii. Tree habitat : 1. Upright 2. Spreading 3. Drooping 4. Weeping
- iv. Shoot tip surface : 1. Glabrous 2. Pubescent 3. Densely pubescent
- v. Shoot tip colour : 1. Green 2. Purple

**II. LEAF**

- vi. Vegetative life cycle : 1. Evergreen 2. Semi-deciduous 3. Deciduous
- vii. Type of leaf : 1. Simple 2. Trifoliate
- viii. Leaf form : 1. Sessile 2. Brevipetiolate 3. Longipetiolate
- ix. Petiole wing : 0. Absent 3. Narrow 7. Broad
- x. Shape of petiole wing : 1. Cordiform 2. Deltoid 3. Obovate
- xi. Leaf margin : 1. Crenate 2. Dentate 3. Entire 4. Wavy
- xii. Length of spine at leaf axil (mm)
- xiii. Shape of spine : 1. Curved 2. Straight
- xiv. Leaf length (mm)
- xv. Leaf width (mm)
- xvi. Leaf shape : 1. Elliptic 2. Ovate 3. Obovate 4. Lanceolate
- xvii. Leaf apex : 1. Acute 2. Obtuse 3. Round
- xviii. Leaf colour : 1. Light green 2. Green 3. Dark green

**III. FLOWER**

- xix. Arrangement of flowers : 1. Solitary 2. In an inflorescence
- xx. Position of flowers or inflorescence : 1. Axillary 2. Terminal
- xxi. Type of inflorescence : 1. Panicle 2. Raceme 3. Cyme
- xxii. Number of flower buds per inflorescence
- xxiii. Colour of flower buds : 1. Greenish 2. White 3. Yellow 4. Purple 5. Pink
- xxiv. Length of Colour of flower buds pedicel (mm)
- xxv. Length of flower bud (mm)

- xxvi. Colour of open flowers: 1. White 2. Yellow 3. Purple

- xxvii. Length of petal (mm)

- xxviii. Width of petal (mm)

- xxix. Number of stamens

- xxx. Length of anther (mm)

**IV. FRUIT : External characters**

- xxxi. Fruit shape : 1. Spheroid 2. Ellipsoid 3. Pyriform 4. Oblique 5. Oblate 6. Ovoid-oblique 7. Ovoid

- xxxii. Fruit weight (g)

- xxxiii. Fruit height (mm)

- xxxiv. Fruit diameter (mm)

- xxxv. Shape of base of fruit : 1. Necked 2. Convex 3. Truncate 4. Concave 5. Concave collared 6. Concave with neck

- xxxvi. Shape of apex of fruit : 1. Mammiform 2. Angular 3. Convex 4. Truncate 5. Depressed

- xxxvii. Epicarp colour : 1. Green 2. Yellow 3. Orange

- xxxviii. Surface of epicarp : 1. Smooth 2. Rugose 3. Papillate 4. Pitted 5. Bumpy

**V. FRUIT : Internal characters**

- xxxix. Adherence of epicarp to mesocarp : 3. Slight 5. Moderate 7. Strong

- xL. Nature of oil glands : 1. Inconspicuous 5. Conspicuous 9. Very conspicuous

- xLi. Thickness of mesocarp (mm) :

- xLii. Colour of mesocarp : 1. White 2. Yellow

- xLiii. Number of segments per fruit

- xLiv. Adherence of segments to each other : 3. Slight 5. Moderate 7. Strong

- xLv. Toughness of skin around segments : 3. Very delicate 5. Delicate 7. Tough

- xLvi. Fruit axis : 1. Solid 2. Semi-hollow 3. Hollow

- xLvii. Cross-section of fruit axis (mm)

- xLviii. Colour of pulp : 1. Yellow 2. Orange 3. Pink 4. Red 5. Green

- xLix. Uniformity of colour of pulp : 3. Uniform 7. Streaked

- L. Texture of pulp : 3. Tender 5. Firm 7. Tough

- Li. Size of vesicles : 3. Small 7. Large

- Lii. Shape of vesicles : 3. Thin 7. Thick

- Liii. Juice in endocarp : 3. Low 5. Medium 7. High

- Liv. Colour of juice : 1. Greenish 2. White 3. Pale Yellow 4. Yellow 5. Orange 6. Reddish
- Lv. Taste of juice : 1. Very poor 3. Poor 5. Fair 7. Good 9. Excellent
- Lvi. Aroma of juice : 3. Weak 7. Strong

#### VI. SEED

- Lvii. Average number of seeds per fruit
- Lviii. Average length of seeds (mm)
- Lix. Average width of seeds (mm)
- Lx. Shape of seeds : 1. Fusiform 2. Clavate 3. Cuneiform 4. Ovoid 5. Deltoid 6. Globose 7. Semi-spheroid
- Lxi. Texture of seed surface : 1. Smooth 2. Wrinkled 3. Hairy
- Lxii. Seed colour : 1. White 2. Cream 3. Yellowish 4. Green 5. Brown
- Lxiii. Cotyledon colour : 1. White 2. Light green 3. Green
- Lxiv. Chalazal spot colour : 1. White 2. Ivory 3. Cream 4. Yellow 5. Beige 6. Brown 7. Reddish 8. Purple
- Lxv. Average number of embryos per seed

All the statistical computation were performed using a Statistical Software Package, "SPSS for MS Windows Release 6.0".

## RESULTS AND DISCUSSION

Fruit weights of the different biotypes were found to be highly variable. Bira Jora biotype of Jorhat collection showed highest fruit weight (3.5 kg), whereas for the Gondharaj biotypes of Agartala

collection it was 0.75 kg. The length and diameter of the fruits were varied from 13.5-31 cm and 8-16 cm, respectively. Citron fruits are generally characterized by large in size and of irregular shape (Swingle, 1943).

The "Rescaled Reversed Absolute Squared Euclidean Similarity Coefficient Matrix" has been presented in the Table 3. The lowest value 0.000 was observed between Gondharaj (Agartala) and Bira Jora (Jorhat) and highest value between Seuli (Barapani) and Gondharaj (Nowgaon).

Dendrogram utilizing different methods has been presented in the Fig. 1. Utilizing any of the five methods for dendrogram construction, the data can be divided into 3 different clusters. Except the average linkage (between group) method, in all the other four methods, [average linkage (within group), single linkage, complete linkage and median method], the first cluster includes Seuli (Barapani), Gondharaj (Nowgaon) and Gondharaj (Agartala) collections. Whereas Haijange (Imphal), Bira Jora (Titabor) and Jora Tenga (Margherita) falls in the second cluster. In the average linkage (within group) method, Jora Tenga (Margherita) was included in the first cluster. In all the cluster methods the composition of third cluster was found to be same. Bira Jora (Jorhat) and Bira Jora (Teok) collections fall in this cluster (Fig. 1.)

Table 3. Rescaled Reversed Absolute Squared Euclidean Similarity Coefficient Matrix of different biotypes

|                            | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8 |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|---|
| 1. Haijange (Imphal)       | 0      |        |        |        |        |        |        |   |
| 2. Jora Tenga (Margherita) | 0.9762 | 0      |        |        |        |        |        |   |
| 3. Gondharaj (Agartala)    | 0.7718 | 0.9009 | 0      |        |        |        |        |   |
| 4. Seuli (Barapani)        | 0.8827 | 0.9671 | 0.9894 | 0      |        |        |        |   |
| 5. Bira Jora (Jorhat)      | 0.6084 | 0.5257 | 0.0000 | 0.2168 | 0      |        |        |   |
| 6. Bira Jora (Teok)        | 0.8213 | 0.7459 | 0.3168 | 0.5013 | 0.9754 | 0      |        |   |
| 7. Bira Jora (Titabor)     | 0.9849 | 0.9224 | 0.6482 | 0.7859 | 0.7629 | 0.9226 | 0      |   |
| 8. Gondharaj (Nowgaon)     | 0.8787 | 0.9706 | 0.9945 | 1.0000 | 0.2094 | 0.4970 | 0.7743 | 0 |

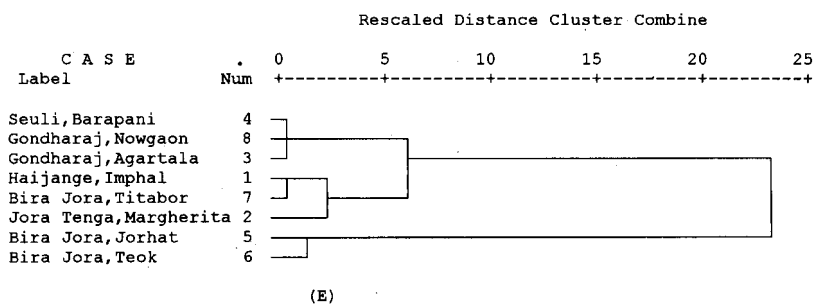
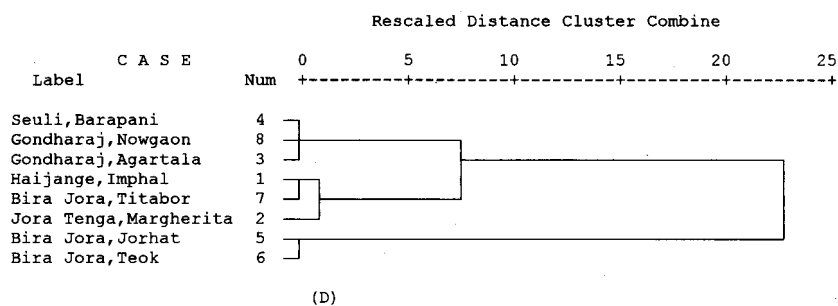
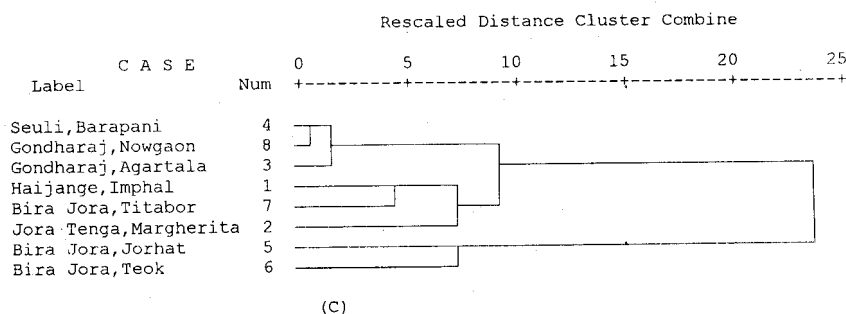
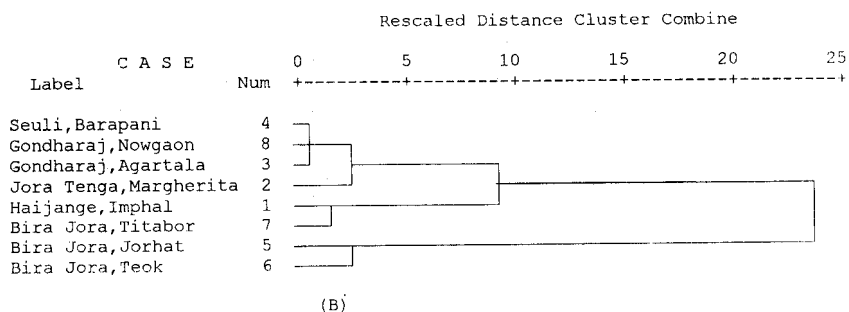
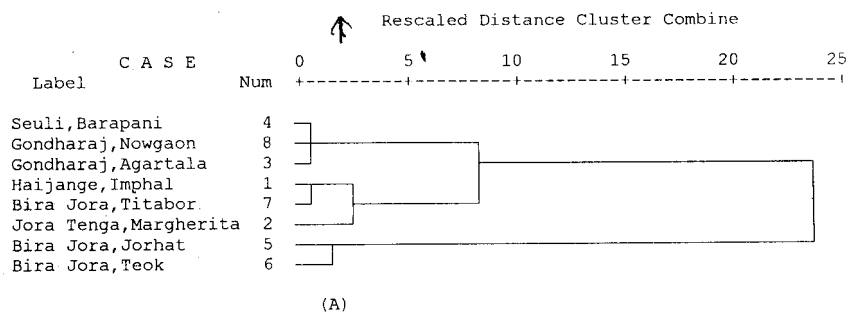


Fig. 1. Dendrogram using (A) Average linkage (between group); (B) Average linkage (within group); (C) Single linkage; (D) complete linkage and (E) Median method

Thus for the utilized procedures for cluster formation the results of the clustering information are nearly identical. Lebeda and Jendrulek (1987) also found in their analysis of host-parasite interaction, that for six of the used procedures, results were nearly identical.

The genotypes which are included into a cluster are having less variation within themselves, whereas genotypes of one cluster should have wide variation between individuals of another cluster. *C. medica* is a monoembryonic species and commonly propagated through seeds which creates free gene exchange and recombination during their sexual reproduction. But this species has maintained its unique phenotypic characters. *C. medica* was considered to be a basic species by several workers (Swingle 1943; Barret and Rhodes, 1976; Green *et al.*, 1986 and Sugawara *et al.*, 1995). The native home of this species has not been determined with certainty. The citron is commonly supposed to be indigenous to India (Scora, 1988). The present results strongly support the above view that citron is indigenous to the north-east India.

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## STATUS OF RESISTANT GERMPLASM IN EGGPLANT (*Solanum melongena* L.) AND WILD *Solanum* SPECIES

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Resistant sources reported from *Solanum melongena* L. and wild *Solanum* species, for various pests and diseases have been listed and references cited. Several agricultural universities and research institutes have collected rich diversity of eggplant landraces and other species of non-tuberiferous *Solanum*. The national germplasm collection and conservation responsibility is with the National Bureau of Plant Genetic Resources (NBPGR) and a total of 2419 accessions have been collected, conserved and evaluated for 44 agro-botanical characters at the Bureau. Scope for further identification and utilization of resistant sources has been discussed.

Key words : Aubergines, brinjal, eggplant, multiple resistance, *Solanum melongena* L., wild *Solanum*

The eggplant, also known as brinjal and aubergine, is a native of India and has been cultivated in this country since ancient times. In India, the National Bureau of Plant Genetic Resources (NBPGR) is actively involved in building up germplasm through explorations and introductions, its characterization and subsequent identification of suitable donor types for utilization by user agencies in crop improvement programmes. Further, International Plant Genetic Resources Institute, has also given top priority for collection, characterization, evaluation, documentation and conservation from South Asia.

The main objectives in eggplant breeding are to incorporate traits for good quality, resistance to diseases such as little leaf, bacterial wilt, *Fusarium* wilt and *Phomopsis* blight and pests viz., shoot and fruit borer, jassids, aphids and spotted beetles and nematodes. In this article an attempt has been made to review the work done at various research centres and the progress made in resistance breeding in eggplant and to suggest further avenues of its breeding.

### PEST AND DISEASE PROBLEMS IN EGGPLANT

In most of the tropical countries including India, eggplant is attacked by a number of insect pests, diseases and nematodes during various stages of its growth. The extent of losses caused by these pests depend on season, variety, soil and other factors (Dhamdhare *et al.*, 1995; Roy and Pande, 1995).

Shoot and fruit borer (*Leucinodes orbonalis* Guen.) infestation is the major constraint to the production of eggplant not only in the Indian sub-continent but also in South Africa, Congo and Malaysia. In India, the states in which very high yield losses have been recorded are Haryana, 63 per cent (Dhankar *et al.*, 1977), Punjab - 61 per cent (Singh and Guram, 1967), Tamil Nadu - 54 per cent (Srinivasan and Gowder, 1959), West Bengal - 50 per cent (Som Chaudhury, 1973) and Maharashtra - 48 per cent (Mote, 1981). Vitamin C in affected plants is reported

to be reduced by 60 per cent (Hami, 1995). The other insect-pests, which cause considerable losses to the eggplant crop due to attack, include the jassid *Amrasca biguttula biguttula* Ishida, the aphid *Aphis gossypii* Glover and spotted beetle *Epilachna vigintioctopunctata* Fabr. (Borah, 1995).

Among the diseases, *Phomopsis* blight, a serious disease of eggplant whose infestation as seedling blight, leaf spot and fruit rot are very common. This fungus perpetuates in soil and lives on affected host tissues, and is specific to eggplant. Once the seeds are sown or the seedlings are transplanted in the infested soil, the organism becomes active. Bacterial wilt caused by *Pseudomonas solanacearum* has become a serious problem in India and most of the commercial varieties are susceptible to this disease. Little leaf of eggplant caused by mycoplasma is another serious disease resulting in crop damage ranging from 40 to 80 per cent.

To protect eggplant from depredation of common insect-pests and from attack by different diseases and root-knot nematodes, several workers have suggested various control measures in the past. With the continuous use of chemicals for control, the targeted pests may become resistant to chemicals. Further, the present control measures are not fully effective, more over they are expensive and hazardous. Hence there is need for resistant cultivars.

### EGGPLANT GERMPLASM RESISTANT TO PESTS AND DISEASES

*Solanum melongena* L and its wild relatives are widely distributed in this sub-continent. About 22 species of non-tuberiferous *Solanum* are recorded in India (Bhaduri, 1951). A large number of workers have attempted screening of available germplasm including landraces, local cultivars and wild *Solanum* species to detect the source of

resistance against various pests and diseases. Source of resistance has been identified against major pests in the cultivated species viz., *Solanum melongena*. The major pests against which the resistance source has been identified are bacterial wilt, *Phomopsis* blight, little leaf, brinjal shoot and fruit borer, leafhoppers, spotted beetles and root-knot nematodes (Table 1).

### Multiple resistance

Although several workers have reported multiple resistance in the wild species of *Solanum*, there is not enough success in transferring resistance to *Solanum melongena* cultivars due to the incompatibility arising from the genetic make up as they belong to different species. Mukhopadhyay and Mandal (1994) described cultivars Shyama Dhepa, Kalo Dhepa, Improved Muktakeshi, Banaras Long Purple and BB-1, as having multiple resistance against all the important insect pests. Literature search revealed that some more cultivars of *S. melongena* having resistance to more than one pest (Table 2).

### Resistance source from wild *Solanum* species

A large number of workers have found that wild *Solanum* species related to eggplant possess genes for resistance to diseases and insects (Table 3). The wild species of *Solanum* have shown high degree of resistance besides immune reactions to several diseases and insects (Kale *et al.*, 1986). But these genes appear to have limited use in resistance breeding because of the difficulties in the interspecific hybridization. Sharma *et al.*, (1980) successfully crossed *S. khasianum* and *S. melongena* by embryo culture, but further studies were impossible due to failure in germination of the F<sub>2</sub> seed. Field resistance to fruit and shoot borer in the progenies derived from interspecific hybridization such as *S. incanum* × *S. melongena* (Baksh and Iqbal, 1979; Rao, 1981), *S. melongena*

× *S. indica* (Rao and Kumar, 1980) and *S. melongena* × *S. integrifolium* (Rao and Baksh, 1981) has been reported. It remains to be seen whether the resistance of wild relatives can be combined with acceptable fruit quality.

Kalada *et al.*, (1976) studied the resistance to *Phomopsis vexans* in 300 entries, including wild *Solanum* species, eggplant cultivars and interspecific F<sub>1</sub> hybrids. *S. xanthocarpum*, *S. indicum*, *S. gilo*, *S. khasianum*, *S. nigrum* and *S. sisymbirifolium* were highly resistant and 2 lines of *S. melongena* were found resistant. The reactions of F<sub>1</sub> hybrids were variable. It was further observed that resistance to *Phomopsis* blight was recessive and governed by polygenes. Dominance gene effects were more pronounced than the additive in most of the crosses (Kalada *et al.*, 1977). Decker (1951) released two cultivars by hybridization namely Florida market and Florida beauty resistant to *Phomopsis* blight. The wild eggplant *S. melongena* var. *insanum* is reported to be resistant to bacterial wilt and is highly compatible with certain cultivars of eggplant (Gopimany and George, 1979).

It was reported that Sel. 96-2, Sel. 419, Polbaigan and the wild species *S. sisymbirifolium* and *S. elaeagnifolium* are highly tolerant to *Meloidogyne* spp under field and lab conditions.

### Resistance Mechanism

Unfortunately, not much information is available on the genes involved in the resistance to eggplant pests. Identification of morphological or biochemical factors governing resistance will be helpful in the development of rapid screening technique.

Resistance may be due to antixenosis or non-preference, and appears to have a biochemical basis in the case of insect pest complex, although non-preference for some cultivars has been attributed to histological factors such as compact vascular bundles in a thick layer, with dignified

cells and less area of pith in the shoots (Panda *et al.*, 1971; Chellaiah and Srinivasan, 1983). Similarly, hardness of fruit skin and flesh due to a compact seed arrangement (Srinivasan and Basheer, 1961; Krishnaiah and Vijay, 1975; Mishra *et al.*, 1988), tight calyx to hinder initial larval entry into fruits (Panda *et al.*, 1971; Chellaiah and Srinivasan, 1983; Malik *et al.*, 1986), contribute to the non-preference for cultivars. Singh and Chadha (1991) attributed the resistance in SM-17-4, PBr-129-5 and Punjab SM202×PPI (F<sub>1</sub>) were fairly resistant. Medium and long fruited, KT-4, Largew Round White and Long White Cluster were graded as tolerant. According to Pradhan (1966) long narrow fruited eggplant varieties were less infested than spherical fruited. Preference for egg laying was low in resistant varieties than susceptible ones, which may be one of the mechanisms of resistance. Larvae bore more successfully in round fruits than long fruits.

Resistance to jassid reported by earlier workers was due to more density and length of the hair on the leaves (Canden and Balatezar, 1947). Gaikwad *et al.*, (1991) attributed resistance to jassid to leaf and midrib thickness and leaf area in eggplant.

Antibiosis as a basis for resistance in case of shoot and fruit borer was reported by Panda and Das (1975), who found that higher silica and crude fiber content in the shoots of resistant cultivars adversely affected the survival, growth, pupal period, sex ratio and fecundity. The higher content of sugars and amino acids acted as feeding stimulants in susceptible cultivars. Similarly, Ishaque and Chaudhuri (1984) observed a low protein and sugar contents in resistant genotypes. Panda and Das (1975) suggested that resistance in Thorn Pendy and Black Pendy was due to combined effect of antixenosis and antibiosis. As a result of high silica and crude fiber in the shoots, the larvae found difficulty in feeding. The insect also disliked feeding on them due to their

Table 1. Sources of resistant germplasm from eggplant cultivars against various pests and diseases

| Pest/Disease                                                | Source of resistance                                                                                                                                                                                                                                                                                                                                                                                           | Reference                         |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Bacterial wilt<br>( <i>Pseudomonas solanacearum</i> )       | WCGR 112-8 (resistant)                                                                                                                                                                                                                                                                                                                                                                                         | Gopinath & Madalageri (1986)      |
|                                                             | Dingra's Multiple Purple, Sinampiro, Pusa Purple Cluster (resistant)                                                                                                                                                                                                                                                                                                                                           | Rao <i>et al.</i> , (1976)        |
|                                                             | Pusa Purple Cluster (PPC), (resistant)                                                                                                                                                                                                                                                                                                                                                                         | Mukherjee & Mukhopadhyay (1982)   |
|                                                             | BB-11, BB-7 (resistant)                                                                                                                                                                                                                                                                                                                                                                                        | Sharma & Kumar (1995)             |
|                                                             | BWR-34, PPC (resistant)                                                                                                                                                                                                                                                                                                                                                                                        | Bora <i>et al.</i> (1993)         |
|                                                             | BWR-54, PPC (immune)                                                                                                                                                                                                                                                                                                                                                                                           | Baleswar Singh (1991)             |
| Phomopsis blight<br>( <i>Phomopsis vexans</i> )             | 11a, 264 & 238 (highly resistant)                                                                                                                                                                                                                                                                                                                                                                              | Kalada <i>et al.</i> (1976)       |
| Little leaf (Mycoplasma)                                    | PPC (resistant)                                                                                                                                                                                                                                                                                                                                                                                                | Kale <i>et al.</i> (1986)         |
|                                                             | Nurki, Bowad Local No.4, Chikalgaon Loal No.1, PPC (resistant)                                                                                                                                                                                                                                                                                                                                                 | Chakrabarty & Chaudhury (1974)    |
|                                                             | Hisar Shyamal & H-10 (tolerant)                                                                                                                                                                                                                                                                                                                                                                                | Kaloo (1994)                      |
|                                                             | Sel.212-1, Sel.252-2-1 (resistant)                                                                                                                                                                                                                                                                                                                                                                             | Chakrabarty & Chaudhury (1975)    |
|                                                             | SM-78 × SM-79, SM-78 × S-745 SM-77 × SM-60, SM-75 × SM-74 SM-75 × SM-60 (F <sub>2</sub> generations of these crosses found resistant)                                                                                                                                                                                                                                                                          | Ponnuswami & Irulappan (1993)     |
| Root-knot Nematodes                                         |                                                                                                                                                                                                                                                                                                                                                                                                                |                                   |
| <i>M. incognita</i> race 1 & 2                              | Gulla (resistant)                                                                                                                                                                                                                                                                                                                                                                                              | Ravichandra <i>et al.</i> (1990)  |
| All root-knots                                              | Black Beauty, T-2 (UP), Vijaya, Banaras Giant (resistant)                                                                                                                                                                                                                                                                                                                                                      | Nandwana <i>et al.</i> (1980)     |
| Shoot & Fruit borer<br>( <i>Leucinodes arbonalis</i> Guen.) | Banaras Giant, S-34, Arka Kusumakar, SM-215, S-258, SM-62, P-5-8, SM-2, S-2070<br>Malkapuri, Shirur Khandala-1, Khanpur, rajangona, songona Kagal (moderately resistant)<br>Tambalwadi Local, Gopuri, Pusa Purple Round, Jalagaon Local, Hingana Dorla, Baramati, Punjab Bahar, Junagadh Bhattu (highly resistant to shoot infestations cvs), Nurki, PPC, Gulabi Dorla (highly resistant to fruit infestation) | Pawar <i>et al.</i> (1986)        |
|                                                             | Arka Kusumakar, Nischintapur, Brinjal Long Green, Attapati, Arka Shirish, Manipur, Makra and Chikon Long (relatively resistant)                                                                                                                                                                                                                                                                                | Gangopadhyay <i>et al.</i> (1996) |
|                                                             | Pusa Purple Long, H-128, H-129                                                                                                                                                                                                                                                                                                                                                                                 | Gill & Chadha (1979)              |
|                                                             | Aushey (tolerant)                                                                                                                                                                                                                                                                                                                                                                                              | Dhankar <i>et al.</i> (1977)      |
|                                                             | Thorn Pendy, Black Pendy H-165, H-407 (tolerant)                                                                                                                                                                                                                                                                                                                                                               | Panda <i>et al.</i> (1971)        |
|                                                             | Ex Beckwai, IHR-191 (tolerant)                                                                                                                                                                                                                                                                                                                                                                                 | Krishnaiah & Vijay (1975)         |
|                                                             | SM-202, S-519, S-520, S-521, Solan-11, PPC-2 (tolerant)                                                                                                                                                                                                                                                                                                                                                        | Lal <i>et al.</i> (1976)          |
|                                                             | S-4, H-4, Punjab chamkila, PPC (tolerant)                                                                                                                                                                                                                                                                                                                                                                      | Gill & Chadha (1979)              |

Table 1. Contd.

| Pest/Disease                                              | Source of resistance                                                                                                                                                              | Reference                        |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Leaf hoppers ( <i>Amrasca biguttula biguttula</i> Ishida) | SM-17-4, PBR-129-5, Punjab Barsati (tolerant)                                                                                                                                     | Singh & Chadha (1991)            |
|                                                           | Nischchintapur Local, Muktajhuri, Shymala Dhepa, Navkiran, Banaras Long Purple, BB-1, Murshidabad Local (tolerant)                                                                | Mukhopadhyay & Mandal (1994)     |
|                                                           | Long Purple (tolerant)                                                                                                                                                            | Meheto & Lal (1981)              |
|                                                           | Nimbkar Green, Arka Kusumakar, SM-213 (tolerant)                                                                                                                                  | Mote (1981)                      |
|                                                           | Ringan Giant, PPC, SM-62 (tolerant)                                                                                                                                               | Nathani (1983)                   |
|                                                           | Kuchia                                                                                                                                                                            | Ishaq & Chaudhuri (1984)         |
|                                                           | Singnath                                                                                                                                                                          | Kabir <i>et al.</i> (1984)       |
|                                                           | IC-089864A and IC-144524                                                                                                                                                          | Sarath Babu <i>et al.</i> (1997) |
|                                                           | H- 4, Round Green, Dorly, Aushey, Jumblimulayam (resistant)                                                                                                                       | Mote (1978)                      |
|                                                           | Junagarh Sel.1, Aushey, R-34, H-4, T-3 (resistant)                                                                                                                                | Bindra & Mahal (1981)            |
| Aphids ( <i>Aphis gossypii</i> Glover)                    | S-188-2, S-258, S-34, PPC, Manjri Gota, Dorli, Mukti Borgona-1, Local Khandesh, Khedshivpur (moderately resistant)                                                                | Pawar <i>et al.</i> (1986)       |
|                                                           | Pusa Kranti (tolerant)                                                                                                                                                            | Mote, (1982)                     |
|                                                           | Sufal, Navkiran, ARM- 3, Krishna, Brinjal Long Green, Suttons Long (tolerant), KB- 9, PPR, PPL, Banaras Giant, L-13, KB-5, Navkiran, BB-1, KB-10, Improved Muktakheshi (tolerant) | Mukhopadhyay & Mandal (1994)     |
| Spotted beetles ( <i>Epilachna</i> spp.)                  | Arka Shirish, Hisar Sel. 1-4 Shankar Vijay (resistant cvs)                                                                                                                        |                                  |
|                                                           | Shyamala Bhangar                                                                                                                                                                  | Mukhopadhyay & Mandal (1994)     |

low sugar and amino acid content. Due to the adverse affect on the pest life cycle, infestation of these genotypes started late and remained at a low level. Bajaj *et al.*, (1989) reported that the variety SM-17-4 which is relatively field resistant to shoot and fruit borer had higher glycoalkaloid content, peroxidase and polyphenol oxidase activity than the susceptible Punjab Chamkila. It is suggested that glycoalkaloids in association with phenolic compounds may be conferring resistance to eggplant against the pest. Similar results were obtained by Darekar *et al.* (1991). Gaikwad *et*

*al.* (1991) reported that total level of sugars, free amino acids and polyphenols in the leaves of eggplant were negatively correlated to jassid infestation.

It has been observed that resistance to *Phomopsis* blight was recessive and genetically inherited. Dominance gene effects are more pronounced than additive in most of the crosses studied. Also they indicated that the resistance to bacterial wilt was controlled by single dominant gene. Chadha (1988) reported that *Solanum torvum* was resistant to root knot nematodes. It was used

as a rootstock for tongue grafting in a number of chosen cultivars of eggplant. The grafted hybrids behave as perennials and yield 3 to 4 times more.

**Table 2. Available cultivars with multiple resistance**

| Cultivars                                                                     | Resistance Available Against                                |
|-------------------------------------------------------------------------------|-------------------------------------------------------------|
| Pusa Purple Cluster                                                           | Bacterial wilt, Little leaf and Shoot and fruit borer       |
| Pusa Kranti                                                                   | Leaf hopper and Bacterial wilt                              |
| Sm-17-4                                                                       | Shoot and fruit borer and Little leaf                       |
| Pusa Purple Long, S-34, S-258, Aushey and H-4                                 | Leaf hopper and Shoot and fruit borer                       |
| Shyama Dhepa, Kalo Dhepa, Improved Mukthakheshi, Banaras Long Purple and BB-1 | Shoot and fruit borer, Leaf hopper and Aphids               |
| Vijaya and Black Beauty                                                       | All species of <i>Meloidogyne</i>                           |
| Banaras Giant                                                                 | Shoot and fruit borer and all species of <i>Meloidogyne</i> |

### SCOPE FOR FURTHER UTILIZATION OF RESISTANCE SOURCES

During the last three decades, work on eggplant collection from within the country and introduction from abroad has been in progress at the NBPGR, New Delhi. Extensive collections have been made under NBPGR/IPGRI collaborative project from all parts of India and parts of neighbouring countries like Bangladesh, Sri Lanka and Nepal. As a result about 2531 germplasm accessions of *S. melongena* and about 337 accessions of related wild species have been assembled and these germplasm have been characterized in phased manner at NBPGR. Information on 1188 accessions characterized for 52 agro-botanic descriptors has been documented in the form of catalogue at NBPGR.

**Table 3. Source of resistant germplasm from wild eggplant relatives**

| Pest                        | Sources of resistance                                                                                               | Reference                      |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------|
| Bacterial wilt              | <i>Solanum melongena</i> var. <i>insanum</i> (resistant & highly compatible with certain cvs)                       | Gopimany & George (1979)       |
| Phomopsis blight            | <i>S. xanthocarpum</i> , <i>S. i. s. gilo</i> , <i>S. khasianum</i> , <i>S. nigrum</i> <i>S. torvum</i> (resistant) | Kalada <i>et al.</i> , (1976)  |
| Little leaf                 | <i>S. viarum</i> (immune), <i>S. indicum</i> & <i>S. sisymbirifolium</i> (resistant)                                | Chakrabarty & Choudhury (1974) |
|                             | <i>S. integrifolium</i> , <i>S. gilo</i> (resistant)                                                                | Chakrabarty & Chaudhury (1975) |
|                             | <i>S. viarum</i> (immune)                                                                                           | Kale <i>et al.</i> , (1986)    |
| <i>Meloidogyne javanica</i> | <i>S. torvum</i> , <i>S. macrocarpum</i> , <i>S. sisymbirifolium</i> , <i>S. warscewiczii</i> (resistant)           |                                |
| <i>M. incognita</i>         | <i>S. khasianum</i> , <i>S. torvum</i> , <i>S. toxicarium</i> (immune)                                              | Ali <i>et al.</i> , (1992)     |
|                             | <i>S. torvum</i> , <i>S. seaforthianum</i> (resistant)                                                              | Shetty & Reddy (1985)          |
|                             | <i>S. torvum</i> , <i>S. macrocarpum</i> , <i>S. sisymbirifolium</i> , <i>S. warscewiczii</i> (resistant)           | Vito <i>et al.</i> , (1992)    |
| <i>M. arenaria</i>          | <i>S. sisymbirifolium</i> , <i>S. torvum</i> (resistant)                                                            | Vito <i>et al.</i> , (1992)    |
| All root-knots              | <i>S. torvum</i> (resistant)                                                                                        | Chadha (1988)                  |
|                             | <i>S. sisymbirifolium</i> , <i>S. elaeagnifolium</i> (resistant)                                                    | Verma & Chaudhury (1974)       |
| Shoot & Fruit borer         | <i>S. incanum</i> , <i>S. xanthocarpum</i> , <i>S. khasianum</i> , <i>S. sisymbirifolium</i> (immune)               | Kale <i>et al.</i> , (1986)    |

|                                                                                                                                               |                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| <i>S.symbirifolium</i> ,<br><i>S.khasianum</i><br><i>S.xanthocarpum</i> ,<br><i>S.nigrum</i> (resistant)                                      | Lal <i>et al.</i> , (1976)            |
| <i>S. incanum</i> ,<br><i>S.khasianum</i> ,<br><i>S.macranthum</i> ,<br><i>S.mammosum</i><br>(resistant)                                      | Baksh & Iqbal<br>(1979)               |
| <i>S.macrocarpon</i><br>(resistant)                                                                                                           | Gangopadhyay <i>et al.</i> , (1996)   |
| <i>S.surattense</i> ,<br><i>S.sisymbirifolium</i> ,<br><i>S.indicum</i> ,<br><i>S.viarum</i> . <i>S.aculeatissim</i><br><i>um</i> (resistant) | Sarath Babu <i>et al.</i> ,<br>(1997) |

**Table 4. Potential eggplant morphological character and the number of corresponding germplasm available at NBPGR for use in the resistance breeding**

| Character                                | Number of Accessions available |
|------------------------------------------|--------------------------------|
| Stem spininess                           | 14                             |
| Petiole spininess                        | 5                              |
| Leaf spininess                           | 80                             |
| Long fruited (more than 35 cm long)      | 14                             |
| Fruit calyx prickles (many)              | 2                              |
| Fruit pedicle prickles                   | 3                              |
| Very many seeds/fruit (tightly arranged) | 8                              |
| Number of fruits/cluster (more than 4)   | 14                             |
| Number of clusters/plant                 | 18                             |

Review of resistance indicates that information in sources and mechanism of resistance is available only for insects pests and that too for shoot and fruit borer and leafhoppers. A number of morphological characters have been identified that have a direct or indirect bearing on pest resistance in eggplant Table 4 lists these characters and their pest resistance. The number of accessions in the NBPGR germplasm collection having other features are also indicated in the table.

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## GENETIC DIVERSITY OF SALT-TOLERANT INDIGENOUS RICE GERMPLASM OF WEST BENGAL

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Genetic diversity of indigenous West Bengal salt-tolerant rices was made on yield and seven other yield attributes. Eighteen rice varieties, selected on salinity tolerance character, could be grouped into four clusters. The observations show that two Chinsura-Boro rice varieties may be of distant origin or have diverged at two rice research stations of W. Bengal. Two Patnai rice varieties, P 23 and P298, collected from CRRS, are distantly placed.

**Key words:** Rice, *Oryza sativa*, clustering, genetic diversity, salt tolerance

The final goal of rice breeding programme is to develop hybrids having stress tolerance and out-yielding the existing yield potential (hybrid vigour). To harness better recombinants, breeders choose genetically diverse parents. The variability and reliability of divergence, therefore, lies in the parents showing heterotic relationship with degree of divergence. Statistical distance of the parents represents the index of genetic diversity. Members grouped in a cluster would be least diverse and they could be utilized to develop a population. In general, indigenous rice germplasm possess high adaptability, because they were built up on agro ecological niches. Intermating of these varieties would give desirable recombinants with mixed characters. An attempt was, therefore, made to study the genetic diversity of indigenous rice germplasm, using multivariate statistical technique based on yield and seven yield-attributes.

The aim of the study is to note clustering, and probable inter-mixing, of these rice varieties,

at two research station fields, namely Chinsura Rice Research Station (CRRS), Chinsura and Central Soil Salinity Research Institute (CSSRI), Canning Centre, West Bengal. Clustering of indigenous rice, which would be obtained from this analysis, based on genetic divergence, may provide a basis for selecting parents for heterotic combination. To our knowledge, in last few decades, no such report was published on these germplasm.

### MATERIALS AND METHODS

Eighteen genotypes of rice were collected from the CSSRI at Canning and from the CRRS at Chinsura. The genotypes were planted in a randomized block design with two replications. Thirty days old seedlings were used for transplantation in the month of July, at 5m × 3m plot for each cultivar, and normal cultural practices were followed. The experiments were conducted for two consecutive years. The following observations were recorded for ten randomly

selected plants in each replication, except for the border plants.

**Table 1. Rice cultivars with their accessions**

| Rice cultivars | Accession No. | Rice cultivars | Accession No. |
|----------------|---------------|----------------|---------------|
| Nigra          | C05           | FR13A          | IR-FR13       |
| Patnai23       | C07           | Rupsail        | CAC 56        |
| Patnai298      | C09           | Latisail       | CAC174        |
| CBII           | C11           | Kalma 222      | CAC243        |
| Tilakachari    | C31           | Damodar        | CAC334        |
| NC1281         | C49           | CBI            | CAC396        |
| OC1393         | C51           | Pokkali        | CAC652        |
| Hamilton       | C52           | Bhasamanik     | CAC667        |
| Matla          | C55           | SR26B          | CAC676        |

IR-FR means International Rice Research Institute's (Philippines) accession,

CAC means Central Soil Salinity Research Institute's (Canning, W. Bengal) accession;

C means Chinsura Rice Research Station's (Hoogly, W. Bengal) accession.

## RESULTS AND DISCUSSION

The agro-morphological characters used for this study are: plant height (cm), number of panicle per plant, thousand seed weight (g), yield (tons/ha), grains per panicle, 50% flowering or heading date (D) and duration (D). Canonical analyses were done according to the method of Anderson (1958) (Table 3). Study of analysis of variance (ANOVA) shows distances in indigenous rice genotypes for 8 characters. Mean characters were found to be significant and represented by double asterisk in the table. The ANOVA calculation was made on the following model:  $Y_{ij} = m + g_i + r_j + e_{ij}$ , where  $Y_{ij}$  = phenotypic observation in  $i^{th}$  genotype and  $j^{th}$  replication;  $m$  = general mean;  $g_i$  = effect of  $i^{th}$  genotype;  $r_j$  = effect of  $j^{th}$  replication;  $e_{ij}$  = random error associated with  $i^{th}$  genotype and  $j^{th}$  replication. Differences between genotypes for different

**Table 2. Values of physiological characters of indigenous salt-tolerant rice varieties of West Bengal**

| Var. Acs. | 50% F1<br>Period (D) | Duration<br>(D) | Panicle no. | Inflores.<br>length (cm) | Height (cm) | Grains/1000 seeds wt(g) |      | Yield (q/ha) |
|-----------|----------------------|-----------------|-------------|--------------------------|-------------|-------------------------|------|--------------|
| CAC396    | 100                  | 143             | 21          | 19                       | 83          | 103                     | 21   | 26           |
| C11       | 100                  | 143             | 17          | 19                       | 83          | 95                      | 25   | 24           |
| CAC667    | 98                   | 128             | 14          | 22                       | 124         | 126                     | 19.4 | 30           |
| CAC174    | 94                   | 125             | 12          | 25                       | 117         | 103                     | 26   | 28           |
| CAC243    | 98                   | 128             | 7           | 26                       | 122         | 97                      | 28   | 28           |
| C07       | 98                   | 128             | 8           | 26                       | 139         | 117                     | 32   | 31           |
| CAC676    | 83                   | 101             | 8           | 26                       | 124         | 87                      | 26   | 34.9         |
| C09       | 82                   | 128             | 8           | 26                       | 139         | 117                     | 32   | 31           |
| C31       | 112                  | 157             | 7           | 26                       | 137         | 119                     | 20   | 25           |
| IR-FR13   | 103                  | 143             | 8           | 23                       | 126         | 152                     | 25   | 24           |
| CAC56     | 100                  | 130             | 11          | 27                       | 142         | 163                     | 17   | 25           |
| C49       | 112                  | 148             | 10          | 28                       | 147         | 230                     | 23.6 | 38           |
| C51       | 112                  | 148             | 13          | 31                       | 165         | 137                     | 29   | 35           |
| C05       | 118                  | 168             | 12          | 31                       | 146         | 134                     | 27   | 34.6         |
| CAC652    | 82                   | 100             | 8           | 29                       | 159         | 102                     | 25   | 16.6         |
| CAC334    | 82                   | 100             | 9           | 30                       | 113         | 73                      | 22   | 17           |
| C 52      | 88                   | 104             | 10          | 30                       | 110         | 80                      | 31   | 21.1         |
| C 55      | 88                   | 104             | 10          | 30                       | 120         | 85                      | 23   | 21           |

characters were tested for significance using ANOVA. It is shown here that eight physiological characters are significant according to the variance ratio value.

**Table 3. Analysis of Variance of 18 indigenous rice genotypes**

| Physiol Characters         | Source of variation | Total sum of squares (TSS) | Mean sum of squares (MSS) | Variance ratio (F) |
|----------------------------|---------------------|----------------------------|---------------------------|--------------------|
| Fl. Period                 | Replication         | 266.78                     | 33.39                     | 162.612**          |
|                            | Variety             | 6720.833                   | 95.343                    | 481.953**          |
|                            | Error               | 27.89                      | 0.8203                    |                    |
| Duration                   | Replication         | 130.26                     | 65.13                     | 42.799**           |
|                            | Variety             | 21873.70                   | 1286.699                  | 845.524**          |
|                            | Error               | 51.74                      | 1.5218                    |                    |
| Panicle no.                | Replication         | 13.48                      | 6.741                     | 193.373**          |
|                            | Variety             | 698.535                    | 41.090                    | 1064.850**         |
|                            | Error               | 1.185                      | 0.03486                   |                    |
| Infl. Length (cm)          | Replication         | 26.926                     | 13.463                    | 190.171*           |
|                            | Variety             | 678.815                    | 39.930                    | 564.034**          |
|                            | Error               | 2.407                      | 0.0708                    |                    |
| Height (cm)                | Replication         | 26.93                      | 13.495                    | 190.754**          |
|                            | Variety             | 25221.70                   | 1483.63                   | 21018.102**        |
|                            | Error               | 2.40                       | 0.0706                    |                    |
| Grains/ panicle            | Replication         | 69.59                      | 34.795                    | 24.104**           |
|                            | Variety             | 69382.81                   | 4081.342                  | 2827.335**         |
|                            | Error               | 49.08                      | 1.4435                    |                    |
| Thousand Grains weight (g) | Replication         | 29.16                      | 14.58                     | 246.627**          |
|                            | Variety             | 940.695                    | 55.335                    | 936.016**          |
|                            | Error               | 2.01                       | 0.0591                    |                    |
| Yield (q/ha)               | Replication         | 0.096089                   | 0.048                     | 33.860**           |
|                            | Variety             | 19.654                     | 1.156                     | 814.785**          |
|                            | Error               | 0.0482                     | 0.0014                    |                    |

\*\*Means characters are significant; Degree of Freedom (DF) for replication, variety and error are 2,17,34 respectively.

The genetic divergence of 18 rice cultivars was studied by means of Mahalanobis  $D^2$  technique (1936). Uncorrelated functions of the original values were obtained by transforming the original correlated non-standardized character-mean by the pivotal condensation method described by Rao (1952). The differences between the varieties for physiological character set, taken together, were tested by Wilk's criteria (1932). After testing the feasibility of characters, a computer-assisted  $D^2$  statistic was used for assessing the genetic divergence between populations. One thousand divergence values were computed for 18 rice local genotypes and their  $D^2$  statistic are shown in table 4.

Possible physiological character values, of 18 indigenous rice cultivars, were calculated utilising uncorrelated varietal means, with respect to yield and its seven attributes, namely, 50% flowering period, duration, panicle number, inflorescence length, height, grains/panicle, 1000 grains weight, yield in q/ha (Rao, 1952). The rice germplasm selected for this study are salinity tolerant, though their tolerance levels are not the same. For example, cv. Pokkali, SR26B, Matla, Hamilton, Damodar could tolerate high level of salinity; Patnai 23, Patnai 298, Latisail, Rupsail, CBI, CBII, Bhasamanik, Tilakachari could tolerate medium level of salinity, and, remaining five rice cultivars can withstand salinity for a short duration or mild salinity. The clustering analysis could substantiate their adaptability to saline soil (vide table 5).

Based on these calculations, a clustering analysis was done for these rice germplasm (Table 5). It shows four groups. This clustering agrees to a large extent to the clustering made by molecular (DNA) and protein markers (data not shown here) (Das, 1997; Prasad, 1998). The salt-tolerant rice cultivars could be grouped into

Table 4. Genetic divergence ( $D^2$ ) values for 18 rice genotypes

| GENOTYPES |   |     |      |      |      |       |      |      |      |      |      |      |      |       |       |       |      |      |
|-----------|---|-----|------|------|------|-------|------|------|------|------|------|------|------|-------|-------|-------|------|------|
|           | 1 | 2   | 3    | 4    | 5    | 6     | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14    | 15    | 16    | 17   | 18   |
| 1         | 0 | 1.3 | 56.3 | 36.7 | 46.7 | 100.2 | 57.3 | 98.4 | 88.9 | 52.1 | 0.7  | 12.0 | 23.2 | 12.4  | 4.2   | 0.6   | 1.3  | 1.6  |
| 2         |   | 0   | 62   | 39.5 | 47.5 | 104.4 | 60.3 | 103  | 91.8 | 55   | 118  | 130  | 243  | 131.5 | 213.8 | 2.6   | 26.8 | 49.0 |
| 3         |   |     | 0    | 3.9  | 5.7  | 8.9   | 5.1  | 8.5  | 9.2  | 3.3  | 10.0 | 19.2 | 64.4 | 17.8  | 50.6  | 11.5  | 14.7 | 4.8  |
| 4         |   |     |      | 0    | 1.6  | 16.0  | 4.2  | 15.6 | 14.9 | 4.0  | 23.9 | 35.0 | 14.9 | 29.8  | 71.4  | 3.2   | 3.8  | 1.7  |
| 5         |   |     |      |      | 0    | 12.4  | 3.7  | 12.9 | 10.6 | 4.2  | 23.9 | 37.3 | 83.5 | 26.7  | 64.1  | 4.4   | 5.8  | 2.3  |
| 6         |   |     |      |      |      | 0     | 10.7 | 0.7  | 5.7  | 11.4 | 6.8  | 16.9 | 33.4 | 5.8   | 23.1  | 26.8  | 30.9 | 13.9 |
| 7         |   |     |      |      |      |       | 0    | 9.7  | 15.9 | 7.6  | 20.4 | 29.0 | 77.1 | 27.0  | 59.3  | 9.2   | 10.9 | 4.8  |
| 8         |   |     |      |      |      |       |      | 0    | 8.5  | 10.7 | 6.5  | 14.0 | 36.6 | 8.4   | 25.6  | 26.7  | 29.8 | 14.2 |
| 9         |   |     |      |      |      |       |      |      | 0    | 10.3 | 10.6 | 29.2 | 43.6 | 7.9   | 30.2  | 21.9  | 28.4 | 12.1 |
| 10        |   |     |      |      |      |       |      |      |      | 0    | 14.6 | 22.2 | 76.4 | 24.1  | 58.9  | 10.3  | 12.3 | 6.1  |
| 11        |   |     |      |      |      |       |      |      |      |      | 0    | 7.4  | 30.3 | 7.9   | 21.3  | 36.2  | 42.9 | 21.0 |
| 12        |   |     |      |      |      |       |      |      |      |      |      | 0    | 43.3 | 21.7  | 39.6  | 53.4  | 56.5 | 36.6 |
| 13        |   |     |      |      |      |       |      |      |      |      |      |      | 0    | 17.8  | 6.3   | 110.6 | 19.8 | 80.9 |
| 14        |   |     |      |      |      |       |      |      |      |      |      |      |      | 0     | 15.4  | 43.2  | 48.7 | 25.9 |
| 15        |   |     |      |      |      |       |      |      |      |      |      |      |      |       | 0     | 85.3  | 96.3 | 60.7 |
| 16        |   |     |      |      |      |       |      |      |      |      |      |      |      |       |       | 0     | 1.6  | 2.4  |
| 17        |   |     |      |      |      |       |      |      |      |      |      |      |      |       |       |       | 0    | 4.9  |
| 18        |   |     |      |      |      |       |      |      |      |      |      |      |      |       |       |       |      | 0    |

The number designates the rice accessions in the following manner :

1 = CAC396; 2 = C11; 3 = CAC667; 4 = CAC 174; 5 = CAC243; 6 = C07; 7 = CAC676; 8 = C09; 9 = C31; 10 = IR-FR; 11 = CAC56; 12 = C49; 13 = C51; 14 = C05; 15 = CAC652; 16 = CAC334; 17 = C52; 18 = C55

4 inter-variety clusters, when clusters, computed in relation to Matla, a CSSRI rice accession (Table 5).

Table 5. Group clustering of 18 indigenous rice cultivars with respect to cultivar Matla

| Group I        | Group II     | Group III | Group IV    |
|----------------|--------------|-----------|-------------|
| C55, CAC174    | C52, IR-FR13 | C05, C07  | C11, C49    |
| CAC243, CAC334 | CAC667       | C09, C31  | C51, CAC652 |
| CAC576         |              | CAC56     | CAC396      |

This grouping shows interesting observations, *viz.*, new and old Chinsura collections, mentioned herein as NC1281 and OC1393, form a cluster with Pokkali, Chinsura Boro (CB) I and II.

Similarly, Tilakachari could be grouped with Rupsail, Nigra, Patnai 23 and Patnai 298, and Bhasamanik, another Chinsura collection was grouped with FR13A and CSSRI Hamilton. On the other hand, cv Matla was grouped with indigenous non-familiar cultivars like Kalma, Damodar and the popular rice SR26B. However, these associations became insignificant when ten traits of 18 rice cultivars were analyzed statistically. The following observations were noticed: Chinsura Boro rices (CBI and CBII) are not very close ( $D$  value 9.5); they are almost equidistant with SR26B ( $D$  value 10.7). It is possible that two CB rice varieties had diverged during years of maintenance at two rice-research stations at W. Bengal. Our molecular biology studies (Prasad 1998) also

supported this observation in that these two West Bengal rice accessions have distinct DNA patterns. From D2 analysis CBII is very close to the FR13A (D value 0.7), and this divergence value is lowest in our analysis (table 4). (ii) Similarly, other two Chinsura collections, Patnai rice (P23 and P298), were found to have distant genotypes (D value 85.3). Here also, P298 is more close to latisail (D value 1.6), Rupsail (D value 2.4) and NC1281 (D value 3.2). Close relative of P23 is Hamilton (D value 6.3) and most distant relatives of this rice variety are Bhasamanik (D value 206) and Matla (D value 213). These values are the maximum D2 values observed for indigenous rice varieties (iii) close relative of NC1281 is not OC1393 (D value 3.9) but is Rupsail (D value 1.7) and, as mentioned above P. 298 (iv) close relatives of cv. Tilakachari are NC1281 (D value 1.6) and Rupsail (D value 2.3). From table 4 many such conclusions could be made which were supported by our molecular biology studies (Das 1997; Prasad, 1998).

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## EXPLOITATION OF SUNFLOWER GERMPLASM FOR DEVELOPING NEW POPULATIONS AND HYBRIDS

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The genetic resources activities have been initiated at the Project Co-ordinating Unit, Bangalore through NBPGR to conserve and supply germplasm to the breeders in the country. Currently around 2000 accessions are conserved in the project. These include open pollinated populations, inbred lines, CMS lines, restorer lines, wild types/species and cytoplasm sources for male sterility. Characterization and evaluation of germplasm accessions has been done in a phased manner. Germplasm accessions of economic importance which can be used in breeding programmes are identified. Two catalogues incorporating characterization and evaluation data have been developed. Good number of populations/hybrids have been developed by different breeders in the country by using parental lines supplied from the unit. Out of these, at least 20-25 populations/hybrids are superior to already recommended hybrids. Present sunflower cultivars have a narrow genetic base. To overcome this, germplasm enhancement for broad genetic base has been initiated in two directions - i) Creation of gene pools using desirable germplasm of diverse geographic origin and ii) Utilization of selected wild species for germplasm introgression to generate wide variability.

**Key words:** Sunflower, genetic resources, oil content, variability, male sterile lines, gene pool introgression

Sunflower is grown for oil and protein throughout the world. It has genetic variability for adoption in variable climates. The crop is becoming popular in view of its high yield potential and short duration. Germplasm evaluation and utilisation is imperative for improving the productivity of the crop.

### MATERIALS AND METHODS

The material consisted of open pollinated populations/hybrid derivatives, CMS lines, B lines, restorer lines, inbred lines, CMS sources (Table 1) which were collected from different countries through NBPGR. The total number of germplasm accessions now conserved at the unit is over 2000.

**Table 1. Germplasm accessions conserved in the Project Co-ordinating Unit (Sunflower)**

| Germplasm types                                    | Numbers |
|----------------------------------------------------|---------|
| Open pollinated populations/<br>Hybrid derivatives | 1363    |
| CMS lines                                          | 43      |
| B lines                                            | 60      |
| Restorer lines                                     | 56      |
| Inbred lines                                       | 232     |
| Wild species                                       | 157     |
| CMS sources                                        | 3       |
| Total                                              | 1914    |

Over 1700 germplasm accessions were evaluated over years and seasons in a Randomised complete block design/simple lattice/Augmented

block design with two replication under rainfed/protective irrigated conditions. The rows were sown 60 cm apart with a plant to plant spacing of 30 cm. A fertilizer dose of 60:60:40 NPK kg/ha was given. Two to three seeds were sown in each hill to ascertain uniform stand of plants. Thinning was done 20 days after sowing to retain one plant per hill. Recommended crop management practices were followed during the crop growth period, except the plant protection measures in order to facilitate screening for pests and pathogens.

Characterization and evaluation was carried out for various qualitative and quantitative characters as per IBPGR (1989) descriptors for sunflower and were screened for *Alternaria*, rust and downy mildew at Bangalore and at Latur as per Nagaraju, *et al.* (1993) and Patil, *et al.* (1992). In addition to this, the accessions were also screened against temperature moisture stress based on Drought Susceptibility Index (DSI) and Temperature induction response. Two catalogues

have been prepared as documents and the lines are conserved (Virupakshappa and Sindagi, 1987; Jayaramaiah *et al.*, 1995).

## RESULTS AND DISCUSSIONS

The accessions were evaluated for seed yield and yield components, biological yield and oil content. The range values are presented in Table 2. The range with respect to days to flowering was 46-80 days, seed yield 2.09-72.47 (g/plant), oil content 14.88-50.74, biological yield 21.82-178.25 g/plant, plant height 48.28-234.50 CMS, number of leaves 22-59, stem girth 0.99-2.79 cm, head diameter 6.75-20.69 cm, 1000 seed weight 20.40-97.00 g and oil yield per plant 1.73-15.49 g. The promising lines for specific attributes of agronomic importance are listed in the table 2 (Jayaramaiah *et al.*, 1993, 94, 95 a and b).

The accessions were also screened for moisture stress based on drought susceptibility index and temperature induction response (Table 3). Based

**Table 2. Genetic resources of breeding importance in sunflower**

| Character                          | Range values | Number of accessions                                                                                                                                               |
|------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Earliness (Days to flowering)      | 46-80        | C0-1, SS-56, Morden, Acc. No. 1541, 1532, M-787-6-, 1398, M-78-6-1, 1408, 1440                                                                                     |
| Seed yield/plant (g)               | 2.09-72.47   | Acc.No. 426,422, 439, 435, 430, 437, 129, 75, 131, 61, 88, 179, 1156, 1219, 1275, 1287, 1461, 1460, 1465, 1210, 765, 1179, 916, 1219, 692, 1134, 86, B1, BC-11,687 |
| Oil content (%)                    | 14.88-50.74  | 655, 521, 657, 470, 60, SG502, 581, 87- R, RLC 4-2, 45, BLC 10-4, 15- 6, 1091, 1092, 1225, 1230, 1423, 881, 779, 1058, 901, 1013, 896, 1223, 1006.                 |
| Biological yield/plant (g)         | 21.82-178.25 | Acc.No.419, 422, 426, 434, 437, 438, 602                                                                                                                           |
| Plant height (cm)                  | 48.28/234.50 | No.414 (Bekees) HA 291 Acc.No.1478, 1874, N-787-9-2                                                                                                                |
| Leaves/plant (Nos)                 | 22-59        | BC- 11, Acc.No.687, 690, 828, 887, 1034, 120, 1222, 1464, 1555                                                                                                     |
| Stem girth (cm)                    | 0.99-2.79    | BC-11 Acc.No. 687, 690, 831, 948, 1056, 1147, 1268, 1465, 1563                                                                                                     |
| Head diameter (cm)                 | 6.75-20.69   | BC- 11, Acc.No.690, 828, 880, 902, 917, 948, 1134, 1268, 1384, 1469, 1563                                                                                          |
| Test weight (g) (1000 seed weight) | 20.40-97.00  | IB-24, 86 B3, Acc No. 916, 1179, 1031, 1217, 1219, 1366, 1464 1560                                                                                                 |
| Oil yield/plant (g)                | 1.73-15.49   | BC-11, 89-B, Acc.No. 687, 765, 828, 873, 1134, 1268, 1366, 1402                                                                                                    |

on DSI values both for seed yield and Total Dry Matter (TDM). EC-68414 was considered to be drought tolerant both under early as well as late stress. The other promising types are EC-68415 and MSFH-17.

**Table 3. Drought susceptibility index of the genotypes based on filled seed weight and TDM under early and late stress conditions**

| Genotypes<br>Acc. No. | Drought susceptibility index |             |              |             |
|-----------------------|------------------------------|-------------|--------------|-------------|
|                       | Seed yield                   |             | TDM          |             |
|                       | Early Stress                 | Late Stress | Early Stress | Late Stress |
| BSH-1                 | 1.22                         | 1.21        | 1.06         | 0.99        |
| 66                    | 1.23                         | 1.38        | 1.17         | 1.51        |
| 88                    | 1.00                         | 1.03        | 1.09         | 0.84        |
| 179                   | 0.93                         | 1.14        | 1.12         | 1.86        |
| 217                   | 1.04                         | 0.21        | 0.94         | 0.26        |
| 226                   | 0.98                         | 1.20        | 1.08         | 1.21        |
| 266                   | 1.34                         | 1.24        | 1.31         | 1.21        |
| 275                   | 0.42                         | 0.00        | 0.88         | 0.74        |
| 314                   | 1.38                         | 1.69        | 1.39         | 1.74        |
| 333                   | 1.63                         | 1.67        | 1.27         | 1.60        |
| 418                   | 1.22                         | 1.43        | 1.21         | 0.90        |
| 430                   | 0.75                         | 0.67        | 0.97         | 0.44        |
| 436                   | 0.48                         | 1.13        | 0.45         | 1.19        |
| 438                   | 0.44                         | 0.90        | 0.83         | 0.28        |
| kbsh-1                | 1.19                         | 1.75        | 0.95         | 1.00        |
| 872                   | 1.27                         | 1.50        | 1.33         | 1.24        |
| 154                   | 0.65                         | 1.07        | 0.79         | 1.37        |
| 37                    | 1.37                         | 1.12        | 1.29         | 1.26        |
| EC-68415              | 0.68                         | 0.35        | 0.97         | 1.24        |
| MSFH-8                | 0.89                         | 1.25        | 0.80         | 1.34        |
| Morden                | 1.35                         | 0.94        | 0.85         | 0.70        |
| MSFH-17               | 0.77                         | 0.86        | 0.68         | 0.37        |
| EC-68414              | 0.72                         | 0.30        | 0.71         | 0.38        |
| 198                   | 1.02                         | 1.76        | 0.83         | 1.16        |
| Drought intensity     | 0.53                         | 0.42        | 0.56         | 0.34        |

Screening for resistance to different diseases like *Alternaria* leaf spot, downy mildew was carried

out and resistant/tolerant lines are listed in Table 4. The promising accession numbers are 5, 7, 14, 284, 353, 832, 886, 889, 1015, 1430, 1440, 1667, 1858, CMS 89 A, 234 B, 341 B, 850 B, RHA 334, 356, 83 R6, 6D-1 (Nagaraju *et al.* 1983, 97).

**Table 4. Sunflower germplasm lines resistant/tolerant to different diseases**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>Alternaria leaf spot</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |
| Acc. Nos. 5, 7, 14, 25, 28, 32, 33, 35, 38, 42, 43, 53, 90, 93, 109, 111, 118, 120, 129, 131, 133, 143, 145, 146, 147, 149, 150, 151, 167, 173, 175, 179, 180, 194, 208, 16, 223, 230, 241, 244, 251, 256, 284, 35, 323, 333, 338, 339, 340, 342, 343, 344, 347, 348, 351, 353, 358, 361, 364, 367, 373, 389, 391, 393, 400, 410, 3423, 426, 430, 431, 438, 444, 446, 450, 451, 456, 690, 702, 765, 776, 785, 798, 810, 829, 832, 848, 860, 873, 875, 880, 881, 886, 887, 889, 892, 901, 905, 912, 914, 916, 918, 931, 1015, 1020, 1029, 1039, 1040, 1052, 1054, 1136, 1139, 1143, 1149, 1153, 1168, 1171, 1174, 1184, 1222, 1223, 1229, 1286, 1381, 1385, 13561391, 1401, 1440, 1424, 1425, 142, 9, 1430, 1431, 1434, 1441, 1442, 1445, 1447, 1467, 1473, 1474, 1483, 1484, 1485, 1589, 1491, 1497, 1510, 1542, 1548, 1559, 1562, 1565, 1581, 1591, 1626, 1631, 1635, 1667, 1717, 1858, 1878, 1888, CMS86A, 86A3, 232A, 291A.300A, 303A, 336A, 341A, 343A, 361A, 597A, 696A, 821A, 822A, 850A, 851A, 62B, 86B, 89B, 219B, 234B, 290B, 302B, 335B, 337B, 341B, 343B, 400N, 850B, 852B, RHA334, 292, 272, 274, 83R6, 3376R, 6D-1 |  |
| <b>Rust</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |
| Acc. Nos. 5, 7, 28, 31, 32, 33, 38, 42, 90, 99, 109, 111, 120, 146, 147, 149, 150, 173, 178, 210, 216, 393, 423, 430, 430, 431, 438, 444, 451, 471, 485, 518, 659, 702, 715, 776, 780, 785, 786, 788, 810, 825, 832, 841, 847, 860, 884, 889, 897, 901, 931, 1009, 1020, 1031, 1052, 1053, 1055, 1058, 1059, 1157, 1167, 1168, 1197, 1215, 1225, 1229, 1232, 1251, 1381, 1440, 1442, 1456, 1473, 1474, 1485, 1489, 1491, 1497, 1500, 1510, 1562, 1626, 1667, 1717, 1858, 1878, CMS 89A, 207B, 234B, 341B, 351B, 850B, RHA 356                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |
| <b>Downy mildew</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
| Acc. Nos. 241, 470, 536, 842, 846, 882, 888, 931, 1234, RHA 278, 334, 344, 345, 346, MRHA-1, MRHA-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |

#### Issues noticed in the crop

1. Lack of self fertility
2. Less productivity in seed and oil yield

3. High quality oil and protein type
4. Lack of sufficient breeding materials
5. Narrow genetic base
6. Lines for better biotic and abiotic stress
7. Non utilisation of wild species
8. Identification of good lines for confectionery purpose

#### Future strategies and action plan

Based on the evaluation strategies an action plan has been initiated on the issues noticed in the crop through utilisation and enhancement of the available germplasm lines.

##### a) Generating new breeding materials/gene pools

Promising germplasm lines were identified after thorough evaluation and were used to generate new breeding material for breeders. Two gene pools - B and R line composites were generated using promising maintainer and restorer lines respectively. These include lines with high oil content, high self fertility, seed yield and resistance to diseases. The gene pools have been supplied to breeders for developing superior parental lines to be used in heterosis breeding.

##### b) Development of inbred lines

Inbreeding is in progress to develop inbred lines using the base population, B-line gene pool, R-line gene pool, AEC-68414, EC-68415 and Morden. Based on the quantitative data the promising progenies were advanced by selfing.

##### c) Development of high oleic acid, high protein and early maturing hybrids

High oleic acid types were identified and crosses were effected to develop high oleic acid hybrid and early maturing hybrids. Four hybrids with oleic acid content, two hybrids for earliness and yield have been identified. (Shekar *et al.*, 1998).

##### d) Diversification of CMS source:

Only one CMS source (derived from *Helianthus petiolaris* by leclerque) is being used at present in the hybrid development programme carried over use of single cytoplasm result in genetic vulnerability of the hybrids to biotic and abiotic stress. Keeping this in view, research work on diversification of CMS sources have been initiated. Out of six new CMS sources, two new CMS sources - CMS-PF (*H. petiolaris* fallex) and CMS-I (*H. lenticularis*) are being used in this programme. Maintainer and restorer lines have been identified for these sources. The promising maintainer lines have been back crossed to develop lines in the new CMS background for their use in hybrid development programme in future. Using new CMS lines hybrids have been synthesised and are being evaluated.

##### e) Germplasm enhancement

Currently grown sunflower entries have a narrow genetic base. It is therefore imperative to generate new breeding material having a broad genetic base. The two approaches for germplasm enhancement are (i) creation of gene pools using desirable germplasm of diverse geographic origin for high oleic acid, high self fertility, resistance to pests and diseases, drought tolerance, earliness and other related desirable attributes. Later on developing inbred lines evaluating for GCA, lines into CMS and restorer lines and developing new CMS sources for obtaining better hybrids. (ii) Utilisation of selected wild species for germplasm intergression to generate wide variability - even though this is a long time process sufficient attention has not been diverted in this direction. There is good amount of genetic variability available among wild species especially for resistance to diseases, good agronomic characters, yield, oil, protein, oleic acid content, confectionary and the like. Wild species which could be used in breeding for improvement of different attributes (Seiler, 1992) are presented in Table 5.

Table 5. Potential wild species usefull for different attributes

| Sl.No. | Species                                 | Attributes                                                                                                |
|--------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------|
| 1.     | <i>Helianthus annuus</i>                | Rust, downy mildew, wilt, brown canker, oleic acid                                                        |
| 2.     | <i>H. petiolaris</i>                    | Rust, Wilt                                                                                                |
| 3.     | <i>H. praecox</i> spp. <i>runvonii</i>  | Rust, Oleic acid                                                                                          |
| 4.     | <i>H. praecox</i> ssp. <i>hirsutus</i>  | Rust, downy mildew                                                                                        |
| 5.     | <i>H. argophyllus</i>                   | Rust, downy mildew, brown canker, oleic acid, leaf area duration, drought resistant, self incompatibility |
| 6.     | <i>H. grosseserratus</i>                | Downy mildew, wilt                                                                                        |
| 7.     | <i>H. maxximiliani</i>                  | Downy mildew, protein, leaf area duration, lowest molecular weight, rubber                                |
| 8.     | <i>H. nuttallii</i>                     | Downy mildew, rust, protein                                                                               |
| 9.     | <i>H. tuberosus</i>                     | Downy mildew, Alternaria, wilt, brown canker, head, starch, sugar, protein & mineral                      |
| 10.    | <i>H. tementosus</i>                    | Wilt                                                                                                      |
| 11.    | <i>H. pauciflorus</i>                   | Alternaria, wilt, head                                                                                    |
| 12.    | <i>H. niveus</i> ssp. <i>canesceus</i>  | Oil (anual and Pernnia)                                                                                   |
| 13.    | <i>H. anomalus</i>                      | Oil                                                                                                       |
| 14.    | <i>H. petiolaris</i> ssp. <i>fallax</i> | Oil                                                                                                       |
| 15.    | <i>H. porteri</i>                       | Linolenic acid, protein                                                                                   |
| 16.    | <i>H. debilis cucumerifolius</i>        | Oleic acid                                                                                                |
| 17.    | <i>H. atrorubens</i>                    | Wilt, oleic acid, protein                                                                                 |
| 18.    | <i>H. paradoxus</i>                     | Protein, salinity                                                                                         |
| 19.    | <i>H. silphioides</i>                   | Wilt, Powdery mildew, oleic acid, protein                                                                 |
| 20.    | <i>H. hirsutus</i>                      | Alternaria, powdery mildew, oleic acid                                                                    |
| 21.    | <i>H. calitronicus</i>                  | Powdery mildew                                                                                            |
| 22.    | <i>H. divaricatus</i>                   | Head rot                                                                                                  |
| 23.    | <i>H. mollis</i>                        | Leaf area duration, population/unit area                                                                  |
| 24.    | <i>H. salicifolius</i>                  | Leaf area duration, oil                                                                                   |
| 25.    | <i>H. radula</i>                        | Leaf area duration, rubber                                                                                |
| 26.    | <i>H. deserticola</i>                   | Drought resistant                                                                                         |

Table 6. Varieties and hybrids recommended for different states

| Sl.No.              | Variety/<br>Hybrid | Year of<br>release | State for<br>which<br>recommended | Remarks                                                        |
|---------------------|--------------------|--------------------|-----------------------------------|----------------------------------------------------------------|
| <b>A. VARIETIES</b> |                    |                    |                                   |                                                                |
| 1.                  | EC 68414           | 1972               | All India                         | Suitable also for late sowing                                  |
| 2.                  | EC-68415           | 1972               | Karnataka                         | Prone for lodging under high fertility conditions              |
| 3.                  | Morden             | 1979               | All India                         | Suitable for multiple and mixed cropping systems               |
| 4.                  | Surya              | 1983               | Maharashtra                       | Striped seed                                                   |
| 5.                  | CO-1               | 1983               | Tamilnadu                         | Closer spacing of 20 cm x 15 cm to be followed, short duration |
| 6.                  | CO-2               | 1986               | Tamilnadu                         | Medium duration                                                |
| 7.                  | SS-56              | 1988               | Maharashtra                       | Short duration                                                 |
| 8.                  | GAU SUF-15         | 1994               | Gujarat                           | Medium duration, tall type                                     |
| 9.                  | PKVSF-9            | 1995               | Maharashtra                       | Vidarbha area of Maharashtra                                   |
| 10.                 | TNAU SUF-7         | 1996               | Tamilnadu                         | Medium duration                                                |
| 11.                 | LS-11              | 1998               | Maharashtra                       | Variety from Latur                                             |
| <b>B. HYBRIDS</b>   |                    |                    |                                   |                                                                |
| 1.                  | BSH-1              | 1980               | Karnataka                         | Resistant to rust and tolerant to Alternaria leaf spot         |

(Cont. on next page)

|    |          |      |                |                                                                  |
|----|----------|------|----------------|------------------------------------------------------------------|
| 2. | APSH-11  | 1987 | Andhra Pradesh | Medium duration                                                  |
| 3. | LDMRSH-1 | 1988 | Maharashtra    | Resistant to downy mildew                                        |
| 4. | LDMRSH-3 | 1988 | Maharashtra    | Resistant to downy mildew                                        |
| 5. | KBSH-1   | 1992 | All India      | High yielding and high oil content hybrid with wide adaptability |
| 6. | PSFH-67  | 1993 | Punjab         | Suitable for spring season                                       |
| 7. | PKVSH-27 | 1995 | Maharashtra    | Drought resistant                                                |
| 8. | DSH-1    | 1998 | Karnataka      | Recommended for North Karnataka                                  |

Hybrids MSFH-1, 8, 17, PAC-3425, Advance, SH-3322, PAC-9128, PAC-8699, PAC-36, PAC-308, Jwalamukhi, Sungene-85, PAC-1091 have been recommended for cultivation from the private sector.

#### f) Purification of parental lines diagnostic characters of male sterile and restorer lines

The diagnostic characteristics of the parental lines of the hybrids are essential in seed certification for maintenance of genetic purity of the lines to produce high quality seeds. The details of seed production technology has also been developed (Jayaramaiah, 1997).

#### g) Germplasm supply and accomplishments

Priority has been laid to supply germplasm material to various scientists in the country. Nearly 4000 to 5000 seed samples of different accessions and gene pools, derived materials have been supplied to different indentors. By using these lines supplied by the centre, a number of hybrids and populations have been developed at different locations in the country. Some of the varieties and hybrids released for cultivation are presented

in Table 6. In addition 1000 hybrids are in testing stages, whereas 20-30 hybrids are significantly superior to the available commercial hybrids. They are PCSP-47, PCSH-21, PCSH-23 from Project Co-ordinating Unit, Bangalore, KBSH-35, 39, 40, 41, 42 from AICRPO Bangalore, DSH-102 from Dharwad, LSFH-115, 12 from Latur, PSFH-10, 118, 125, 95, 226 from Ludhiana, HSFH-795, HSFH-792 from Hissar. In addition to this many Private hybrids are also in offing (Jayaramaiah, 1998).

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## RANDOMLY AMPLIFIED POLYMORPHIC DNA (RAPD) ANALYSIS OF PHOTOPERIOD SENSITIVE ACCESSIONS OF RICE (*Oryza sativa* L)

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RAPD patterns were studied using twenty photoperiod sensitive accessions of rice for assessing genetic diversity among them. Out of 60 decamer random primers used, six primers (OPE 9, OPG 14, OPJ 14, OPK 12, OPN 18 and OPO 15) revealed polymorphic DNA banding pattern. All the genotypes were uniquely distinguished and were clustered into six distinct clusters based upon similarity index represented by the ratio of common bands and total number of bands for each pair of all the accessions. Maximum number of genotypes were found to occur in clusters IV and V each having five genotypes followed by the cluster I which comprised four genotypes. The cluster II was monogenotypic.

**Key words :** Rice, RAPD, photoperiod sensitivity, diversity.

Rice (*Oryza sativa* L.) is one of the most important food crop grown over variable agro-climatic conditions ranging from rainfed upland to deep water conditions. Possibly this resulted in accumulation of greater diversity in this food crop. Genetic markers are of great value in crop improvement and inheritance studies (Weining and Langridge, 1991). Traditionally, markers based on morphological characters have been used. Different biochemical and molecular markers have also been employed for germplasm characterisation because of their added advantage over morphological markers. Variation in protein profiles and isozyme pattern have frequently been used as biochemical markers (Smith, 1986) but were unable to maintain specificity in most cases. The development of new techniques involving polymorphism in naturally occurring DNA sequences have represented a significant improvement in this regard as they offer greater diversity (Waugh and Powell, 1991). The techniques like restriction fragment length polymorphism (RFLP) and randomly amplified

polymorphic DNA (RAPD) have added a new dimension to the development of genetic markers to construct genetic maps and tagging of agronomically and physiologically important trait (Brown *et al.*, 1991, Mohapatra *et al.*, 1992 and Wang *et al.*, 1994) including rice crop (Second, 1991). However, the technical complexity commonly associated with the use of radioactive isotope has restricted the applied aspects of RFLP specially in crop improvement programmes (Waugh and Powell, 1991). Contrary to this, polymerase chain reaction based technique, RAPD, primarily based on primers of arbitrary sequences, has been preferred in a variety of applications over RFLP's due to its simplicity (Mullis and Floona, 1987).

Taking above consideration in view, RAPD analysis was conducted to assess the genetic diversity in twenty accessions of photoperiod sensitive rice genotypes from Germplasm Centre of International Rice Research Institute, Manila, Philippines.

## MATERIALS AND METHODS

A. *Plant material* : 20 accessions of photoperiod sensitive rice *viz.*, 4131, 4132, 4135, 4137, 4138, 4144, 4145, 4147, 4151, 4152, 4153, 4154, 4155, 4156, 4158, 4165, 4167, 4168, 4172 and R 9678 were obtained from Germplasm Centre of IRRI, Manila, Philippines. These accessions were grown in glasshouse conditions at IRRI.

B. *DNA extraction* : Total DNA was extracted from young leaves as per method developed by Dellaporta, *et al.* (1983) with suitable modifications as per requirement.

C. *Primer for amplification* : A set of sixty decamer (10-mer) oligonucleotides (Primers) of arbitrary sequences from Operon Technologies, California, USA were used for screening polymorphism.

D. *RAPD analysis* : The starting mixture of PCR was made in 25 µl volume containing 5 µl DNA, 1.25 µl primer, 2.5 µl PCR buffer, 2.5 µl dNTP, 2.5 µl Mg Cl<sub>2</sub>, 2.0 µl Taq polymerase and 9.25 µl water. DNA amplification was performed in techne Thermalcycler programmed for 45 cycles of 1.0 min at 92°C, 1.0 min at 34°C and 2.0 min at 70°C.

The DNA fragments, thus generated by PCR, were electrophoresed on 2 per cent agarose gel containing 1 per cent agarose and 1 per cent nusieve. The ethidium bromide (1 µg/ml) stained gels were photographed under UV-Transilluminator with Polaroid camera.

E. *Data analysis* : Data obtained from RAPD patterns were used to calculate the similarity index. Diversity and clustering analysis were done as per standard statistical procedure of Nei and Li (1979) and Rao (1952).

## RESULTS AND DISCUSSION

A total of sixty primers of arbitrary sequences were surveyed to generate amplification products (RAPD). It was observed that most of the amplification products, thus generated, were monomorphic or in few cases proper amplification could not occur. In case of only six primers *viz.*, POE 9, OPG 14, OPJ 14, OPK 12, OPN 18 and OPO 15, the polymorphic bands among the genotypes were observed. A few typical example of amplification pattern has been presented in Fig. 1.

All the 20 genotypes under study were grouped into six clusters based on the similarity index values. The cluster composition (Table 1)

**Table 1. Cluster composition of 20 photoperiod sensitive accessions of rice based on RAPD analysis**

| Cluster | Number of genotypes | Accession number             |
|---------|---------------------|------------------------------|
| I       | 4                   | 4137, 4151, 4153, 4154       |
| II      | 1                   | 4145                         |
| III     | 2                   | 4131, 4158                   |
| IV      | 5                   | 4132, 4135, 4144, 4152, 4168 |
| V       | 5                   | 4155, 4156, 4165, 4167, 4172 |
| VI      | 3                   | 4147, 4148, R 9678           |

indicated that clusters IV and V were consisting of 50 per cent of the genotypes having five genotypes in each cluster. The number of genotypes in other cluster were monogenotypic (cluster II), two (cluster III), three (cluster VI) and four (cluster I). These observations clearly indicated that sufficient genetic variability is present at molecular level in these genotypes although they belong to only one group i.e. photoperiod sensitive based on morphological assessment. In addition, these genotypes also have other morphological features more or less identical e.g., plant height, foliage color and maturity

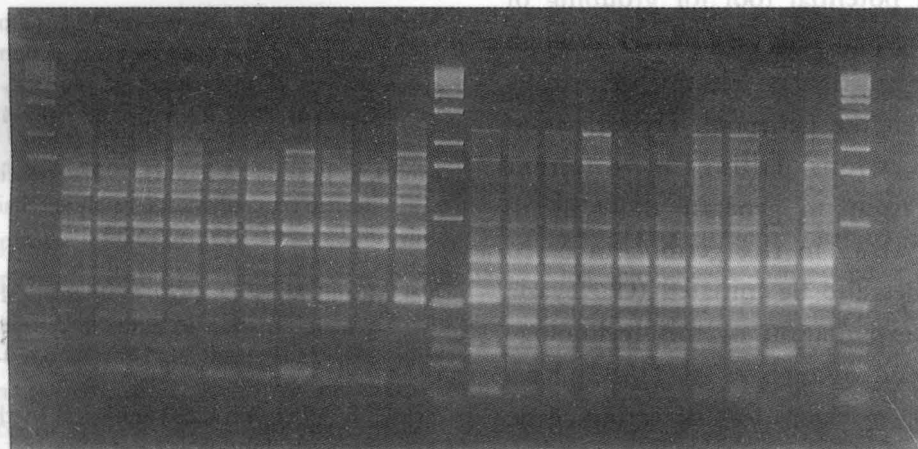
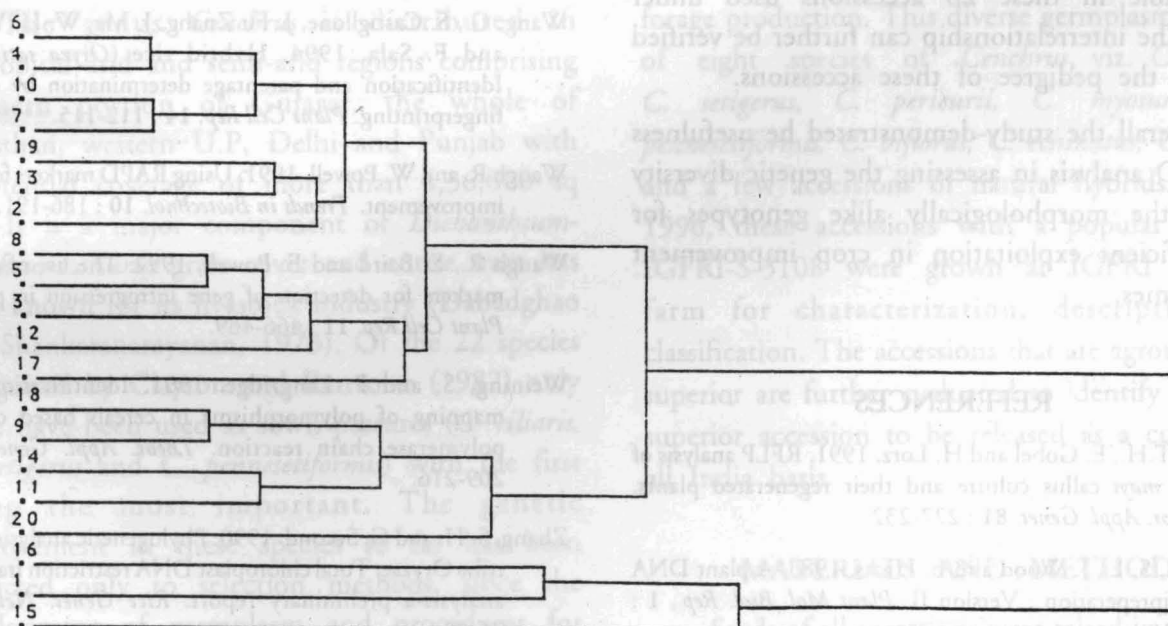


Fig. 1. Amplification pattern of 20 photoperiod sensitive accessions with the primer OPN-18 (Lane 1-DNA marker, Lane 2-Acc. 4148, Lane 3-Acc 4131, Lane 4-Acc 4135, Lane 5-Acc 4151, Lane 6-Acc 4152, Lane 7-Acc 4137, Lane 8-Acc 4154, Lane 9-Acc 4144, Lane 10-Acc 4156, Lane 11-Acc 4145, Lane 12-Acc 4165, Lane 13-Acc 4168, Lane 14-Acc 4158, Lane 15-Acc 4172, Lane 16-Acc R-9678, lane 17-Acc 4147, Lane 18-Acc 4132, Lane 19-Acc 4155, Lane 20-Acc 4153, Lane 21-Acc. 4153, Lane 22-DNA markers



DENDROGRAM OF PHOTOPERIOD SENSITIVE ACCESSIONS BASED ON RAPD ANALYSIS

Fig. 2. 1. Acc-4148, 2. Acc-4131, 3. Acc-4135, 4. Acc-4151, 5. Acc-4152, 6. Acc-4137, 7. Acc-4154, 8. Acc-4144, 9. Acc-4156, 10. Acc-4145, 11. Acc-4165, 12. Acc-4167, 13. Acc-4168, 14. Acc-4158, 15. Acc-4172, 16. Acc-9678, 17. Acc-4153, 18. Acc-4155, 19. Acc-4147, 20. Acc-4132

duration. It is practically not possible to distinguish these genotypes based on their morphological features. In this context, the present investigation offers RAPD as a potential tool for grouping of closely related genotypes. This may provide enough opportunity to the breeders in selecting genetically diverse parents from the genepool. Hybridization between the accessions falling in different groups/clusters is likely to generate more useful segregates. The diversity in rice germplasm based on PCR analysis has also been initiated (Garzeyazie *et al.*, 1995) for exploitation of this technology in rice improvement. Waugh *et al.* (1992) have also used RAPD markers for detecting gene introgression in potato.

The average linkage dendrogram (Fig. 2) based on genetic distances was also prepared to show the inter-relationship among these genotypes as per Zhang and Second, 1990. The pattern confirmed the finding that enough genetic diversity is available in these 20 accessions used under study. The interrelationship can further be verified through the pedigree of these accessions.

Overall the study-demonstrated the usefulness of RAPD analysis in assessing the genetic diversity among the morphologically alike genotypes for their efficient exploitation in crop improvement programmes.

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## STRATEGIES FOR UTILIZATION OF THE GERMPLASM OF A TROPICAL APOMICTIC BUFFEL GRASS

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A global germplasm collection of 372 accessions of *Cenchrus* have been characterised for their morphological, phenological and reproductive parameters. This germplasm comprised eight species of *Cenchrus*, viz., *C. ciliaris*, *C. setigerus*, *C. glaucus*, *C. penneisetiformis*, *C. prieurii*, *C. biflorus*, *C. echinatus* and *C. myosuroides* along with some putative natural hybrids. These accessions were collected from more than 30 countries, majority of them from African countries. Range of variation recorded among these accessions for 21 parameters exhibited high amount of diversity. Based on the yield analysis eleven superior accessions were identified for further evaluation in All India Co-ordinated Trials. The results will be presented in detail and the strategies for conservation and utilization of this predominantly apomictic forage grass will be discussed.

**Key words :** Buffel grass, *Cenchrus*, apomixis, genetic divergence, ecotypes

The genus *Cenchrus* is distributed in subtropical arid and semi-arid regions comprising northern portion of Gujarat, the whole of Rajasthan, western U.P, Delhi and Punjab with a potential coverage of more than 4,36,000 sq km. It is a major component of *Dichanthium-Cenchrus-Lasiurus* grass cover and entire tract has been known for its livestock industry (Dabadghao and Shankaranarayanan, 1973). Of the 22 species recognised by Clayton and Renvoize (1982) only three have been used as sown pastures (*C. ciliaris*, *C. setigerus* and *C. penneisetiformis*) with the first being the most important. The genetic improvement in these species so far has been restricted only to selection methods, since the development of germplasm and procedures for hybridization and gene transfer are the greater challenges in breeding apomictic grasses.

A global germplasm of 372 accessions had been collected under an Indo-UK project on

forage production. This diverse germplasm consists of eight species of *Cenchrus*, viz. *C. ciliaris*, *C. setigerus*, *C. prieurii*, *C. myosuroides*, *C. penneisetiformis*, *C. biflorus*, *C. echinatus*, *C. glaucus* and a few accessions of natural hybrids. During 1996, these accessions with a popular cultivar, IGFRI-S-3108 were grown at IGFRI Research farm for characterization, description and classification. The accessions that are agronomically superior are further evaluated to identify the most superior accession to be released as a cultivar on all India basis.

### MATERIALS AND METHODS

Seeds of all accessions were raised in polythene bags during 1996 and the seedlings were transplanted into the field after about 5 weeks. Ten plants of each accession were planted with a spacing of 0.5 × 0.5m. Data on fourteen quantitative traits were recorded at fifty per cent

bloom stage on randomly selected 5 plants and averaged, while, data on seven qualitative traits were ranked under different classes. A complete list of attributes used in the analysis is given in Table 1.

**Table 1. Attributes measured for 372 accessions of *Cenchrus* species**

|     |                                 |                                                                                                               |
|-----|---------------------------------|---------------------------------------------------------------------------------------------------------------|
| 1.  | Dry matter yeild                | g/plant                                                                                                       |
| 2.  | Dry matter content              | in per cent                                                                                                   |
| 3.  | Green Fodder yield              | g/plant                                                                                                       |
| 4.  | Number of days to 50% flowering | 1 to 5 scale (Early to Late)                                                                                  |
| 5.  | Plant height                    | 1 to 5 scale (Low to high)                                                                                    |
| 6.  | No. of tillers per plant        | No./plant                                                                                                     |
| 7.  | No. of leaves per plant         | No./plant                                                                                                     |
| 8.  | Leaf length                     | cm                                                                                                            |
| 9.  | Leaf breadth                    | cm                                                                                                            |
| 10. | Peduncle length                 | cm                                                                                                            |
| 11. | Spike length                    | cm                                                                                                            |
| 12. | Spike width                     | cm                                                                                                            |
| 13. | No. of spikelets per spike      | No./spike                                                                                                     |
| 14. | Wt. of 100 fascicles            | g                                                                                                             |
| 15. | Early vigour                    | Excellent, Very good, Good, Poor, Very poor                                                                   |
| 16. | Growth habit                    | Erect, Semi-erect, Prostrate                                                                                  |
| 17. | Leaf type                       | Rough, Smooth                                                                                                 |
| 18. | Plant/Leaf colour               | Dark green, Light green                                                                                       |
| 19. | Culm formation                  | Very low                                                                                                      |
| 20. | Bur colour                      | Black Brown, Purple straw, Purple Green straw                                                                 |
| 21. | Spine arrangement               | Highly spined long, Highly spined short, Moderately spined, Less spined long, Less spined short and Spineless |

The selected superior accessions with a popular cultivar as a check were evaluated in a randomised complete block design with 3 replications. Each replication consisted of 12 blocks of 40 plants each. Observations on ten

agronomically important traits were recorded. The data on twenty one traits of the germplasm were tabulated as a frequency distribution in 5 groups for quantitative traits and under respective classes as measured for qualitative traits. The analysis of variance was carried out for ten agronomic traits using the statistical package SPAR1.

## RESULTS AND DISCUSSION

The results of the analysis on the range of variation and the frequency distribution of accessions is presented in Table 2a and 2b. A wide range of variation was observed in both quantitative and qualitative traits. Morphotypes in the study demonstrated the vast diversity found in natural populations of apomictic *Cenchrus*. Wide differences were observed among accessions in plant height, number of tillers per plant, leaf characteristics, number of spikelets per spike, 100 fascicle weight, dry matter percentage, growth habit, culm formation and spine arrangement. These differences suggested the possibility of different apomictic taxa in the population. Many accessions were found to be either early maturing or late maturing. Hignight *et al.*, (1991) had also observed vast diversity in the natural populations of *Cenchrus ciliaris* in plant height, leaf characteristics, growth habit and foliage colour. In another study, Pengelly *et al.*, (1992) found no variation in caryopsis weight, whereas maturity and plant height contributed the most to delineate the groups. In Australia, a large collection of *C. ciliaris* and *C. setigerus*, including some hybrid accessions has been characterized on the basis of physiological, morphological and agronomic features of four plants of each accession (Eagles *et al.*, 1992). There was no consistent relationship between both country of origin and the six groupings based on 16 traits. They found that some of the measured traits were mutually

Tabl 2a. Range of variation and frequency distribution for 14 quantitative characters in *Cenchrus* species

| S.No. | Characters                      | Range of variation in each of 5 groups and number of cultivars in each group |                  |                  |                 |                 |
|-------|---------------------------------|------------------------------------------------------------------------------|------------------|------------------|-----------------|-----------------|
|       |                                 | 1                                                                            | 2                | 3                | 4               | 5               |
| 1.    | Dry matter yeild (g/pl)         | 10-96<br>148                                                                 | 96.1-182<br>104  | 182.1-268<br>29  | 268.1- 354<br>6 | 354.1-440<br>2  |
| 2.    | Dry matter %                    | 18.8-23.9<br>22                                                              | 23.93-29<br>97   | 29.07-34<br>128  | 34.2-39<br>33   | 39.3- 44.4<br>8 |
| 3.    | Green Fodder yield (g/pl)       | 15-3021<br>32                                                                | 302.7-590<br>117 | 590.5- 878<br>32 | 878-1166<br>9   | 1166-1450<br>2  |
| 4.    | Number of days to 50% flowering | 16-44<br>220                                                                 | 44.4-72<br>15    | 72.9- 101<br>2   | 10.4,129<br>77  | 129.9-158<br>40 |
| 5.    | Plant height                    | 21.6-41<br>70                                                                | 41.1-60<br>149   | 60.5-80<br>89    | 80.1-99<br>35   | 99.5-118<br>16  |
| 6.    | No. of tillers per plant        | 7.2-55<br>68                                                                 | 55.6-104<br>152  | 104.1-152<br>98  | 152.6-201<br>38 | 201.1-249<br>3  |
| 7.    | No. of leaves per plant         | 0.46-3<br>1                                                                  | 3.2-6<br>21      | 6.1-8<br>163     | 8.9-11<br>153   | 11.7-14.5<br>21 |
| 8.    | Leaf length (cms)               | 5.2-1.0<br>52                                                                | 10.8-16<br>165   | 16.4-22<br>115   | 22.1- 27<br>21  | 27.6-33.2<br>6  |
| 9.    | Leaf breadth (cms)              | 0.4-0.5<br>42                                                                | 0.53-0.6<br>141  | 0.67-0.8<br>132  | 0.81-0.9<br>35  | 0.94-1.08<br>9  |
| 10.   | Peduncle length (cms)           | 2.8-9<br>101                                                                 | 9.6-16<br>166    | 16.5-23<br>79    | 23.3- 30<br>11  | 30.2-37<br>2    |
| 11.   | Spike length (cms)              | 2.5-5<br>55                                                                  | 5.04-7<br>190    | 7.5-10.1<br>105  | 10.1- 12<br>8   | 12.6-15.2<br>1  |
| 12.   | Spike width (cms)               | 0.42-0.9<br>79                                                               | 0.98-1.5<br>252  | 1.54-2<br>25     | 2.1- 2.5<br>1   | 2.66-3.22<br>1  |
| 13.   | No. of spikelets per spike      | 11.0-49.0<br>92                                                              | 49.9-88<br>166   | 88.8127<br>87    | 127.7-166<br>8  | 166.6-205<br>2  |
| 14.   | Wt. of 100 fascicles            | 0.053-0.2<br>96                                                              | 0.21-0.3<br>161  | 0.36-0.5<br>41   | 0.52-0.6<br>20  | 0.68-0.83<br>4  |

antagonistic and there was no indication of phenotypic plasticity. Nicholson *et al.* (1985) included rhizome number and growth habit in their list of attributes most useful in distinguishing between cultivars of *C. ciliaris*. Our collection is dominated by *C. ciliaris* followed by *C. setigerus* and *C. preieurii* with only one accession of *C. echinatus*, *C. glaucus* and *C. biflorus* and two accessions of *C. myosuroides* and *C. pennesetiformis*. Hence, there is some merging of these species in

different groups indicating *C. ciliaris* as a most widespread and diverse species.

Based on the results of analysis of germplasm for agronomic traits, eleven superior accessions were identified and were further evaluated along with a check variety IGFR1 3108 for yield and related agronomic traits. The mean performance of these twelve accessions for ten traits with their analysis of variance is shown in Table 3. These selected accessions differed significantly among

Table 2b. Range of variation and frequency distribution for seven qualitative traits

|    |                   |                |                   |                  |                     |                 |              |         |
|----|-------------------|----------------|-------------------|------------------|---------------------|-----------------|--------------|---------|
| 1. | Early vigour      | Excellent<br>7 | Very good<br>69   | Good<br>154      | Poor<br>131         | Very poor<br>10 |              |         |
| 2. | Growth habit      | Erect<br>67    | Semi erect<br>137 | Prostrate<br>155 |                     |                 |              |         |
| 3. | Leaf type         | Rough<br>302   | Smooth<br>57      |                  |                     |                 |              |         |
| 4. | Plant/Leaf colour | DG<br>29       | DGP<br>16         | G<br>142         | G<br>P42            | LG<br>97        | LGP<br>18    | PG<br>5 |
| 5. | Culm formation    | Very low<br>19 | Low<br>86         | Moderate<br>121  | High<br>88          | Very High<br>45 |              |         |
| 6. | Bur colour        | Black<br>1     | Brown<br>8        | Purple<br>63     | Straw purple<br>134 | Green<br>2      | Straw<br>118 |         |
| 7. | Spine arrangement | 1<br>73        | 2<br>61           | 3<br>78          | 4<br>63             | 5<br>50         |              |         |

Table 3. Mean performance of 12 accessions of *C. ciliaris* for ten agronomic traits

| Accession Number | Plant height | Number of leaves | Leaf length | Leaf length | Leaf breadth | Number of tillers | Leaf/stem FW | Leaf/stem DW | GFY   | DMY   | Seed no./100 burs |
|------------------|--------------|------------------|-------------|-------------|--------------|-------------------|--------------|--------------|-------|-------|-------------------|
| 1. EC 397712     | 97.33        | 10.77            | 33.77       | 33.77       | 0.81         | 27.43             | 0.7          | 0.67         | 22.9  | 44.68 | 98                |
| 2. EC 397707     | 106.43       | 11.9             | 35.13       | 35.13       | 0.8          | 24                | 0.66         | 0.73         | 20.93 | 41.42 | 77.67             |
| 3. EC 397692     | 114.9        | 12.1             | 33.47       | 33.47       | 0.79         | 31.13             | 0.56         | 0.6          | 25.53 | 46.16 | 68.33             |
| 4. EC 397631     | 118.87       | 11.03            | 38          | 38          | 1.08         | 41                | 0.8          | 0.81         | 29.97 | 64.14 | 25                |
| 5. EC 397497     | 122          | 11.77            | 34.37       | 34.37       | 0.97         | 39.33             | 0.57         | 0.56         | 27.4  | 57.65 | 36.67             |
| 6. EC 397490     | 80.23        | 11.1             | 25.63       | 25.63       | 0.75         | 42.57             | 0.75         | 0.81         | 18.27 | 33.98 | 34.67             |
| 7. EC 397488     | 110.23       | 12.1             | 39.57       | 39.57       | 0.8          | 28.77             | 0.69         | 0.67         | 25.07 | 50.65 | 77.33             |
| 8. EC 397486     | 108.9        | 11.77            | 39          | 39          | 0.8          | 32.8              | 0.65         | 0.82         | 29.1  | 50.31 | 57.67             |
| 9. EC 397434     | 108          | 13.1             | 40.57       | 40.57       | 0.89         | 35.23             | 0.71         | 0.74         | 27.13 | 44.88 | 52                |
| 10. EC 397410    | 130.33       | 12.77            | 42.67       | 42.67       | 0.94         | 38.43             | 0.57         | 0.56         | 31.97 | 65.85 | 69.33             |
| 11. EC 3108      | 123.57       | 12.57            | 37.43       | 1.17        | 35           | 0.58              | 0.51         | 26.6         | 60.17 | 43    |                   |
| 12. EC 397327    | 126.43       | 11.8             | 34.1        | 34.1        | 0.97         | 32.57             | 0.53         | 0.48         | 27.03 | 55.8  | 43.33             |
| Mean             | 112.27       | 11.89            | 36.14       | 0.89        | 34.02        | 0.65              | 0.66         | 25.99        | 51.31 | 56.92 |                   |
| F' value         | 2.58*        | 1.08             | 2.02        | 2.02        | 3.99**       | 1.82              | 2.43*        | 2.88*        | 2.25* | 2.43* | 2.86*             |

\*Significant at 5% level \*\*Significant at 1% level

themselves for green fodder yield, dry matter yield, number of caryopsis per 100 fascicles, plant height, leaf width, leaf to stem fresh and dry weight. Whereas, there was no significant difference for

traits such as number of leaves, leaf width and number of tillers. This once again confirmed the presence of high amount of variation for most of the characters in the germplasm. Thus, six

superior accessions *viz.*, ECS 397497, 397631, 397434, 397410, 397327 and 397490 that performed better than the check variety for yield (Green fodder yield and dry matter yield) were entered into All India Co-ordinated trials for multi-locational testing during 1998. Performance of eight strains of *C. ciliaris* was studied by Rai *et al.*, (1982) under rain-fed conditions. They also observed significant variations in forage yield of these strains. They found that two cultivars, namely IGFR-S-3108 and S-357 were equally good for quality forage production.

The results of this study provide a better understanding of the nature of morphological differences among native apomictic *Cenchrus* accessions and help to clarify relationships among a selected group of diverse apomictic ecotypes of this species. Although most *Cenchrus* ecotypes reproduce by obligate apomixis, completely sexual plants are very rare in the native habitat. Based on the information obtained in this study it is postulated that the investigated divergent ecotypes represent a primary gene pool to improve this species.

The range of variation recorded was significant for its ultimate use in breeding. Where sexual material is available, manipulation by breeders may be done through direct hybridization between parents for recombination and selection of desirable traits. Thus, screening of the collection for the mode of reproduction would, however, first be necessary. A rapid practical approach to exploit this high level of variability found would be to multiply seed stocks and construct a series of composite cultivars. These should be assessed in different environments. Artificial selection of

adapted strains would in times lead to the establishment of cultivars with a wide genetic base. This has obvious advantage in stress environments.

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## COMPONENT ANALYSIS FOR GRAIN YIELD IN SORGHUM

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Variability and path coefficient analysis were carried out in 170 germplasm lines of sorghum. The study revealed high estimates of genotypic coefficient of variation (GCV), heritability and genetic gain for plant height, stover yield, leaf area, flag leaf area, peduncle length and harvest index. Grain yield/plant showed positive and significant association with plant height, flag leaf area, panicle weight, panicle girth, number of primaries and whorls of primaries per panicle. Characters like panicle weight, panicle girth and days to 50% flowering revealed higher positive direct effect on grain yield in path coefficient analysis.

**Key words :** Sorghum, germplasm, variability

Sorghum (*Sorghum bicolor* (L.) Moench), locally known as jowar is grown as food, feed and fodder crop. Since last few years the yield level of sorghum varieties have stagnated. Variability in the population, especially for the characters where improvement is sought for, is important for successful crop improvement programme, whereas character association and path coefficient analysis helps in indirect selection for the trait. Although reports on evaluation of the germplasm of sorghum are quite frequent in literature, yet an attempt has been made in the present study to evaluate the exotic germplasm of different eco-geographic sources for genetic variability in some agro-morphological traits.

### MATERIAL AND METHODS

The experimental material comprised 170 accessions (including 158 exotic and 12 indigenous) obtained from ICRISAT and five standard checks *viz.*, CSH-9, CSV-10, CSV-13,

SPV-96 and SPH-468. In all 175 germplasm lines were grown in an Augmented Complete Randomized Block Design at the experimental field of Rajasthan College of Agriculture, Udaipur. Each entry was grown in single row plot of 4m long spaced 45 cm apart. Plant to plant distance was maintained at 10 cm. Observations were recorded on five randomly selected plants for sixteen different traits and were used to compute the analysis of variance and covariance as prescribed by Federer (1956). Path coefficient analysis was carried out according to Dewey and Lu (1959).

### RESULTS AND DISCUSSION

Analysis of variance revealed significant variability for all the characters studied. The highest percentage of Phenotypic Coefficient of Variation (PCV) (61.18) and Genotypic co-efficient of variation (GCV) (60.39) were observed for stover yield per plant while these were lowest (5.17 and 4.99) for days to maturity (Table 1). The heritability in broad sense was highest for days

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Table 1. Estimates of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (H), genetic advance (GA) and genetic gain (GG) for different characters studied in Sorghum (*Sorghum bicolor* (L.) Moench)

| S.No. | Character                                   | GCV  | PCV  | H(%) | GA     | GG    |
|-------|---------------------------------------------|------|------|------|--------|-------|
| 1.    | Days to 50 per cent flowering               | 12.5 | 12.6 | 98.1 | 16.1   | 25.6  |
| 2.    | Days to maturity                            | 5.0  | 5.2  | 92.9 | 9.9    | 9.9   |
| 3.    | Plant height (cm)                           | 25.2 | 25.7 | 95.8 | 112.9  | 50.7  |
| 4.    | Number of leaves per plant                  | 16.5 | 17.3 | 90.7 | 3.8    | 32.4  |
| 5.    | Leaf area per plant (cm <sup>2</sup> )      | 31.3 | 33.2 | 89.0 | 2627.2 | 60.2  |
| 6.    | Flag leaf area per plant (cm <sup>2</sup> ) | 33.3 | 36.0 | 85.1 | 1054.4 | 63.2  |
| 7.    | Peduncle length (cm)                        | 27.4 | 29.7 | 85.1 | 19.2   | 52.0  |
| 8.    | Panicle length (cm)                         | 21.0 | 22.9 | 84.2 | 6.7    | 39.7  |
| 9.    | Panicle girth (cm)                          | 17.9 | 20.6 | 75.4 | 3.5    | 32.0  |
| 10.   | Panicle weight (g)                          | 37.7 | 43.6 | 75.1 | 19.2   | 67.4  |
| 11.   | Number of primaries per panicle             | 22.1 | 25.5 | 75.4 | 20.2   | 39.6  |
| 12.   | Number of whorls of primaries per panicle   | 13.7 | 18.4 | 55.2 | 2.1    | 21.0  |
| 13.   | Stover yield per plant (g)                  | 60.4 | 61.2 | 97.4 | 112.5  | 112.8 |
| 14.   | Harvest index                               | 39.3 | 42.7 | 84.8 | 15.6   | 74.5  |
| 15.   | 500-grain weight (g)                        | 17.4 | 19.0 | 83.7 | 4.0    | 32.9  |
| 16.   | Grain yield per plant (g)                   | 38.9 | 47.4 | 67.4 | 14.4   | 65.8  |

to 50 per cent flowering (98.14%) followed by stover yield per plant, plant height days to maturity and number of leaves per plant. Number of whorls of primaries per panicle recorded lowest estimate of heritability (55.17%). The estimate of genetic gain ranged from 9.91 per cent for days to maturity to 122.79 per cent for stover yield per plant. To formulate an efficient breeding programme, heritability along with genetic gain should be considered (Johnson *et al.*, 1955). In the present study, plant height, stover yield, leaf area, flag leaf area, peduncle length and harvest index showed high GCV, high heritability and high genetic gain. Hence selection based on these traits would be more effective for their improvement.

Grain yield per plant showed positive and significant correlation with plant height, flag leaf area, panicle weight, panicle girth, number of

whorls of primaries and number of primaries per panicle (Table 2). Mutual correlations among traits panicle weight, panicle girth, stover yield and grain yield per plant were positive and significant. It suggests that simultaneous selection for these characters should have a better efficiency for improving the grain yield. Patil *et al.*, (1990) and Cheralu and Rao (1989) also reported similar results for panicle height and number of primaries per panicle.

Path coefficient analysis indicate that out of six traits which were positively correlated with grain yield, only three traits *viz.*, panicle weight, panicle girth and days to 50 per cent flowering had positive and high direct effects (Table 3). Borikar *et al.*, (1985) and Patil *et al.*, (1990) observed higher direct effect of panicle weight while, Sisodia *et al.*, (1982) noticed maximum direct influence due to panicle girth on yield.

Table 2. Genotypic (rg) and phenotypic (rp) correlation coefficient between different characters studied in Sorghum (*Sorghum bicolor* (L.) Moench)

| S. No. | Name of variety (Entry)                     | Days to maturity (cms) | Plant height (cms) | No. of leaves/plant | Leaf area per plant (cm <sup>2</sup> ) | Flag leaf area/plant (cm <sup>2</sup> ) | Panicle length (cms) | Panicle girth (cms) | Panicle weight (gms) | No. of primaries/panicle | No. of whorls of primaries/panicle | Stover yield per plant (gms) | Harvest index | 500-grain weight (gms) |
|--------|---------------------------------------------|------------------------|--------------------|---------------------|----------------------------------------|-----------------------------------------|----------------------|---------------------|----------------------|--------------------------|------------------------------------|------------------------------|---------------|------------------------|
| 1.     | 2.                                          | 3.                     | 4.                 | 5.                  | 6.                                     | 7.                                      | 8.                   | 9.                  | 10.                  | 11.                      | 12.                                | 13.                          | 14.           | 15.                    |
| 1.     | Days of 50% flowering                       | rg 0.82                | rp 0.17            | 0.92                | 0.79                                   | 0.55                                    | -0.66                | -0.08               | 0.18                 | 0.14                     | 0.08                               | 0.4                          | -0.54         | 0.04                   |
| 2.     | Days to maturity                            | rg 0.79                | rp 0.17            | 0.86                | 0.74                                   | 0.50                                    | -0.61                | -0.07               | 0.15                 | 0.11                     | 0.07                               | 0.45                         | -0.50         | 0.03                   |
|        |                                             | rg                     | 0.13               | 0.76                | 0.68                                   | 0.42                                    | -0.55                | 0.08                | 0.09                 | 0.17                     | 0.09                               | 0.25                         | 0.25          | 0.45                   |
|        |                                             | rp                     | 0.13               | 0.68                | 0.60                                   | 0.36                                    | -0.48                | 0.06                | 0.08                 | 0.1                      | 0.03                               | 0.14                         | 0.14          | 0.42                   |
| 3.     | Plant height (cm)                           | rg                     |                    | 0.29                | 0.35                                   | 0.34                                    | -0.12                | -0.02               | 0.44                 | 0.43                     | 0.46                               | 0.31                         | 0.51          | -0.38                  |
|        |                                             | rp                     |                    | 0.28                | 0.35                                   | 0.35                                    | -0.07                | 0.04                | 0.43                 | 0.41                     | 0.43                               | 0.28                         | 0.5           | 0.31                   |
| 4.     | Number of leaves per plant                  | rg                     |                    |                     | 0.87                                   | 0.73                                    | -0.69                | -0.19               | 0.40                 | 0.29                     | 0.17                               | 0.071                        | 0.54          | -0.60                  |
|        |                                             | rp                     |                    |                     | 0.85                                   | 0.70                                    | -0.64                | -0.12               | 0.39                 | 0.32                     | 0.022                              | 0.13                         | 0.52          | -0.48                  |
| 5.     | Leaf area per plant (cm <sup>2</sup> )      | rg                     |                    |                     |                                        | 0.82                                    | -0.62                | -0.09               | 0.51                 | 0.46                     | 0.32                               | 0.21                         | 0.56          | -0.51                  |
|        |                                             | rp                     |                    |                     |                                        | 0.81                                    | -0.54                | 0.02                | 0.50                 | 0.48                     | 0.34                               | 0.25                         | 0.54          | -0.37                  |
| 6.     | Flag leaf area per plant (cm <sup>2</sup> ) | rg                     |                    |                     |                                        | -0.55                                   | -0.04                | 0.56                | 0.55                 | 0.31                     | 0.29                               | 0.44                         | -0.39         | 0.30                   |
|        |                                             | rp                     |                    |                     |                                        | -0.43                                   | 0.07                 | 0.55                | 0.57                 | 0.32                     | 0.29                               | 0.42                         | -0.24         | 0.16                   |
| 7.     | Peduncle length (cm)                        | rg                     |                    |                     |                                        |                                         | 0.47                 | -0.58               | -0.26                | -0.26                    | 0.03                               | -0.42                        | 0.42          | 0.03                   |
|        |                                             | rp                     |                    |                     |                                        |                                         | 0.47                 | -0.41               | -0.15                | -0.19                    | 0.06                               | -0.37                        | 0.40          | 0.06                   |
| 8.     | Panicle length (cm)                         | rg                     |                    |                     |                                        |                                         |                      |                     | -0.54                | 0.04                     | -0.12                              | 0.38                         | -0.01         | 0.17                   |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     | -0.28                | 0.18                     | 0.00                               | 0.35                         | 0.03          | 0.23                   |
| 9.     | Panicle girth (cm)                          | rg                     |                    |                     |                                        |                                         |                      |                     |                      | 0.77                     | 0.65                               | 0.39                         | 0.30          | -0.10                  |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      | 0.78                     | 0.58                               | 0.30                         | 0.30          | 0.03                   |
| 10.    | Panicle weight (gms)                        | rg                     |                    |                     |                                        |                                         |                      |                     |                      |                          | 0.51                               | 0.54                         | 0.23          | 0.19                   |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          | 0.48                               | 0.43                         | 0.24          | 0.22                   |
| 11.    | Number of primaries per panicle             | rg                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    | 0.55                         | 0.24          | 0.17                   |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    | 0.56                         | 0.24          | 0.26                   |
| 12.    | Number of whorls of primaries per panicle   | rh                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              | 0.15          | 0.01                   |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              | 0.13          | 0.06                   |
| 13.    | Stover yield per plant (g)                  | rg                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | -0.61                  |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | -0.55                  |
| 14.    | Harvest index                               | rg                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | -0.14                  |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | -0.13                  |
| 15.    | 500-grain weight (g)                        | rg                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | 0.27                   |
|        |                                             | rp                     |                    |                     |                                        |                                         |                      |                     |                      |                          |                                    |                              |               | 0.20                   |

\*Significant at 5%; \*\*Significant at 1%

Table 3. Path coefficient analysis indicating direct and indirect effects of various components on seed yield in sorghum (*Sorghum bicolor* (L.) Moench)

| S. No. | Character                                   | Days to 50% flowering | Days to maturity | Plant height (cm) | Number of leaves per plant | Leaf area per plant (cm <sup>2</sup> ) | Flag leaf area per plant (cm <sup>2</sup> ) | Peduncle length (cm) | Panicle length (cm) | Panicle girth (cm) | Panicle weight (g) | Number of primaries per panicle | Number of whorls | Stover yield per plant (g) | Harvest index | 500-grain weight (g) | Correlation with grain yield per plant |
|--------|---------------------------------------------|-----------------------|------------------|-------------------|----------------------------|----------------------------------------|---------------------------------------------|----------------------|---------------------|--------------------|--------------------|---------------------------------|------------------|----------------------------|---------------|----------------------|----------------------------------------|
| 1.     | Days to 50% flowering                       | 0.428                 | 0.140            | 0.014             | -0.465                     | -0.138                                 | 0.055                                       | -0.083               | -0.004              | 0.048              | 0.132              | -0.007                          | -0.003           | -0.018                     | 0.000         | 0.004                | 0.094                                  |
| 2.     | Days to maturity                            | 0.353                 | 0.170            | 0.011             | -0.385                     | -0.118                                 | 0.0548                                      | -0.069               | 0.005               | 0.023              | 0.157              | -0.008                          | -0.021           | -0.018                     | 0.000         | 0.003                | 0.137                                  |
| 3.     | Plant height (cm)                           | 0.73                  | 0.023            | 0.082             | -0.145                     | -0.061                                 | 0.0295                                      | -0.019               | -0.001              | 0.113              | 0.394              | -0.042                          | -0.026           | -0.021                     | 0.000         | 0.051                | 0.455                                  |
| 4.     | Number of Leaves per plant                  | 0.395                 | 0.130            | 0.023             | -0.505                     | -0.152                                 | 0.00                                        | -0.086               | -0.011              | 0.106              | 0.278              | -0.016                          | -0.006           | -0.022                     | 0.000         | 0.022                | 0.216                                  |
| 5.     | Leaf area per plant (cm <sup>2</sup> )      | 0.39                  | 0.115            | 0.029             | -0.442                     | -0.174                                 | 0.079                                       | 0.078                | -0.005              | 0.135              | 0.436              | -0.029                          | -0.018           | -0.023                     | 0.000         | 0.019                | 0.373                                  |
| 6.     | Flag leaf area per plant (cm <sup>2</sup> ) | 0.234                 | 0.072            | -0.369            | -0.144                     | 0.024                                  | -0.09                                       | -0.002               | 0.148               | 0.523              | -0.028             | -0.025                          | -0.025           | -0.018                     | 0.000         | 0.023                | 0.459                                  |
| 7.     | Peduncle length (cm)                        | -0.284                | -0.094           | -0.090            | 0.349                      | 0.108                                  | -0.055                                      | 0.125                | 0.026               | -0.152             | 0.244              | 0.023                           | -0.003           | 0.017                      | -0.000        | 0.003                | -0.180                                 |
| 8.     | Panicle length (cm)                         | -0.033                | 0.04             | -0.090            | 0.099                      | 0.015                                  | -0.033                                      | 0.059                | 0.056               | 0.143              | 0.034              | 0.011                           | -0.033           | 0.000                      | 0.000         | -0.015               | 0.062                                  |
| 9.     | Panicle girth (cm)                          | 0.08                  | 0.015            | 0.035             | -0.203                     | -0.089                                 | 0.045                                       | -0.072               | -0.029              | 0.264              | 0.72               | -0.059                          | -0.046           | -0.012                     | 0.000         | 0.024                | 0.692                                  |
| 10.    | Panicle weight (g)                          | 0.060                 | 0.025            | 0.034             | -0.148                     | -0.080                                 | 0.045                                       | -0.032               | 0.002               | 0.204              | 0.945              | -0.049                          | -0.046           | -0.009                     | 0.000         | 0.024                | 0.979                                  |
| 11.    | Number of primaries per panicle             | 0.033                 | 0.015            | 0.038             | -0.087                     | -0.056                                 | 0.025                                       | 0.032                | -0.007              | 0.172              | 0.486              | -0.091                          | -0.047           | -0.047                     | 0.000         | 0.029                | 0.468                                  |
| 12.    | Number of whorls of primaries per panicle   | 0.012                 | 0.042            | 0.026             | -0.036                     | -0.037                                 | 0.023                                       | 0.004                | 0.021               | 0.103              | 0.514              | -0.050                          | -0.085           | -0.006                     | 0.000         | 0.027                | 0.562                                  |
| 13.    | Stover yield per plant (g)                  | 0.197                 | 0.077            | 0.042             | -0.272                     | -0.097                                 | 0.036                                       | -0.052               | -0.000              | 0.081              | 0.219              | -0.022                          | -0.013           | -0.041                     | 0.000         | 0.019                | 0.174                                  |
| 14.    | Harvest index                               | -0.231                | -0.079           | -0.031            | 0.306                      | 0.089                                  | -0.032                                      | 0.053                | 0.009               | -0.027             | 0.178              | 0.005                           | 0.002            | 0.025                      | -0.000        | -0.015               | 0.250                                  |
| 15.    | 500-grain weight (g)                        | 0.016                 | 0.004            | 0.038             | -0.106                     | -0.039                                 | 0.016                                       | 0.003                | -0.007              | 0.058              | 0.209              | -0.024                          | 0.021            | 0.007                      | 0.000         | 0.111                | 0.269                                  |

Residual effect = 0.1203; Figures in under line indicated direct effect

\*Significant at 5%; \*\*Significant at 1%

Plant height, yield, leaf area, peduncle length and harvest index, revealed high GCV,  $h^2$  and genetic gain also showed positive and significant correlation with grain yield. Hence, selection for the traits would be more effective to improve grain yield. Panicle weight, panicle girth and days to 50 per cent flowering showed high direct effect on grain yield. Therefore, more importance should be given for the selection of these attributes to identify better genotypes for high grain yield in sorghum.

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## ARID AGROBIODIVERSITY AND CONSERVATIVE DESERT DWELLERS

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Over a large part of the State of Rajasthan, agriculture is a struggle against inhospitable nature. About a third of the state is stark desert - the Thar, which represents the harshest agricultural environment of India. Conservatism, as regards to agricultural practices and utilisation of agricultural produce is deeply ingrained in the cultivators of Thar desert and is the outcome of loosing everything year in and year out. In a bid to grow, multiply and utilise every blade of grass available, the desert dwellers have found out innovative means of sowing, managing, harvesting and utilizing agro-biodiversity around them. In fact, their livelihood and lives revolve around the genetic wealth which is used extensively and resolutely. Traditionally, they have been very conscious of conservation and have allowed multiplication and regeneration of plants even when utilising it. Some of the practices of biodiversity conservation are unique in this land and have strengthened the life support system of the area for facing challenges of inhospitable hot deserts. The awareness of phenological stages of plants, the optimum time of harvest, the quantum of utilisation and the amount of conservation is ingrained in the traditions and folklores. Though natural catastrophes, overgrazing and overutilisation has threatened plant genetic resources since ages, but in this century it is the fast pace of human intervention, much faster than nature and natural calamities that are a threat to such fragile ecosystems. The need is thus to understand and practice the conservation of desert wealth with the involvement of conservative desert dwellers and their indigenous technical knowledge (ITK) thereby promoting the conservation ethics and retaining the traditional cultural values.

**Key words:** Arid agrobiodiversity, Rajasthan, indigenous technical knowledge.

The Indian arid zone extending from 24° to 30° N and 70° to 76° E occupies nearly 32 million ha of land, of which 28.6m ha comprised the Thar desert of Western India in Rajasthan and partly States of Gujarat, Haryana and Punjab. Sandy soils of aeolian origin dominate the desert environment. Nearly 62 per cent of the area is occupied by dunes and interdunal plains. Agriculture, here, is a struggle against inhospitable nature. The scenario has been shifting from bad to worse in some situations due to natural resource constraints on one hand and submarginal lands, overgrazing of pasture land and indiscriminate cutting of vegetation for fodder

and fuel are the main causal factors. If the cycle goes on without suitable interventions, the process may no longer be reversible. It is inevitable thus, to make the system sustainable and protect the depleting PGR by planning a farming system research (FSR) with maximum possible involvement of farmers/desert dwellers. Planning an on-farm system research requires a perfect understanding of what farmers are actually doing. Three sets of information are needed to initiate FSR- existing resources and socioeconomic conditions of people; their perceptions, priorities, requirements and indigenous technical knowledge.

## NATURAL RESOURCES AND EXISTING SYSTEMS

The very reference of Rajasthan brings to our mind the vast number of shifting sand dunes, caravans of camels, scanty, scrubby vegetation and above all too frequent famines. About a third of the State is stark desert. Shifting sand dunes submerge the thin layer of good top soil in adjoining areas. The rainfall is scanty and erratic, resulting in drought conditions once every three years in eastern region and once every two years in the Western region. The State has no perennial rivers and the groundwater resources so far brought under exploitation are meagre. The water table lies very deep and much of the water is brackish and saline. The vegetation is sparse, consists of thorny, stunted shrubs and it occurs in open clump formations with spaces in between. It can be distinctively divided into ephemerals and perennials, is zerophytic in character and contain highly specialised plants (Bhandari, 1990).

## THE DESERT DWELLER

Amidst all harsh environmental conditions lives the desert dweller, who had adapted their way of life so as to match the availability of resources and environment. Basically, the requirements are limited and they are very simple people.

*Navi munjha ri khat, kay na choovay tapri,  
Bhaisan la diya do char, kay na doojay bapri,  
Bajar handa vot, dahi mein oolnan,  
Itra dey karttar, pher na boolan.*

(A bed of newly twisted cords, an unleaking roof, two or three milch cows, bajra bread with curd are all that I desire. If I get all this then I want no more)

They are also knowledgeable and have gradually acquired ways and means to learn about their surroundings, the weather, the crop and the

management strategies to be adopted from natural phenomenon occurring periodically or seasonally.

*Sawan patti panchmi, jo baje bahu baya,  
Kal pare sare des mein, minakh minakh ne  
khaya.*

(If strong winds blows on fifth day of the second half of sawan (July-August), it is a sign of country wide famine when man will eat man).

*Sawan mein jo suryo chale, bhaduri purvai,  
Asojan mein pichwa chale, bhar bhat quara  
lai.*

(If the wind blows from north east in Sawan (July-August), from east in bhadon (August-September), from west in Asoj (September-October), the harvest will be a bumper one.)

*Khad pare to khet, nahin to kori ret.*

(Without fertilizer or manure, agricultural field is nothing but a heap of sand).

## As a Custodian

The indigenous landraces of various crop plant species, their wild relatives, the wild and weedy species, shrub and trees that form the basis of arid/semiarid plant genetic resources are all highly prized for their potential value as sources of important variations for crop improvement programmes.

Among the most important traits that are believed to exist in these materials are earliness, disease and pest resistance, nutritional quality, resistance to drought and other stresses and characteristics especially useful in low input agriculture. The existence of such diversity has special significance in maintenance and enhancement of productivity of agricultural crops of dry regions with harsh and diverse growing conditions. Such diversity provides security for the farmer against adverse growing conditions. It

also allows farmers to exploit full range of highly varied microenvironments such as soil, water, temperature, altitude, slope and fertility. Diversity among species is specially significant to Indian arid region as it represents an important subsistence resource to farming communities in the country. A wide variety of plant and animal species provides material for food, fibre, medicine and other socioeconomic uses. Such diversity is also crucial to sustain current production systems essential for the livelihood of local communities.

### As a Cultivator

In Indian arid region, the cultivator or the farmer is instrumental in conserving germplasm as they control the bulk of the specialised and unique genetic resources. His decision making is influenced by socio-economic factors, cultural factors, government policies and environmental factors, on one hand. On the other hand, his

diversity management has consequences for the genetic structure of the crop and is also influenced by environmental factors through natural selection. Furthermore, although farmers cannot observe or appreciate the genetic structure of the crop, they gain knowledge of morphological traits expressed (e.g., yield, plant stature, resistance to drought, insects). This knowledge is in turn used in their decision making processes regarding their management of diversity as is done by farmers all over the world (Bellon *et al.*, 1997).

Despite modernisation in agriculture and modern varieties, the small farmer of this region is very conservative in his approach to accepting a change. They use modern varieties, especially of bajra, but yet they continue to grow locally adapted or *desi* varieties. They grow mostly rainfed crops (bajra, mung, moth, guar and til) and some irrigated crops like chillies, groundnut, wheat and brassica wherever irrigation facilities are available.

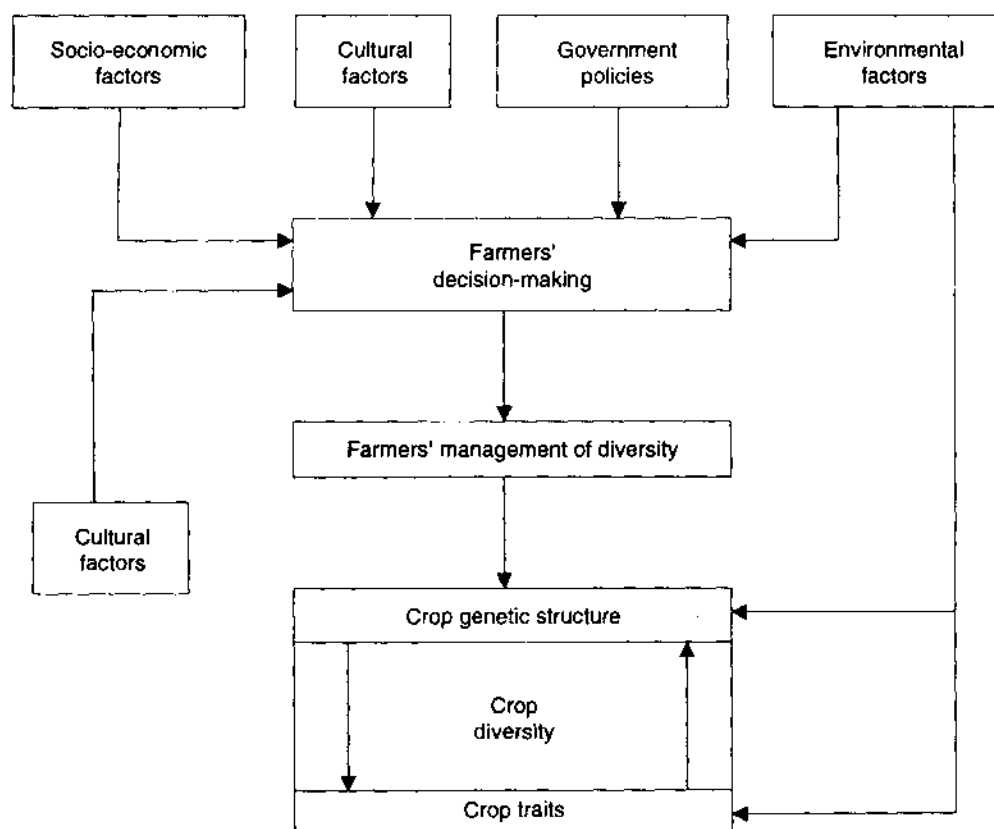


Fig. 1. Conceptual model of the factors that influence farmers' management of diversity



Fig. 2. Sowing of crops in mixtures to ensure survival of at least few of them in the event of drought. Seen here are plants of cucurbits, bajra, mothbean and mungbean crop.

#### As a Consumer

He uses every blade of grass available :

*Ak ra jhopra, phog ra bar,*

*Bajra ri roti, moth ri dal,*

*Dekho ho raja, teri marwar*

(We live in huts made of *Calotropis* plants, put fences of *Calligonum* and other plants, we eat roti (bread) made of pearl millet flour along with dal of moth. This is all about your Marwar O'King). Some of the major plants used by desert dweller are as in Table 1.

#### As a Conservor

Conservation efforts as regards to agricultural practices and utilization of agricultural produce is deeply ingrained in the desert dweller; a sad



Fig. 3. Selective pruning of khejri trees leaving behind few apical portions to ensure regeneration of entire tree.

outcome of loosing everything year in and year out. They have devised several ways and methods to conserve plant, vegetation, trees, shrubs and agricultural produce in usable form.

Farmers always retain some seed stock of numerous crops for severity unless disruptive circumstances prevent them from doing so. Mechanism have also been developed for safe storage of seeds.

Individual farmers often store seeds in clay pots and straw baskets which are sealed, buried or stored in secure places. Length of storage may vary from a year as seed stock, for food in current year or for long term storage for some social event. In times of famine, farmers bury their seeds in some secured place within farm premises

Table 1. Some plants commonly used by desert-dwellers

| Forage Plants                 | Medicinal Plants              | Industrial Plants              |                                |
|-------------------------------|-------------------------------|--------------------------------|--------------------------------|
| <i>Lepidagathis cristata</i>  | <i>Barleria prionites</i>     | <b>Fibre Plants:</b>           | <i>Acacia nilotica</i>         |
| <i>Pluchea lanceolata</i>     | <i>Blepharis indica</i>       | <i>Calotropis gigantea</i>     | <i>Acacia planifrons</i>       |
| <i>Tecomella undulata</i>     | <i>Lepidagathis cristata</i>  | <i>Calotropis procera</i>      | <i>Acacia senegal</i>          |
| <i>Sarcostemma</i>            | <i>Wrightia tinctoria</i>     | <i>Leptadenia pyrotechnica</i> | <i>Prosopis cineraria</i>      |
| <i>pauviflorum</i>            | <i>Sarcostemma acidum</i>     | <i>Opuntia elatior</i>         | <i>Flacourtia sepiaria</i>     |
| <i>Opuntia elatior</i>        | <i>Dicoma tomentosa</i>       | <i>Cordia dichotoma</i>        | <i>Moringa oleifera</i>        |
| <i>Kochia indica</i>          | <i>Heliotropium strigosum</i> | <i>Acacia leucophloea</i>      | <i>Calligonum polygonoides</i> |
| <i>Anogeissus pendula</i>     | <i>Boswellia serrata</i>      | <i>Butea monosperma</i>        | <i>Mitragyna parviflora</i>    |
| <i>Acacia nilotica</i>        | <i>Opuntia elatior</i>        | <i>Crotalaria burchia</i>      | <i>Morinda citrifolia</i>      |
| <i>Acacia planifrons</i>      | <i>Capparis decidua</i>       | <i>Sida cordifolia</i>         | <i>Ailanthus excelsa</i>       |
| <i>Acacia senegal</i>         | <i>Haloxylon recurvum</i>     |                                |                                |
| <i>Alhagi psuedalhagi</i>     | <i>Kochia indica</i>          | <b>Fuel Plants :</b>           | <b>Dye and tannin plants</b>   |
| <i>Crotalaria burhia</i>      | <i>Cressa cretica</i>         | <i>Aerva persica</i>           | <i>Wrightia tinctoria</i>      |
| <i>Crotalaria medicagenia</i> | <i>Citrullus colocynthis</i>  | <i>Leptadenia pyrotechnica</i> | <i>Kochia indica</i>           |
| <i>Prosopis cineraria</i>     | <i>Euphorbia caudicifolia</i> | <i>Sarcostemma acidum</i>      | <i>Anogeissus pendula</i>      |
| <i>Rhyncosia aurea</i>        | <i>Acacia senegal</i>         | <i>Boswallia serrata</i>       | <i>Acacia nilotica</i>         |
| <i>Rhyncosia minima</i>       | <i>Butea monosperma</i>       | <i>Capparis decidua</i>        | <i>Butea monosperma</i>        |
| <i>Anamitra cocculus</i>      | <i>Crotalaria burhia</i>      | <i>Haloxylon recurvum</i>      | <i>Cassia auriculata</i>       |
| <i>Aristida adscensionis</i>  | <i>Crotalaria medicagenia</i> | <i>Euphorbia caudicifolia</i>  | <i>Morinda citrifolia</i>      |
| <i>Cenchrus ciliaris</i>      | <i>Dichrostachys cinerea</i>  | <i>Securinega leucopyrus</i>   |                                |
| <i>Cenchrus setigerus</i>     | <i>Mimosa rubicaulis</i>      | <i>Acacia jacquemontii</i>     | <b>Gum, wax and</b>            |
| <i>Cymbopogon jwarancusa</i>  | <i>Prosopis cineraria</i>     | <i>Acacia nilotica</i>         | <b>resin Plants:</b>           |
| <i>Dactyloctenium</i>         | <i>Flacourtia sepiaria</i>    | <i>Acacia planifrons</i>       | <i>Sarcostemma acidum</i>      |
| <i>aegypticum</i>             | <i>Secrinega leucopyrus</i>   | <i>Acacia senegal</i>          | <i>Boswellia serrata</i>       |
| <i>Dactyloctenium</i>         | <i>Leucas cephalotus</i>      | <i>Prosopis cineraria</i>      | <i>Commiphora wightii</i>      |
| <i>indicum</i>                | <i>Leucas utricaeifolia</i>   | <i>Moringa oleifera</i>        | <i>Anogeissus pendula</i>      |
| <i>Desmostachya</i>           | <i>Anamitra cocculus</i>      | <i>Calligonum polygonoides</i> | <i>Acacia jacquemontii</i>     |
| <i>bipinnata</i>              | <i>Mollugo nudicaulis</i>     | <i>Zizyphus nummularia</i>     | <i>Acacia nilotica</i>         |
| <i>Eleusine compressa</i>     | <i>Chionachne koenigii</i>    | <i>Mitragyna parviflora</i>    | <i>Acacia senegal</i>          |
| <i>Elyonurus hirsutus</i>     | <i>Cymbopogon</i>             | <i>Balanites aegyptica</i>     | <i>Butea monosperma</i>        |
| <i>Eragrostis ciliaris</i>    | <i>jwarancusa</i>             | <i>Grewia tenax</i>            | <i>Prosopis cineraria</i>      |
| <i>Lasiurus ecaudatus</i>     | <i>Desmostachya bipinnata</i> | <b>Timber Plants:</b>          | <i>Moringa oleifera</i>        |
| <i>Melanocenchris</i>         | <i>Zizyphus nummularia</i>    | <i>Wrightia tinctoria</i>      | <i>Salvadora oleoides</i>      |
| <i>jacquemontii</i>           | <i>Morinda citrifolia</i>     | <i>Tecomella undulata</i>      | <i>Salvadora persica</i>       |
| <i>Panicum turgidum</i>       | <i>Salvadora oleides</i>      | <i>Boswellia serrata</i>       | <i>Ailanthus excelsa</i>       |
| <i>Sehima nervosum</i>        | <i>Salvadora persica</i>      | <i>Anogeissus acuminata</i>    |                                |
| <i>Zizyphus nummularia</i>    | <i>Ailanthus excelsa</i>      | <i>Anogeissus latifolia</i>    |                                |
| <i>Salvadora oleides</i>      | <i>Balanites aegyptica</i>    | <i>Anogeissus pendula</i>      |                                |
| <i>Salvadora persica</i>      | <i>Tamarix troupii</i>        | <i>Anogeissus rotundifolia</i> |                                |
| <i>Ailanthus excelsa</i>      | <i>Grewia tenax</i>           | <i>Cordia dichotoma</i>        |                                |
| <i>Grewia tenax</i>           | <i>Clerodendrum phlomidis</i> | <i>Cordia gharaf</i>           |                                |



Fig. 4. Some permanent/semi permanent structures created for long term seed storage in villages by desert dwellers. They store entire cereals and pulses in these structures even today.

before they migrate to other regions, returning to reclaim and plant the seeds after the drought is over. The desert dwellers have also been instrumental in creating, maintaining and promoting crop genetic diversity through a series of other long standing activities which include sowing of mixture of seeds in order to ensure survival of atleast one or two type of crop (Fig. 2), planting trees in farm, optimum drying of seeds, optimum pruning of trees especially khejri trees (Fig. 3), etc. They have also designed storage structures for seeds (Fig. 4) like *kinaras*, *kothis*, etc. They mix the seeds with *rakh* or ash (Fig. 5) and store the seeds. Specialized storage structures have also been developed for the storage of fodder

and fuel for short as well as long term. Medicinal plants deserve special attention because not only are they of immense value in averting or treating common ailments but their conservation also means retention of the indigenous knowledge associated with their unique properties and correct applications.

#### THREAT OF GENETIC EROSION

The broad range of genetic diversity existing in Indian arid region (like in other arid regions of the world) particularly the primitive and wild gene pools, is presently subjected to serious genetic erosion and irreversible losses. This threat which



Fig. 5. An old desert dweller displaying the mixture of mung seeds and rakh kept for storage. She has been using this method since long now and is not aware of any other way the seed could be stored.

involves the interaction of several factors, is progressing at an alarming rate. The most crucial ones include displacement of indigenous landraces by new genetically uniform crop cultivars, changes and development in agriculture or land use, destruction of habitats and ecosystems and drought.

Famines and severe droughts sometimes force the farmers to eat their conserved seeds in order to survive or to sell the seed as food commodity. This often results in massive displacement of native seed stock by seeds of hybrid varieties provided by relief agencies in the form of food grains. Also a high proportion of alleles of the major crop plants have been conserved *ex-situ*, with the evolutionary process nearly frozen in time, such that new germplasm is not generated (Worede, 1997). On the social front, there has

also developed a communication gap between the youth and elders in farming communities which affects the flow of indigenous knowledge related to biodiversity and its utilization in farming systems (Damania, 1996).

### NEED FOR *IN-SITU* CONSERVATION

The maintenance of species and genetic diversity in fields is an effective strategy that desert dwellers have long adapted to sustain a stable system of conservation for low input agriculture. *In-situ* (on site) conservation of land races on peasant farms which is also known as evolutionary conservation would therefore, provide a valuable option for conservation of crop diversity (Worede, 1991). More importantly, it will help to sustain the evolutionary systems that are responsible for the generation of genetic variability. This is especially significant in regions of the country subject to drought and other stresses, because it is under such environmental stresses that variation useful for stress resistance breeding is generated. Also, under these conditions, access to a wide range of local land races would probably provide the only reliable source of planting material. The ability of landraces to survive under these stresses is conditional by their inherent broad genetic base (Worede, 1997).

Under these extreme environments, locally adapted landraces would provide suitable base material for institutional crop improvement programmes. Thus, *in-situ* conservation provides a broad genetic base, maintenance of population structure, stability of population numbers and opportunities for future adaptive expansion. However, agricultural crop diversity cannot be preserved *in-situ* without simultaneously encouraging the traditional culture of the farm community which fostered it and protected it. There is therefore, an outstanding need to maintain landraces growing under these conditions in their dynamic state and this can probably be best

achieved through farm or community based conservation programmes.

### CONSERVATION AND UTILIZATION

The value of landraces to farming communities in region which are dry and with erratic rainfall lies in their utility as a dependable source of planting and breeding material. It is therefore, important that locally adapted/enhanced seeds are multiplied and distributed to farmers whose requirements have not been adequately met by modern high input cultivars. It may otherwise make very little sense to conserve landraces or may even be difficult to convince farmers to do so unless the landrace conservation activity is oriented towards supporting sustainable production.

The Community Seed Banks can be established. These are low cost technological systems that can be used and managed by local communities involving existing community service cooperatives. It comprises of two major components, a seed store and a germplasm repository for local crop improvement. The seed store represents a seed reserve system. The small traditional storage units clay pots, pits etc., form an integral part of traditional storage systems.

Lately, on-farm conservation (Altizeri and Merrick, 1987; Oldfield and Alcorn, 1987; Brush, 1991a) has been advocated to complement *ex-situ* conservation. For more than two decades, on farm conservation of crop and landraces was considered impractical and inappropriate (Arnold *et al.*, 1986). However, concern in developing countries about the concentration of genetic resources in genebanks and the fact that static conservation halts evolutionary processes have opened a debate concerning the value and objectives of on-farm conservation methods. Rural societies maintain agricultural biodiversity because it is essential for their survival. They select and breed new varieties

for the same reason. There is no useful distinction for them between conservation and development. Indeed, conservation as such may not be a concept known to farmers. On-farm conservation of local varieties is an existing strategy for food security. By its very nature on-farm conservation is dynamic because the varieties farmers use continue to evolve in response to natural and human selection. It is believed that in this way crop population retain adaptive potential for the future (Bellon, *et al.*, 1997).

Endowed with so much knowledge on use and conservation of indigenous plant species besides crop, the desert dwellers of Indian arid zone cannot be ignored during planning elaborative conservation programmes. In fact, the Vishnoi people, basically a farming community of Rajasthan have communal ownership of land and they assign rights to the whole ecosystem in the land under their influence. Their benevolent and peaceful disposition towards all forms of life precludes the cutting of living trees for wood and they have conserved innumerable forms of indigenous crops, flora and fauna for many centuries (Tiwari, 1993). Thus, they need to be involved as primary consultants of conservation programmes.

Till now more than 12,000 germplasm accessions have been assembled of diverse crops for *ex-situ* conservation. But little effort has been made to document the wealth of information available with these villagers on economic and medicinal plants, then utilize the information by actually finding the scientific principle behind each tradition and trying to upgrade this information and modify this information to be returned to villagers.

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## PROBLEMS AND PROSPECTS IN CONSERVATION OF GENETIC RESOURCES IN RADISH (*Raphanus sativus* L)

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Radish germplasm is commonly conserved through the seeds. These are relatively short lived under ambient conditions. Seeds of cv 'Pusa Reshmi' dried to 6.5 per cent moisture were packed in glass, kraft paper, polyethylene bags (300 gauge) and laminated aluminium foil pouches, stored at low (5°C) and sub-zero (-20°C) temperatures for 15 years. Seed viability was successfully conserved for 15 years both at 5°C and -20°C storage. The retention of high viability and vigour observed in seeds stored in polyethylene and laminated aluminium foil pouches at 5°C and in laminated aluminium foil pouches at -20°C. There were no morphological changes in shoot and root characteristics. This conservation process can easily be practiced, which is cheaper and retains the identity of genotype.

**Key words:** Radish, conservation, seed storability

Radish is an important commercial vegetable crop in temperate, sub-tropical and tropical regions. Its fleshy tuberous roots are eaten fresh and cooked. Also tender foliage and pods are used as vegetables. It exhibits large variations for root shape, size and colour. The preference and choice of genotype vary in different agro-climatic regions of the world. The variations for plant characteristics genetically controlled and required for survival of plant under changing environments includes emergence of pests and diseases. Now these valuable genes are being eroded due to changing cultivation practices wherein low yielding cultivars have been replaced with high yielding ones. Non-availability of suitable simple storage technology poses threat to genetic conservation. In radish, seeds are predominantly used for cultivation. Seeds exhibit orthodox storage behaviour. It deteriorates faster especially at higher storage temperatures and humidity (Abdul-Baki and Anderson, 1972). Seed longevity depends on age and nature of seed conservation (Harrington

and Satyati-Harjadi, 1966) and method of storage (Popovska *et al.*, 1981). The crop yields are also affected by raising the plants from older seeds (Frohlich and Henkel, 1964). Certain packaging materials are effective in protecting seeds from high level of humidity, insect pests and other storage fungi. Selection of suitable packaging depends on kind of seed material and duration of storage. Such information is lacking in radish that is essential for designing suitable techniques for long term genetic conservation. Thus, an experiment conducted with the view to enhance seed storability in radish by using certain packaging and storage temperatures.

### MATERIALS AND METHODS

Seeds of radish cv Pusa Reshmi extracted from mature pods and dried to 6.5 per cent moisture with the help of silica gel were packed in glass, kraft paper, polyethylene bags (300 gauge) and laminated aluminium foil pouches and stored at (5°C) and sub-zero temperatures (-20°C) for

15 years. Seed viability is expressed in percentage of germination. Seed was tested for viability and vigour periodically. One hundred seeds in each replication, in three replications germinated by 'top of paper' method at an alternate temperature of 20-30°C for 16 and 8 hours respectively in seed germinator. Seedlings were evaluated according to the standard ISTA procedures. Seedling vigour compared by means of coefficient of germination, root length, shoot length, dry weight and vigour indices. Shoot and root length recorded on 7 days old seedlings. Dry weight was recorded on seedlings dried at 60°C for 48 hours. Seed vigour was calculated by using germination speed and expressed as sum of days taken for germination while vigour indices I and II were calculated by multiplying percentage of germination with seedling length and dry weight respectively.

## RESULTS AND DISCUSSION

Seed viability was significantly affected by packaging and storage temperatures. Radish seeds could be conserved successfully for 15 years during experimentations. It has been reported that viability was lost after 7 years of ambient storage wherein only about 50 per cent of seeds germinated (Doijode, 1991). Further, seed storability extended

longer with the help of certain packaging and storage temperature. At 5°C storage, seeds exhibited higher percentage of germination (> 99) when stored in polyethylene, glass and laminated aluminium foil pouches whereas only 54 per cent seeds germinated when stored in kraft paper bags. Likewise, there was significant decline in coefficient of germination and delay in emergence of seedlings in kraft paper bags stored seeds. This suggests commencement of seed deterioration process which follows by the reduction in germination percentage.

**Table 1. Influence of packaging and storage temperatures on seed viability during 15th years of storage**

| Storage Temp (°C) | Storage Containers | Coeff of germination | Germination (%) after 24 hrs | Final 15 days |
|-------------------|--------------------|----------------------|------------------------------|---------------|
| 5                 | Glass              | 60.8                 | 40                           | 99            |
|                   | Kraft paper        | 26.4                 | 0                            | 54            |
|                   | Polyethylene       | 82.5                 | 79                           | 100           |
|                   | Al foil            | 91.3                 | 89                           | 99            |
| - 20              | Glass              | 0                    | 0                            | 0             |
|                   | Kraft paper        | 0                    | 0                            | 0             |
|                   | Polyethylene       | 50.2                 | 35                           | 89            |
|                   | Al foil            | 83.7                 | 83                           | 99            |
| C D at 1%         |                    | 14.9                 | 8.3                          | 8.9           |

**Table 2. Effect of packaging and storage temperature on seedling vigour of stored seeds for 15 years**

| Storage Tempr. (°C) | Storage Containers | Shoot length (cm) | Root length (cm) | Dry wt. (mg) | Vigour | Vigour indices |     |
|---------------------|--------------------|-------------------|------------------|--------------|--------|----------------|-----|
|                     |                    |                   |                  |              |        | I              | II  |
| 5                   | Glass              | 5.3               | 4.6              | 9.3          | 68.9   | 953            | 887 |
|                     | Kraft paper        | 2.9               | 1.5              | 3.2          | 16.2   | 242            | 171 |
|                     | Polyethylene       | 4.2               | 2.6              | 9.3          | 89.3   | 680            | 896 |
|                     | Al foil            | 3.7               | 2.2              | 5.6          | 94.0   | 778            | 812 |
| - 20                | Glass              | -                 | -                | -            | -      | -              | -   |
|                     | Kraft Paper        | -                 | -                | -            | -      | -              | -   |
|                     | Polyethylene       | 5.8               | 4.8              | 8.6          | 90.7   | 973            | 922 |
| C D at 1%           |                    | 1.3               | 1.1              | 3.4          | 8.7    | 167            | 192 |

At sub-zero ( $-20^{\circ}\text{C}$ ) temperature, seeds stored in polyethylene and laminated aluminium foil pouches exhibited greater percentage of germination ( $> 89$ ) unlike none in kraft paper and glass containers, which might be due to moisture. Seeds stored in polyethylene bags exhibited early deterioration as evidenced by decline in coefficient of germination and delay in seedling emergence.

Seedling characteristics such as shoot, root length and dry weight were greater for seeds stored at  $-20^{\circ}\text{C}$  than at  $5^{\circ}\text{C}$  (Table 2). Seed vigour was the maximum in seeds stored in laminated aluminium foil pouches both at  $5^{\circ}\text{C}$  and  $-20^{\circ}\text{C}$  storage. Similarly, vigour indices I and II were greater for seeds stored in laminated aluminium foil pouches at sub-zero temperatures.

Radish seeds are fairly good storer under ambient conditions. Thus, germplasm in the form of seeds can be effectively conserved for shorter period. Fonseca *et al.* (1980) said that seeds stored at ambient temperatures began to deteriorate faster and showed lower germination and low seedling vigour. Seeds stored in polyethylene bags at  $5^{\circ}\text{C}$  retained high viability. The semipervious nature of polyethylene bags prevent the entry of moisture vapour as well as gases to certain extent. Thus it helps in preserving high viability especially for moderate period (15 years). These polyethylene bags are easily available and cheaper therefore germplasm can be conserved economically at  $5^{\circ}\text{C}$  for 15 years. James (1967) reported that high seed moisture is more injurious particularly when stored in moisture proof containers. Therefore care should be taken to preserve well-dried seeds especially while using moisture proof containers like laminated aluminium foil pouches. Seeds stored in laminated aluminium foil pouches

exhibited higher percentage of germination and higher seedling vigour. It has many advantages like moisture vapour proof, handy, moderately expensive and effective in retaining high viability for very long period at sub-zero temperatures. These stored seeds were sown in the field and no morphological differences were noticed for plant characteristics.

It is concluded that seed germplasm can be effectively conserved in polyethylene bags at  $5^{\circ}\text{C}$  for medium term storage (up to 15 years). However, for long term conservation ( $> 15$  years), it is advisable to pack well-dried seeds in laminated aluminium foil pouches and store them at sub-zero temperatures ( $-20^{\circ}\text{C}$ ), resulting effective germplasm conservation in radish.

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## USE OF TRADITIONAL KNOWLEDGE AND BIOTECHNOLOGICAL INTERVENTIONS FOR SUSTAINABLE DEVELOPMENT

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Parallel to its rich agroclimatic diversity, India is equally rich in biodiversity. These biological resources have provided useful gene pool to humankind since time immemorial. However, a number of such biological resources have been lost due to over-exploitation on the one hand, and immense selection and domestication of fewer species on the other. Thus in the context of the present demand and future needs, the major global concern is for the conservation and sustainable utilization of our genetic resources for sustainable growth. The Convention of Biological Diversity was formulated during the UNCED Earth Summit held at Rio de Janeiro in Brazil in June 1992 to achieve these goals. While the technologically rich developed countries lack genetic resources, most of the developing countries including India, have not been able to get full benefit from its biological riches due to lack of sound technologies. It is, therefore, important to strengthen our technologies and rise to the much desired status of technologically and genetic resources rich nation. It becomes mandatory to bioprospect, document and conserve the valuable gene pool. It may also involve adequately compensating the indigenous communities that have conserved the biological resources through centuries, and have also generated valuable knowledge regarding their use. There is a need for using traditional knowledge and biotechnological interventions for sustainable utilization of plant genetic resources. This paper highlights an urgent need for systematic programme of bioprospecting of India's rich biodiversity using molecular and biochemical approaches. Such a systematic study would enable identification of new genes and molecules that may be useful in agriculture, medicine and other cognate disciplines.

**Key words** · Biodiversity, indigenous knowledge, biotechnology, bioprospecting, benefit sharing

India commands a unique phytogeographical and agroecological diversity. With only 2.4 per cent of the total land area of the world, it contributes a significant 8 per cent to the known global biodiversity. It is one of the twelve mega biodiversity centres in the world. India holds tenth position in the world in terms of mammalian species and eleventh in terms of the endemic species of higher vertebrates. It ranks tenth in the world and fourth in Asia with respect to

plant diversity and stands seventh in the world for the number of species contributing to agriculture and animal husbandary.

Out of the 18 hotspots in the world, two are located in India; the eastern Himalayas and the western ghats, both of which have rich genetic diversity. Approximately 1.7 million species have been described so far, out of this 1,26,188 have been recorded in India. Based on about 70 per cent of the total geographical area surveyed so

far, 49,000 plant species and 81,000 animal species have been recorded by the Botanical Survey of India and Zoological Survey of India, respectively (MoEF, 1997).

The existing biodiversity has been a result of billions of years of co-evolution of plants, animals and human beings. During this evolutionary process, the effect of human interference were minimal. However, during subsequent generations, mankind have continuously selected and domesticated fewer species for their specific requirements. While the earth had about 2,50,000 plant species, man has utilized only about 3000 plant species and the present day agriculture is confined to only about 150 species (Rana, 1995). Out of this, 20 crop species provide 90 per cent of the calories to the entire mankind, and rice, wheat and maize supply almost 60 per cent of the calories and protein derived from plants (Zimmerman, 1996).

Some newer varieties have evolved as a continuous process of evolution and selection, however, a wide range of biological resources have been lost which could serve as an invaluable genepool for future generations. Immense selection and domestication of fewer species on one hand, phenomenal population growth and unsustainable harvest on the other, coupled with unmindful exploitation of natural resources due to unplanned developmental activities, have altogether resulted in habitat degradation and loss of precious biological resources.

### **The Convention on Biological Diversity**

In order to reverse the trend of continued loss of biodiversity and to ensure sustainable utilization for growth and development, the major global concerns have been reflected in the form of the Convention on Biological Diversity (CBD), that was formulated during the United Nations Conference on Environment and Development held at Rio de Janeiro in June 1992. The

Convention entered into force on 29 December 1993 and at present 169 countries including India are Parties to the Convention. India ratified the Convention on 18 February 1994, and thus the CBD has come into force for India on 19 May 1994 (MoEF, 1997).

The three principle objectives of the Convention are; the conservation of biological diversity, the sustainable use of the components of biodiversity, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Therefore, the CBD emphasizes the need of sharing in a fair and equitable way, the results of research and development, and the benefits arising from the commercial and other utilization of the genetic resources, with the contracting parties providing the genetic resources.

### **Access to germplasm, technology transfer and Benefit sharing**

The Article 15 of the CBD, while dealing with the issue of Access to genetic resources emphasizes the need of sharing in a fair and equitable way, the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the contracting party providing such resources. The Article 16 of the CBD dealing with access to and transfer of technology, requires that the countries which provide genetic resources are provided access to and transfer of technology, which makes use of those resources, on mutually agreed terms, including technology protected by patents and other IPRs. The countries rich in genetic resources are expected to create conditions to facilitate access to genetic resources for environmentally sound uses by other contracting parties subject to prior informed consent (PIC) of the contracting party providing such resources. But in its present form, CBD does not provide a blue print of the mechanism to be followed by the contracting parties/collaborating groups for

access to genetic resources (Maurice, 1996).

So far, there has been a regular flow of germplasm from the gene-rich technologically poor countries to the gene poor, technologically rich countries. However, an appropriate and proportionate flow of technologies to the genetic resource rich countries has, unfortunately, not been witnessed (Khoshoo 1995). A lot of precious germplasm was transferred from the developing (biological resource rich) countries to the developed (biological resource poor) countries due to free-flow of germplasm between nations prior to the signing of CBD. Many of the developed countries are thus holding vast biological resources in *ex situ* collections. The germplasm that has been transferred before the convention is now under the trusteeship of FAO and cannot be patented as such. The FAO global network of *ex situ* collections prohibit the centres and all subsequent recipients of the material from taking out intellectual property protection on the designated material itself, however, it does not preclude a recipient from filing IPR on breeding/biotechnological products derived from such material (Hawtin, 1996). Thus in the event of a product arising out of its use, it is not clear whether the benefits would go to the country(ies) who provided this germplasm, and may not have it anymore in *in situ*, or to the *ex situ* collections situated outside the country of origin.

The CBD, in its present form, does not provide a model agreement to guarantee fair and equitable compensation to the countries providing the germplasm. Since it also does not provide or propose a IPR like patent on genetic resources, it is not clear what kind of or what percentage of benefit has to be shared between the country/countries of origin/countries supplying germplasm from *ex situ* collections not originating in that country, but acquired from other countries prior to the proposed CBD and now used for commercial gains. Thus there is a need to evolve

a model agreement for guaranteeing fair and equitable compensation to the countries providing the germplasm.

### **Traditional knowledge, Bioprospecting and Benefit sharing**

India's vast and varied climatic conditions are matched with equally diverse and rich plant based preparations. However, much of the knowledge of the beneficial properties of the biological resources is held by traditional communities and this variability has not been systematically documented. Along with the loss of the valuable biological diversity, there has been a continued erosion of valuable knowledge about their usage. This has mainly been due to the lack of scientifically proved and authenticated records about the use of herbal preparations, and a shift in the mindsets of the people towards newer forms of medicines.

Most of the invaluable diversity found in our country has remained unutilized due to a lack of systematic approach to bioprospecting. Now in order to harness the benefits, biotechnological interventions are urgently required to bioprospect, evaluate and characterize the unique wealth of our country. The characterization can be achieved through morphological, cytological, biochemical or molecular markers. This provides useful information about the diversity and usefulness of the germplasm, such as tolerance to biotic and abiotic stresses, special nutritive quality, therapeutic potential etc.

Molecular markers such as species-specific probes, RAPD, AFLP would be helpful in fingerprinting of diverse germplasm with far reaching benefits for utilization as well as protection of our country's genetic resources in view of the CBD and IPR regulations. DNA based markers can also be utilized to assess diversity at all taxonomic levels for molecular breeding. Genetic fingerprinting and gene cloning can help



to identify useful genes such as those responsible for biotic/abiotic stress tolerance. The genetic engineering could be utilized to transfer the genes of interest to the desired species across the compatibility barrier.

Phytochemical characterization of plants with secondary metabolites having insecticidal, pesticidal, special nutritive quality or therapeutic potential will be valuable in characterizing the biochemical diversity. The selected plants having higher active ingredients can be selectively micropropagated to raise need based plantations for reducing pressure on natural populations. The rare and endangered plant species can be clonally propagated through tissue culture techniques to be reintroduced into their natural habitat.

Apart from the need to evolve a model mechanism for access to genetic resources and transfer of technology, it is also necessary to evolve a model for access to traditional knowledge and sharing of benefits arising out of its use. Therefore, it becomes mandatory to include the details of country/countries of origin, proof of prior informed consent, and the knowledge of indigenous people in the patent applications arising out of the use of biological resources. While at global level, it is important to share the benefits between the nations that provide the germplasm/knowledge regarding their use, at national level, it is necessary to share this benefit with the indigenous communities that have evolved and conserved these genetic resources and holds the knowledge for their use.

Keeping this in view, a simple mechanism (modified and based on Khoshoo 1996, Gadgil *et al.* 1996, TERI 1998) is hereby proposed that emphasizes the need to develop a National Biodiversity Resources and Information Data Bank based on monitoring, bioprospecting, and documentation of the valuable genetic resources along with their usage based on indigenous knowledge (Fig. 1). A National Biodiversity

Conservation and Utilization Board may be set up to over look the functioning of the Data Bank and the National Biodiversity Funds being generated through its use. The national industries and multinational companies, utilizing the resource and information from the data bank would contribute to the National Biodiversity Fund in the form of fees and royalty payments. This fund in turn should be effectively utilized for capacity building, *in situ* and *ex situ* conservation, biodiversity monitoring and bioprospecting. A part of this fund should be used for rewarding the indigenous communities. Since many communities and generations have been involved in evolving this diversity and knowledge, it may be difficult to pinpoint a particular persons/persons for the reward. Thus the money could be utilized for social upliftment of such communities and for specific development programmes suited to their requirements.

The indigenous communities have practically been the custodians of the vast biological diversity, have selected and conserved the biological resources since centuries and have also evolved a valuable knowledge base regarding their various usage. Prioritization for bioprospecting of the genetic resources can be based on the available indigenous knowledge regarding their use. The resulting value addition of biological resources, alongwith sharing of the benefits with the indigenous communities, would go a long way towards sustainable development.

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## A NOTE ON THE COLLECTION OF *Zanthoxylum rhetse* — AN UNDER-UTILIZED TREE SPICE IN THE WEST COAST OF INDIA

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*Zanthoxylum rhetse* is distributed in south western peninsular region of India and is an important local spice in Karnataka, Goa and Konkan region of Maharashtra. Although five samples collected have meagre morphological variation but significant difference in aroma was noticed. Its morphology and uses have been described in this communication.

**Key words:** *Zanthoxylum rhetse*, 'Pimentase' West coast, Konkan, collection, Agro-forestry

A few out of the reported 80 species under the genus *Zanthoxylum* L. such as *Z. bungeanum* ('Chinese prickly as pepper' or 'Sechaug pepper'), *Z. rhetse* DC (Portuguese 'Pimentase') and *Z. nitidum* and a few others are used as medicinal and aromatic, spice and as insect repellents respectively. The genus is tropical to subtropical in distribution. A total of 20 species occur in India. *Z. rhetse* synonymous to *Z. oblongatum* Wall., *Fragaria rhetsa* Roxb. and *F. budrunga* Roxb. in part is distributed in South Western peninsular region of India and is an important local spice in the Uttar Kannada of Karnataka, Goa and Konkan region of Maharashtra. Fruit is an important source of essential oil - 'mullilam oil' which is used in indigenous system of medicines, perfumes and flavourings. Seeds are medicinal, astringent, stimulant and digestive. The tree bark is anthelmintic. The biochemical and pharmaceutical properties of the oil extracted from its seeds have been extensively treated (Wlth. India, 1950). *Z. oxyphyllum* is used as a condiment in Assam. Its importance as a medicine is well documented. Kirtikar & Basu (1975) described

various medicinal uses of the species in detail. In coastal and inland areas of Goa and Maharashtra, people use mature fresh and dry fruits in fish preparation. Fresh fruits in bunches kept for sale is a common site in local haats and weekly markets during October and November. As a bio-pesticide, village farmers keep the fruits in between gunny bags containing either paddy or hulled rice for better storage of the grains. In Kerala, collected seeds are marketed outside the state for factories engaged in manufacture of biopesticide formulations. Its wood is also used as timber for furniture and for carvings. The present note pertains to survey and collection of 5 accessions of *Z. rhetse* from Kerala, Maharashtra and Karnataka.

### Etymology

Owing to its local importance as a spice and as a medicinal plant, the tree is known by about 62 names in different Indian and foreign languages. Mainly, it is called as 'Tirphal', 'Triphal', 'Chiphall', 'Chirphala', 'Kokli', 'Sessal', 'Tejbala', 'Tisal', 'Tisul' and 'Tripani' in Marathi and Konkani,

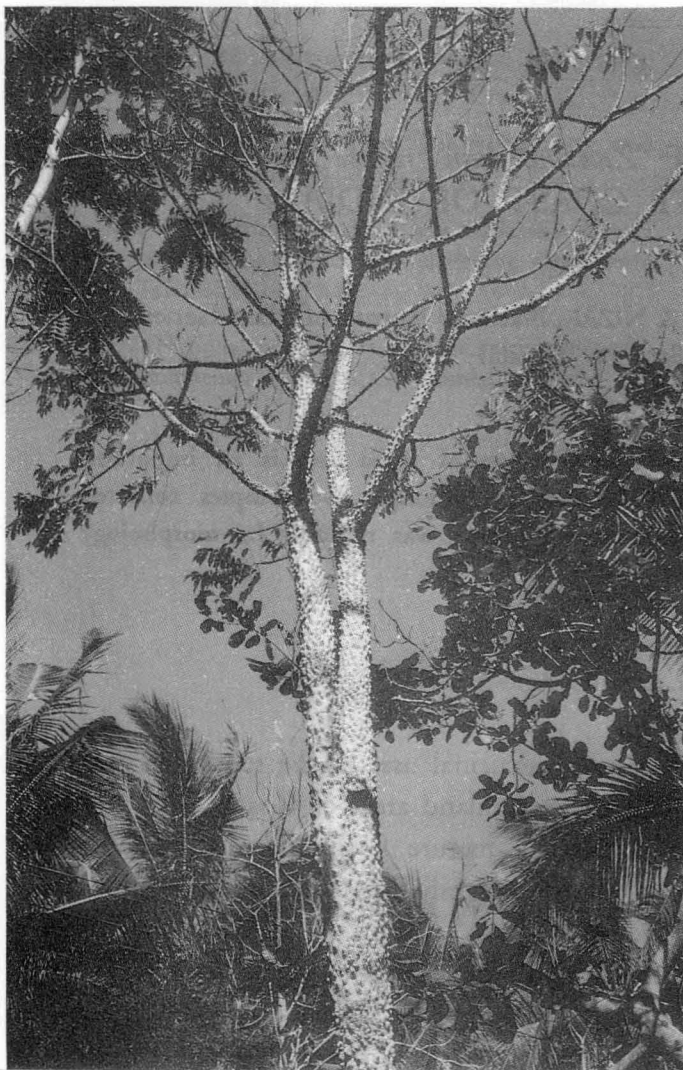


Fig. 1. *Zanthoxylum rhetse* tree in the forest habitat

'Ashvagra' and 'Atitejani' in Sanskrit, 'Mullilam', 'Kujitti', and 'Mulakila' in 'Malayalam', 'Bicholin', 'Satave', 'Arimadalu', 'Aremapala', 'Jimmini', 'Jummene' and 'Sesele' in Canarese; 'Racha' and 'Rachamam' in Telugu and 'Pimentase' in Portuguese.

### Exploration and collection

An extensive area between 10.5° and 11.7°N latitude covering the coastal plains, undulating midlands and hilly mountainous tracts in Northern Kerala, Dakshin Kannada and Uttar Kannada, Coorg and Shimoga districts of Karnataka, Goa and Ratnagiri, Sinddurg and Kolhapur districts

of Maharashtra was surveyed under a multicrop collection trip with an objective to collect mainly the wild crop relatives and other useful plant species. A total of 5 samples of *Z. rhetse* comprising 1 from Konkan in Maharashtra, 2 from Uttar Kannada and two from Kerala were collected. It is partially a shade loving tree and occurs widely in disturbed habitats around village hamlets. The tree was noticed sporadically in almost all areas covered upto 200m elevation. Absolutely no variability was noticed in the morphology of the species, however, differences in aroma was distinct between collections from Konkan region and those from Kerala.

### Morphology

It is a lofty deciduous tree; height 10-15 m, diameter of the trunk 45 cm, canopy 4-6 m, bark 15-20 mm thick, brown, white mottled, armed with conical woody prickles; outer bark dead, corky, pale yellow, inner bark sulphur yellow. Branches fully covered with very sharp spines. leaves alternate, are clustered at the tips of branchlets, 30-35 cm long, simply imparipinnate, leaflets in 7-12 pairs, petioles 3-6 mm long, blade 9-12 × 5-6.5 cm, broadly lanceolate, tip acuminate, base asymmetric, margin entire, lateral nerves 6-12 pairs, glabrous. Pedicel gland dotted. Flowers polygamous in terminal armed paniculate cymes, 2-3 mm across, greenish yellow. Fruits 5-6 mm in size, are single seeded globose capsules and dehisce at maturity. Fruit of 1-4 cocci, purplish, highly aromatic, gland dotted, pungent. Seeds globose, black, shining, endocarp horny, hang out of the wall and albumen fleshy.

### Uses

Its use as a spice in Konkan region probably is a very ancient practice by the fishermen folk. The present status of its importance in the locality will have to be highly strengthened and diversified by developing it from the level of an

undomesticated and under utilised species to the level of an important agri-horti species suited to agro-forestry systems in coastal areas of the South Western peninsula. The priority, of course, lies in exploration, collection, identification of variable types, conservation, utilization and value addition on systematic and scientific basis. The plant is also shade loving and as an agroforestry species Spines on the tree is a disadvantage for easy harvesting and for other management practices.

### ACKNOWLEDGEMENTS

The authors are grateful to Dr. P.L. Gautam, Director, NBPGR, N. Delhi for facilities provided and encouragement given for these studies.

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## A NEW RECORD OF NATURAL STANDS OF *Psidium guineense* SWARTZ FROM KOLLAM, KERALA, INDIA

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*Psidium guineense* Swartz, a native of Central and South America, had been reported earlier to occur as wild in Guwahati (Assam) and Tripura state. This is the first report of this species from Peninsular India. Detailed description, illustration and notes on ecology, adaptability and economic importance are provided.

**Key words:** *Psidium guineense*, distribution, ecology, adaptability

The Central-South American genus *Psidium* with its most important fruit tree species *P. guajava* is represented in Kerala by less popular edible species like *P. littorale* (strawberry guava) and *P. friedrichsthalianum* (Chinese guava). Natural stands of *P. guajava*, mostly with red flesh, grow in heaps from bird castings in open fields and partially disturbed plantation sites. Good variability exists for fruit size (30-225 g), fruit colour (yellow, purple), fruit shape (round, oval, pyriform), flavour, flesh colour (white, yellow, cream, red, deep red) and bearing habit. An interesting specimen of *Psidium* was collected from the banks of Ashtamudi lake at Kumbalam, Kundara, Kollam District of Kerala, which was identified as *P. guineense*. This has been later confirmed by the Herbarium Curator, New York Botanical Garden, USA.

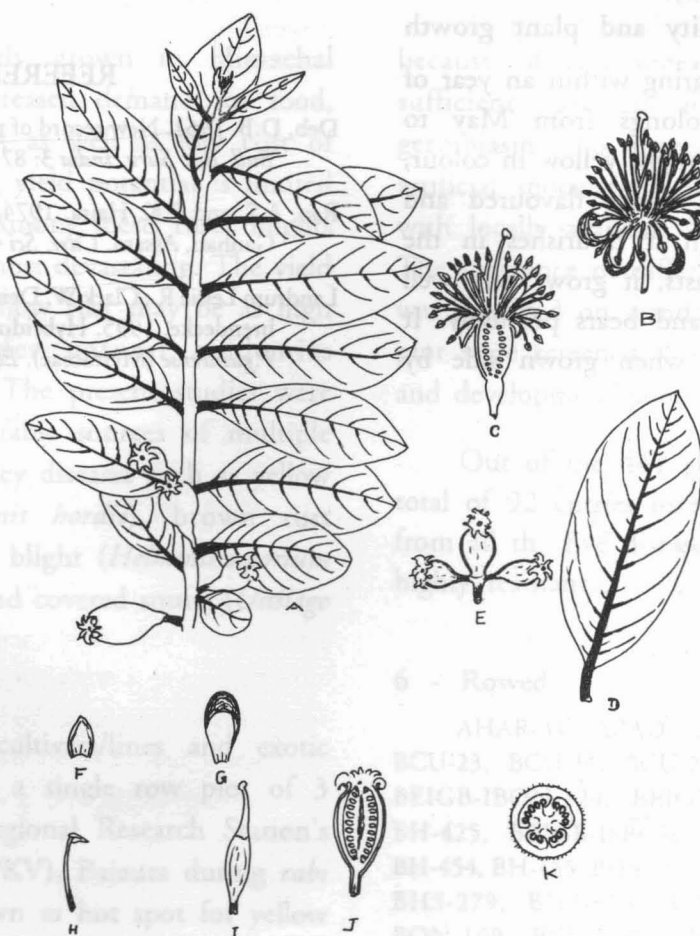
A brief description and diagram/photograph (Fig. 1, 2) is given here to facilitate easy identification: Shrubs, prostrate or erect upto 3m high; stems thin, terete, covered with brown tomentum on growing parts; leaves opposite,

elliptic or elliptic-oblong, 13 × 6 cm, thick, villous below, apex obtuse, base nearly acute, petiole 7-12 mm long, grooved, densely hairy, mid vein hairy on both sides, laterals 6-10 pairs, marginal venation not prominent; inflorescence a simple cyme, triflorous, rarely uniflorous, peduncle 5-25 mm long; mature flower buds 8-11 mm long, pedicels of lateral buds (fruits) closely appressed to the main; calyx 4-6 mm long, splitting irregularly in to 5 parts, persistent in fruit; petals 5, 6-10 mm long, white, spathulate, glabrous; stamens numerous, 7-9 mm long; ovary 3-4 locular, 1.9-2.4 mm diameter; fruits weighing 4-10 g, epicarp green, yellow when ripe, flesh creamy white, temptingly aromatic when ripe.

This specimen differs from the description of *P. guineense* Swartz (Deb, 1961) in having spathulate petals and no modification of the stamens to petals.

### Distribution, plant association and migration

Earlier reports of its occurrence in India are from Tripura (Deb, 1961) and Guwahati, Assam (Rao and Hajra, 1973). They further record the

Fig. 1. *Psidium guineense* SwartzFig. 2. *Psidium guineense* Swartz — A. fruiting twig; B. flower; C. flower L.S.; D. leaf; E. fruits; F. sepal; G. petal; G. stamen; I. pistil; J. ovary L.S.; K. ovary T.S.

introduction of this species to Indian Botanical Garden, Calcutta in 1845 from Guinea via West Indies. It is also reported from Sri Lanka and Indonesia. This species having originated in South America might have come to this particular location through sea route as Kollam was one of the most important ports of the Portuguese, Dutch and later English rulers. Another possibility is through cultural contacts between this part of India and South East Asian countries as many Keralites use to live in Singapore, Colombo, Penang and Malaysia during colonial times. This species, resembling very closely to cultivated guava, is sometimes confused as guava by local inhabitants. Often it grows in association with natural stands of *Annona squamosa* (primitive type) and *P. guajava*.

#### Observation on adaptability and plant growth

Seedlings come to bearing within an year of planting and fruiting prolongs from May to December. Ripe fruits are bright yellow in colour, pyriform, weighing 4-10g, fruity flavoured and agreeable in taste. Though it flourishes in the natural stand near the coasts, it grows very well in midland also (laterite) and bears profusely. It is free from white scales when grown side by

side of guava collections. As it is reported to hybridize freely with *P. guajava* (Landrum *et al.*, 1995), it may be of importance for crop improvement, especially for imparting fruity flavour.

One set of herbarium sheets has been deposited at Madras Herbarium, Coimbatore and another set at the National Herbarium of Cultivated Plants, NBPGR, New Delhi.

#### ACKNOWLEDGEMENTS

Authors are thankful to Dr. Leslie R. Landrum, Curator, New York Botanical Garden for confirming the identity of the species and to the Director, NBPGR, New Delhi for the encouragement and facilities provided.

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## MULTIPLE DISEASE RESISTANCE IN BARLEY GERMPLASM

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Four hundred forty one germplasm lines including exotic material in barley were screened under epiphytotic conditions to find out suitable sources of multiple resistance for major barley diseases (yellow rust, brown rust, barley blight and loose and covered smuts). Ninety two entries (6 & 2 rowed barley accessions) were found free from all the five diseases and were categorized as highly resistant. These can be utilized for evolving disease resistance varieties.

**Key words:** Barley, germplasm, epiphytotic, multiple resistance

Barley is popularly grown in Himachal Pradesh due to its increased demand for food, feed and industrial use; as well as low cost of cultivation. However its yield potential is limited due to many maladies. Among these, rusts, blights and smuts diseases are most devastating. The yield losses mainly due to yellow rust may be as high as 38 per cent under natural epidemics (Suryanarayana, 1979). The present studies were carried out to find suitable sources of multiple resistance for major barley diseases such as yellow rust (*Puccinia striiformis hordie*), brown rust (*Puccinia hordei*), barley blight (*Helminthosporium gramineum*) and loose and covered smuts (*Ustilago nuda* and *U. hordei*).

A total of 441 cultivars/lines and exotic material were sown in a single row plot of 3 meter length at the Regional Research Station's Experimental Farm (HPKV), Bajaura during *rabi* 1997-98, which is known as hot spot for yellow rust and several other barley diseases. As such this centre provides good feasibility for screening the germplasm of barley especially for yellow rust

because of the appearance of the disease in sufficient spectrum for effective screening of germplasm. To increase the disease pressure, artificial inoculation of the materials was done with locally available inoculation of yellow rust. The incidence of different diseases on each entry was recorded on standard scales. The germplasm plot were screened 2-3 times during the growth and development period for incidence of diseases.

Out of the 441 germplasm lines screened a total of 92 entries listed below, were found free from all the five diseases and were categorized as highly resistant :

### 6 - Rowed

AHAR-34, AZAD, BBM-76, BBM-160, BCU-6, BCU-23, BCU-34, BCU-220, BEIGB-95-96, IBON-23, BEIGB-IBON-124, BEIGB-ISBON-LRA-138, BEIGB-BH-425, BEIGB-ISBOW-LRA-237, BH-393, BH-441, BH-454, BH-455, BHS-150, BHS-233, BHS-260, BHS-269, BHS-279, BHS-325, BHS-362, BON-18, BON-52, BON-169, BYDV-45, BYDV-123, C-138, DWR-12, HBL-103, HBL-105, HBL-150, HBL-246, HBL-258, HBL-313, HBL-339, IBON-10, IBON-11, IBON-12, IBON-16, IBON-26, IBON-33, IBON-36, IBON-53,

IBON-55, IBON-129, IBON-179, IBOW-11, IBYT-11, IBFYT-20, IWFBON- 99, RD-2431, RD-2456, RD-2484, RD-2521, RD-3772, SP-38, SONU, SONU-30 KR, USAD-97, VLB-23, VLB-35, VLB-49, VLB-57, VLB-105, VLB-120, VLB-126, VLB-133 and VLB-135.

## 2 - Rowed

BBM-2640, BCU-4, BEIGB-BSP-17, BEIGB-ISBON-LRA-34, BGN-IBON-134, BHS-39, BOM (MON)-MRA-62, BUDU-69, BYDV-1, BYDV-95, BYLYR-79, DWR-17, EIBGN-MRA-9, GHS-440, H-19, H-23, HBL-113, HBL-166, IBON- 34, IBYT-34, IBYT-19, K-587, S-37, SP-48, SP-65, UBE-215 and VLB- 267.

These lines showed a good promise for multiple resistance for the barley diseases and can be utilized for evolving disease resistant varieties. Breeding for disease resistant cultivars has been taken up by different centers under the All-India Co-ordinated Barley Improvement Project (AICBIP) since its inception in 1966-67. Therefore, the present results will be very useful

to the barley breeders of the country. Earlier too, some sources of resistance to major disease of barley were identified from the exotic as well as indigenous barley germplasm and their genetics was also studied (Luthra *et al.* 1991).

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## STUDIES ON SEED GERMINATION IN ASPARAGUS

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Seed germination protocols in respect of *Asparagus officinalis* seeds were worked out. The study suggests that seed scarification at  $-20^{\circ}\text{C}$  for 48 hours was most effective for achieving the highest germination.

Key words : *Asparagus* spp., germination, protocol

The genus *Asparagus* (family-Asparagaceae), well known for its important medicinal properties, food values and horticultural beauty, is distributed in temperate and tropical parts of Old World (Wlth. India. 1985). In all 22 species are reported from India which are found growing wild in tropical and sub-tropical parts including Andamans and Nicobar Islands. The tubers of some species are the source of the drug **Shatawar** which is a tonic, prescribed for increasing lactation in women and is beneficial in nervous breakdown. In Indian systems of medicine, a number of preparations are made from the asparagus such as **shatavari powder**, **shatavari leha**, **shatavari kalp** and **shatavari rasa** (Kumble, 1997).

During routine germination tests, the seeds of *A. officinalis* showed 100 per cent hard seededness. Very little information is available on the germination studies of *Asparagus* seeds. Even under field conditions low germination percentage (40-60%) with very long period of germination (upto 40 days) is reported by Tewari and Misra (1996). The aim of this work was to enhance germination.

Seeds of *Asparagus officinalis* (EC-280563) were received from NBPGR Regional Station,

Bhowali for long term conservation in the National Gene Bank. In the initial tests conducted, germination was found to be nil. Suspecting seed coat impermeability, seeds were subjected to following treatments : seed scarification, i) mechanically by abrasion with a finely grained sandpaper for 5-8 minutes and ii) acid scarification in 50 per cent sulfuric acid for 2 minutes followed by thorough washing in running water for 2 hours. Wet Chilling Treatment by keeping seeds in 1 ml. distilled water at  $-20^{\circ}\text{C}$  for 2 days followed by 2 hours storage at ambient temperature before putting for germination. Seeds were tested for germination on two filter papers, moistened with 2-ml distilled water and placed in sterilized Petriplates at constant temperatures of  $20^{\circ}\text{C}$  and  $30^{\circ}\text{C}$ . Due to the scarcity of the seed material, 2 replicates of 25 seeds each were subjected to germination test for each seed treatment described above. Mean Daily Germination was calculated as a ratio of final germination percentage and total number of days in test.

Remarkable differences were observed in germination percentages attained in various treatments at both the temperatures. Of the two temperatures studied, lower temperature of  $20^{\circ}\text{C}$

favoured the germination. In control, there was no germination. Sulfuric acid treatment enhanced germination upto 36 per cent almost at par with sand paper scarification where it is 32 per cent (Table 1). Earlier studies made by Tewari and Misra (1996) had shown that Gibberellic acid has no significant effect on germination standards. The best effective treatment found is wet chilling at  $-20^{\circ}\text{C}$  which resulted in almost 100 per cent germination at  $20^{\circ}\text{C}$  and 60 per cent germination at  $30^{\circ}\text{C}$ .

Table 1. Effect of various treatments on germination in *Asparagus officinalis*

| Treatments                                    | Temperatures tested  |     |                      |     |
|-----------------------------------------------|----------------------|-----|----------------------|-----|
|                                               | $20^{\circ}\text{C}$ |     | $30^{\circ}\text{C}$ |     |
|                                               | Germination %        | MDG | Germination %        | MDG |
| Sulfuric Acid 50% for 2 min.                  | 34                   | 2.8 | 22                   | 1.8 |
| Sand Paper Scarification                      | 32                   | 2.6 | 14                   | 1.1 |
| Wet chilling $-20^{\circ}\text{C}$ for 2 days | 98                   | 8.2 | 56                   | 4.6 |
| Control                                       | 0                    | 0   | 0                    | 0   |

Chilling of seeds prior to germination is an accepted horticultural practice. Toole (1973) gave a list of chilling requirements for a wide range of species but the overall requirement of seeds of ornamental plants have still not been thoroughly investigated.

There is a considerable variation in germination time. In all the treatments, germination started on 3rd or 4th day but in control it was nil even after a month. Maximum germination was 96 per cent on 12th day with wet chilling treatment. All the germinated seedlings obtained were transferred to the pots in greenhouse and they showed 100 per cent establishment. Thus it can be concluded that chilling stratification to seeds of *Asparagus* was effective in breaking the hard seededness, may be due to the formation ice crystals in seed coat membranes.

Thus present study suggests that seed stratification at  $-20^{\circ}\text{C}$  for 48 hours was most effective for achieving highest germination and reduced MGT.

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## BOOK REVIEWS

**PROSPECTS OF MEDICINAL PLANTS** P. L. Gautam, R. Raina, Umesh Srivastava, S.P. Paychaudhuri and B.B. Singh (Editors). Indian Society of Plant Genetic Resources, NBPGR Campus, New Delhi, India. 1998, xv+ 292p. (Rs. 490.00)

The Indian Society of Plant Genetic Resources (ISPGR) has brought out this publication based on the Proceedings of International Workshop on Prospects of Medicinal Plants, held at Solan (India) 4-9 November 1996, jointly organised by the International Union of Forestry Research Organisation (IUFRO) and Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (Himachal Pradesh), India. It covers topic ranging from propagation techniques, phytochemical investigations, breeding strategies, agronomy, traditional resources, collection, conservation, documentation, utilization, ethnobotany, policy issues, developmental strategies etc and future approaches. Many plants are being locally utilized for indigenous system of medicine (ISM) but utilization of only very few plants have been identified and recognized by Ayurvedic, Unani and Allopathy systems of medicine based on their therapeutic uses or the active principles, chemical composition or ingredients. The popularity and belief in natural and herbal health care system is inseparable from traditional ethos and practices in India. Recent global interest in this area has added new dimensions of judicious exploitation of herbal wealth. The availability of these resources are becoming increasingly scarce. There is an urgent need to protect, preserve, propagate and provide these bio-resources to humanity for ensuring reasonable health care. The information contained in this publication is useful for teachers and researchers engaged in the study of advancement of research in medicinal plants. It will also serve useful purpose in narrowing the gap between information and knowledge regarding these plants.

B M Singh

**PLANT GERMPLASM COLLECTING: PRINCIPLES AND PROCEDURES** P.L. Gautam, B.S. Dabas, Umesh Srivastava and S.S. Duhoon (Editors). National Bureau of Plant Genetic Resources, New Delhi, India. 1998. xxi+218p.

This publication contains well synthesized information on various aspects of plant germplasm collecting. The content includes 31 papers which covers topics ranging from biodiversity conservation, PGR Issues and international developments, national PGR system, Regional co-ordination activities, different strategies in germplasm collecting, appropriate sample size for germplasm collection - theoretical considerations: handling, maintenance and preservation of herbarium specimens, ethnobotany, passport data recording, exploration mission report writing, data base management and characterization/evaluation, documentation exchange, utilization and conservation, besides some papers on broad perspective on the diversity of Indian Gene Centre. It also covers an overview on Plant Germplasm Collecting in Indian region which illustrates history of PGR development with special reference to India and national efforts in germplasm collecting. It covers both theoretical as well as practical guidelines and is quite handy to the users. This publication is expected to stimulate the research workers and those who are engaged/interested in safeguarding plant biodiversity to promote sustainable agriculture intensification for the benefit of humankind. It will be very useful to teachers and postgraduate student involved in collection and conservation of plant genetic resources.

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B M Singh

## PLANT GERMPLASM REGISTRATION NOTIFICATION<sup>1</sup>

The Germplasm Registration committee of ICAR in its 3rd meeting held on 10th December, 1998 at NBPGR approved the registration of the following 34 germplasm lines/genetic stocks out of 57 proposals received.

**INGR 98010** is a genetic male sterile line of cotton (*Gossypium hirsutum*), developed by G.V. Umalkar at Ankur Seeds Pvt. Ltd. Nagpur by crossing CA/H-148 × CA/H-144. The line being GMS system exhibits 50% sterile population and is designated as **CA/MH-133**.

**INGR 98011** is fibre less, soft, necrosis free anola (*Embelica officinalis*) designated as **NA7**. It is a seedling selection from open pollinated strain of Francis, developed by R.K. Pathak, I.S. Singh, R. Dwivedi, A.K. Srivastava and H.K. Singh at NDUAT Faizabad.

**INGR 98012** is a high yielding, drought hardy germplasm of water melon (*Citrullus lanatus*) designated as **Mateera - AHW19**. This sweet, juicy watermelon with longer shelf life and good transportability is selection made from local genetic diversity by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98013** is a high yielding, drought hardy kachari (*Cucumis callosus*) designated as **Kachari AHK 119**. It is a pure line selection from local genetic diversity made by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98014** is a high yielding, drought hardy germplasm of kachari (*Cucumis callosus*)

designated as **Kachari AHK 200**. It is a pure line selection from local genetic diversity made by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98015** is a high yielding, drought hardy germplasm of snap melon (*Cucumis melo var. momordica*) designated as **AHS10**. It is a pure line selection from local genetic diversity of arid region made by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98016** is a high yielding, drought hardy germplasm of snap melon (*Cucumis melo var. momordica*) designated as **AHS 82**. It is a pure line selection from genetic diversity of arid region made by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98017** is high yielding, long fruited genetic stock of cucumber (*Cucumis spp*) designated as **AHC 2**. It is a promising selection made from variable material by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98018** is a high yielding, unique, small fruited, drought hardy cucumber (*Cucumis spp.*) designated as **AHC 13**. It can bear fruits even under high temperature in arid region with limited irrigation. This genetic stock is developed by O.P. Pareek and D.K. Samadia at NRC for Arid Horticulture, Bikaner, Rajasthan.

**INGR 98019** is a aromatic, thermo insensitive, photo period sensitive, extra longkerneled, stem rot resistant rice (*Oryza sativa indica* type) suitable for irrigated conditions. It is designated as **Taraori**

<sup>1</sup>Communicated by Dr. B.B. Singh, Member Secretary, ICAR Committee on Germplasm Registration

**Basmati.** It is a pure line selection from HBC 19 made by D.V.S. Panwar, Ajmer Singh, K.R. Gupta, K.R. Battan, Rishi Pal and Rattan Singh at CCSHAU Rice Research Station, Kaul, Haryana.

**INGR 98020** is a cytoplasmic male sterile mustard (*Brassica juncea*) carrying cytoplasm of *Brassica oxyrrhina* derived from the synthetic allopolyploid *B. oxyrrhina* × *B. campestris*. This CMS line is developed at NRC on Plant Biotechnology, IARI New Delhi by Shyam Prakash and V.L. Chopra.

**INGR 98021** is a Cytoplasmic male sterile mustard (*Brassica juncea*). This CMS line is developed through synthesis of somatic hybrid *Morcanadia arvensis* + *B. juncea* and its repeated backcrossing to *B. juncea* cv. Pusa bold at NRC on Plant Biotechnology, IARI New Delhi by Shyam Prakash, P.B. Kirti, V.L. Chopra and S.R. Bhat.

**INGR 98022** is a fertility restorer for CMS (*Morcanadia*) *B. Juncea*. This fertility restorer CMS is developed by Shyam Prakash, P.B. Kirti, V.L. Chopra and S.R. Bhat at NRC on Plant Biotechnology IARI, New Delhi.

**INGR 98023** is a cytoplasmic male sterile rape seed (*Brassica napus*). This CMS line is developed through synthesis of sexual allopolyploid *Brassic oxyrrhina* × *B. campestris* and its repeated back crossing to *B. napus* by Shyam Prakash, P.B. Kirti and V.L. Chopra at NRC on Plant Biotechnology IARI, New Delhi.

**INGR 98024** is a cytoplasmic male sterile mustard (*Brassica juncea*) developed through protoplast fusion between chlorotic CMS *B. juncea* carrying *Raphanus* logu cytoplasm with floral abnormalities and green fertile *B. juncea* and then backcrossing to *B. juncea*. This CMS is developed by P.B. Kirti, S.S. Banga, Shyam Prakash, and V.L. Chopra at NRC on Plant Biotechnology, IARI, New

Delhi.

**INGR 98025** is a chlorosis corrected, green cytoplasmic male sterile mustard (*B. juncea*) carrying recombinant mitochondria of *Morcanadia arvensis* and chloroplasts of *B. jucea*. This CMS line is developed through protoplast fusion and selection at NRC on Plant Biotechnology, IARI, New Delhi by P.B. Kirti, Shyam Prakash and V.L. Chopra.

**INGR 98026** is a cytoplasmic male sterile rape seed (*B. compestris* ssp. *oleifera* var. brown sarson) carrying cytoplasm of *B. oxyrrhina* derived from synthetic allopolyploid *B. oxyrrhina* × *B. campestris*. This CMS line is developed by Shyam Prakash and V.L. Chopra at NRC on Plant Biotechnology IARI, New Delhi.

**INGR 98027** is a male sterile parental line of safflower (*Carthamus tinctorius*) hybrid DSH129 designated as MS9 (O). This line is developed by M. Ramachandran and K. Anjani at DOR Hyderabad.

**INGR 98028** is a high protein and high lysine content wheat (*Triticum aestivum*) designated as Pusa 5-3. It is developed from cross HW171 × CI 11721 at Genetics Division, IARI, New Delhi by N.C. Singhal and H.K. Jain.

**INGR 98029** is a low ODAP and high yielding khesari (*Lathyrus sativus*) designated as Bio-158. This somaclone is developed from leaf explants of cultivar P-24 by S.L. Mehta, P.K. Roy, G.K. Barat, I.M. Santha and K. Ali at Biochemistry Division, IARI, New Delhi.

**INGR 98030** is a garlic (*Allium sativum*) with compact bulbs, silvery white skin, cream coloured flesh and big cloves designated as Agrifound White. This is a local selection from Biharsharif (Nalanda) made by U.B. Pandey, Lallan Singh and S.R. Bhonde at NHRDF, Nasik.

**INGR 98031** is a garlic (*Allium sativum*) with compact bulbs, creamy white, with creamy flesh designated as **Yamuna Safed-3**. It is a local selection from Dindigul (T.N.) made by U.P. Pandey, Lallan Singh and R.P. Gupta at NHRDF, Nasik.

**INGR 98032** is a fine grained, early maturing (115-120 days) dwarf rice (*Oryza sativa*) designated as **GAURAV Basmati A- 54**. It is a mutant of Basmati-370 developed by S.S. Malik at HAU, Kaul and further tested at NBPGR base center, Cuttack.

**INGR 98033** is a castor (*Ricinus communis*) tolerant to *Fusarium oxysporum* sp. *ricini* wilt and moderately resistant to *Macrophomia phaseolina* root rot designated as **RG392**. It is a selection from Pothineni local - II from Tindivanam, Tamilnadu made by K. Anjani, M.A. Raoof and C. Hanumantha Rao at DOR, Hyderabad.

**INGR98034** is a castor (*Ricinus communis*) tolerant to *Fusarium oxysporum* sp *ricini* wilt and resistant to *Macrophomia phaseolina* root rot designated as **RG47**. It is a selection from SKI-6 collection from Dantiwada, Gujarat made by K. Anjani, M.S. Raoof and C Hanumanta Rao at DOR, Hyderabad.

**INGR 98035** is a pearl millet (*Pennisetum glaucum*) fertility restorter line and parent of very productive released hybrids HHB 45 and HHB 50, designated as **H90/4-5** resistant to drought and tolerant to high temperature stress. It is a selection from synthetic HS 1 developed by R.L. Kapoor, Sain Dass, I.S. Khairwal, H.P. Yadav, Prem Sagar, C.R. Bainsiwal, D.C. Nijhawan and M.S. Narwal in collaboration with D.P. Thakur and M.S. Panwar. This line is developed at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98036** is a pearl millet (*Pennisetum glaucum*) restorter line and parent of very popular released hybrid HHB 67, HHB60 and HHB68. designated

as **H 77/883-2** It is excellent combiner for productivity and gives early/extra early hybrids. It a selection from Haryana land race population and resistant to temperature, drought and salt stress, developed by R.L. Kapoor, Sain Dass, I.S. Khairwal, H.P. Yadav, Prem Sagar, C.R. Bainsiwal, D.C. Nijhawan and M.S. Narwal in collaboration D.P. Thakur and M.S. Panwar. This line is developed at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98037** is a male sterile line of pearl millet (*Pennisetum glaucum*) designated as **HMS 1A** and **1B**. It is developed from DSA 134A  $\times$  H 90/4-5. It is an A3 cytoplasm male sterile line and developed by Prem Sagar, D. C. Nijhawan, R.L. Kapoor, C.R. Bainsiwal, I.S. Khairwal and H.P.Yadav in collaboration with D.P. Thakur at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98038** is a male sterile line pearl millet (*Pennisetum glaucum*) designated as **HMS 2A** and **2B** developed by converting H77/833-2 into male sterile line developed by Prem Sagar, D.C Nijhawan, R.L. Kapoor, C.R. Bainsiwal, I.S. Khairwal and H.P. Yadav in collaboration with D.P. Thakur at Bjara Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98039** is a male sterile line of pearl millet (*Pennisetum glaucum*) designated as **HMS 3A** and **3B** developed by DSA 134A  $\times$  HC 715-1. It is high tillering line developed by Prem Sagar, D.C. Nijhawan, R.L. Kapoor, C.R. Bainsiwal, I.S. Khairwal and H.P. Yadav in collaboration with D.P. Thakur at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98040** is a male sterile, good tillering, early flowering pearl millet (*Pennisetum glaucum*) designated as **HMS 4A** and **4B**. It is a result of a cross DSA 134 A  $\times$  HC 715-2 made by Prem Sagar, D.C. Nijhawan, R.L. Kapoor, C.R.

Bainiwal, I.S. Khairwal and H.P. Yadav in collaboration with D.P. Thakur at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98041** is a male sterile pearl millet (*Pennisetum glaucum*) designated as **HMS 7A** and **7B**. It is a result of cross  $81A \times 35$  made by D.C. Nijhawan, R.L. Kapoor, H.P. Yadav, C.R. Bainiwal, Prem Sagar and M.S. Narwal in collaboration with M.S. Panwar at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98042** is a male sterile pearl millet (*Pennisetum glaucum*) designated as **HMS 8A** and **8B**. This line has experimental potential and

several hybrids have **HMS 8A** as female parent. It is a result of  $81A \times 52 -37-1$  developed by D.C. Nijhawan, R.L. Kapoor, H.P. Yadav, C.R. Bainiwal, Prem Sagar and M.S. Narwal in collaboration with M.S. Panwar at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

**INGR 98043** is a male sterile pearl millet (*Pennisetum glaucum*) designated as **HMS 9A** and **9B** this line is very promising female parent of hybrids is a result of  $843A \times 44-10$  developed by D.C. Nijhawan, R.L. Kapoor, H.P. Yadav, C.R. Bainiwal, Prem Sagar and M.S. Narwal in collaboration with M.S. Panwar at Bajra Section, Department of Plant Breeding, CCS, HAU, Hisar.

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## C O N T E N T S

|                                                                                                                                         |                                                                             |        |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|--------|
| Sampling strategies for developing Indian sesame core collection                                                                        | R. K. MAHAJAN, I. S. BISHT AND P. L. GAUTAM                                 | ... 1  |
| Screening of natural diversity in Karvanda ( <i>Carissa</i> L.) : Commercially potential wild fruit in Maharashtra                      | VINAYA S. GHATE, D. K. KULKARNI AND ANURADHA S. UPADHYE                     | ... 10 |
| Genetic diversity in linseed                                                                                                            | V. D. VERMA                                                                 | ... 16 |
| Variability and association analysis for yield and yield components in cowpea germplasm                                                 | M. K. SINGH AND J. S. VERMA                                                 | ... 20 |
| Comparative evaluation of indigenous and exotic rice ( <i>Oryza sativa</i> L.) germplasm for quality characteristics                    | J. S. CHAUHAN                                                               | ... 23 |
| Evaluation of some cultivars of <i>Capsicum annuum</i> in Saurashtra region with special reference to fruit shape and capsaicin content | M. P. BUCH, S. M. PANDEYA, SEEMA CHAUHAN (nee SOLANKI) AND S. V. S. CHAUHAN | ... 31 |
| Classification of uridbean germplasm from diversity zones of Uttar Pradesh                                                              | M. K. NAUTIYAL AND ARVIND SHUKLA                                            | ... 36 |
| Variability in ascorbic acid content of some <i>Lycopersicon</i> species                                                                | T. RAMA SRINIVAS                                                            | ... 42 |
| Genetic divergence in chickpea                                                                                                          | A. SIROHI, A. SINGH, K. S. PANWAR AND K. C. CHAUHAN                         | ... 46 |
| Characterization of citrons growing in north east india using hierarchical cluster analysis                                             | B. K. RAY AND P. C. DEKA                                                    | ... 50 |
| Status of resistant germplasm in eggplant ( <i>Solanum melongena</i> L.) and wild <i>Solanum</i> species                                | B. SARATH BABU, K. S. VARAPRASAD, S. K. CHAKRABARTY AND N. SIVARAJ          | ... 56 |
| Genetic diversity of salt-tolerant indigenous rice germplasm of West Bengal                                                             | R. K. CHAUDHURI, ANUP DAS AND ILA CHAUDHURI                                 | ... 65 |

(Contd. on inner cover page)

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