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PROGRESS AND PROBLEMS OF PEARL MILLET GERMPLASM MAINTENANCE

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1. The status of world collection of Pearl millet prior to formation of ICRISAT:

Realizing the importance of conserving the genetic resources of Pearl millet Pennisetum americanum (L.) Leeke (formerly P. typhoides (Burm.) Stapf and Hubb.) the Indian Agricultural Research Institute, New Delhi, in co-operation with the Indian Council of Agricultural Research, the State Departments of Agriculture and the Rockefeller Foundation undertook the systematic collection of Pearl millet in India (Rachie, 1963). The project was initiated on October 5, 1959 and largely completed except for some follow-up collecting by May 31, 1962 and collected 754 landrace accessions from India. Prior to, during and following the collecting of Indian materials, 1360 genetic stocks of Pearl millet were exchanged with other breeders in India and abroad. Most of the introduced lines were breeding material, either inbreds or genetic stocks. Contributors to the total collection included the United States Department of Agriculture, the Food and Agriculture Organization of the United Nations, and individual breeders in the USA, Africa, South America, Europe and Asia (Rachie, 1966). Out of 2114 genetic stocks assembled, 1532 lines were evaluated, classified and catalogued by Murty et al. (1967) and a supplement for grain characters was published in 1970 (Murty et al., 1970).
2. Genetic material donated to ICRISAT:

The first task of ICRISAT was to assemble Pearl millet germplasm from all possible sources. Breeders from India and abroad extended their co-operation by contributing whatever germplasm they had. ICRISAT received in 1973-1974, incomplete sets of the IP collection from Ludhiana, New Delhi, Rajendranagar, Jamnagar, and Vizianagaram (India), Bangkok (Thailand) and ALAD (Lebanon).

Duplicate and triplicate sets of the IP lines from the above sources were planted side by side to identify those IP lines which still agreed with the catalogue and to eliminate duplicates and triplicates. Out of 29 descriptors used by Murty et al. (1967) eleven characters were used to identify the "original" IP lines. The descriptors used are:

1. Days to 50% flowering  7. Ear length
2. Plant height          8. Ear girth
3. No. of tillers        9. Glume colour
4. Node colour           10. Glume covering
5. Bristle colour        11. Seed colour
6. Bristle length

Out of 3788 lines (duplicates and triplicates) checked, 1075 lines agreed with the catalogue (Table 1). A number of the remaining lines were retained for breeding purposes.
Table 1: Number of IP lines catalogued by Murty *et al.*, 1967 and the number of lines that agreed with the catalogue.

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of lines classified</th>
<th>No. of lines agreeing with the catalogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congo</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Ghana</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Kenya</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Mali</td>
<td>59</td>
<td>31</td>
</tr>
<tr>
<td>Nigeria</td>
<td>122</td>
<td>92</td>
</tr>
<tr>
<td>N. Rhodesia</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Nyasaland</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Senegal</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td>S. Rhodesia</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sudan</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>S. Africa</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Tanganyika</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Uganda</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Australia</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>Unknown Exotics</td>
<td>70</td>
<td>53</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>49</td>
<td>36</td>
</tr>
<tr>
<td>Gujarat</td>
<td>223</td>
<td>169</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>45</td>
<td>36</td>
</tr>
<tr>
<td>Madras</td>
<td>75</td>
<td>51</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>77</td>
<td>45</td>
</tr>
<tr>
<td>Mysore</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>Orissa</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Punjab</td>
<td>198</td>
<td>122</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>168</td>
<td>121</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>142</td>
<td>124</td>
</tr>
<tr>
<td>Sources Unknown</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>1532</strong></td>
<td><strong>1075</strong></td>
</tr>
</tbody>
</table>
3. Landraces received from India:

Millet breeders from different states of India have been collecting landraces and sent the seed to ICRISAT. G.B. Pant University of Agriculture and Technology sent us 110 landraces of Pearl millet collected from Uttar Pradesh. Mr. Mahadhik, Millet Breeder collected 142 landraces from Madhya Pradesh which we received. Millet Research Stations at Vizianagaram, and Guntur of the Andhra Pradesh Agricultural University sent us more than thousand accessions which are mostly breeding materials.

4. Landraces collected by ICRISAT:

With a view to collect landraces, intermediate forms and wild species of Pennisetum capable of hybridizing with Pearl millet, a collection expedition in the Sahel was organised in 1975 by ORSTOM, supported by FAO and UNEP in which ICRISAT also participated and collected 1352 samples. The 1976-77 expedition to the Eastern Ghats of India enabled us to collect 98 samples of cultivated millet and one wild species identified as Pennisetum pedicellatum Trin*. The expedition to Rajasthan resulted in the collection of 366 landrace accessions and one wild species identified as Pennisetum divisum (Forssk. ex Gmel.) Henr*.

During 1977 the Plant Quarantine Unit of the Government of India (GOI) released 445 accessions of landrace material from Africa identified by Dr. L.J.G. van der Maesen.
(Niger, 194; Nigeria, 144; Ethiopia, 7; Senegal, 3;) together with 9 samples from USSR, 7 from USA and one from Australia. These lines are currently being grown in the Post Entry Quarantine Isolation Area (PEQIA) at ICRISAT undergoing regular inspection by GOI staff. Apart from these, ICRISAT has received a total of 6796 accessions comprising of the various IP collection, inbred lines from Jamnagar, downy mildew resistant lines from Dr. Saffaeulla, male sterile lines and landraces from Madhya Pradesh, Uttar Pradesh, Eastern Ghats and Rajasthan (Table 2). We have 11 wild species and 3 possible interspecific hybrids (Table 3).

5. Objectives of maintenance at ICRISAT:

There are three principal objectives of germplasm maintenance and the method of maintenance varies with the objective.

5.1. To obtain largely cross-pollinated seed from the first grow-out in sufficient quantity both for long term storage and to provide for sub-samples for several evaluation plantings. In the case of accessions which have been previously selfed these will be maintained by selfing.

5.2. To obtain a bulk of S1 seed for each accession to supply to breeders and other interested scientists.

5.3. To make germplasm pools. This will ultimately reduce the number of items to be handled, and concentrate the available genes for a particular cultivar or race.
Table 2: Pearl millet accessions maintained at ICRISAT

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>No. of entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Exotic collection (West and East Africa includes lines, varieties and composite populations)</td>
<td>495</td>
</tr>
<tr>
<td>2.</td>
<td>Indian <em>Pennisetum</em> (I.P.) collection (IP 1 to IP 3118) collection obtained from Lebanon, Bangkok, Rajendra-nagar, Jamnagar and Ludhiana: (duplicate entries ignored for totaling)</td>
<td>1875</td>
</tr>
<tr>
<td>3.</td>
<td>Landraces from Eastern Ghats of Orissa and Andhra Pradesh</td>
<td>98</td>
</tr>
<tr>
<td>4.</td>
<td>Landraces from Rajasthan</td>
<td>366</td>
</tr>
<tr>
<td>5.</td>
<td>Landraces selected from Economics samples</td>
<td>47</td>
</tr>
<tr>
<td>6.</td>
<td>Landraces from Madhya Pradesh</td>
<td>142</td>
</tr>
<tr>
<td>7.</td>
<td>Local cultivars from Uttar Pradesh</td>
<td>110</td>
</tr>
<tr>
<td>8.</td>
<td>Promising lines from Maharashtra (including local collection).</td>
<td>108</td>
</tr>
<tr>
<td>9.</td>
<td>Accessions from Vizianagaram</td>
<td>952</td>
</tr>
<tr>
<td>10.</td>
<td>Accessions from Lam, Guntur.</td>
<td>356</td>
</tr>
<tr>
<td>11.</td>
<td>Downy mildew resistant material from Dr. Safeeulla</td>
<td>119</td>
</tr>
<tr>
<td>12.</td>
<td>Disease resistant inbreds (Dr. N.V. Sunderam, IARI, New Delhi)</td>
<td>170</td>
</tr>
<tr>
<td>13.</td>
<td>Disease resistant lines (downy mildew, ergot, smut) from CNRA, Senegal.</td>
<td>9</td>
</tr>
<tr>
<td>14.</td>
<td>Jamnagar (Gujarat, India inbred lines and selections among them)</td>
<td>1873</td>
</tr>
<tr>
<td>15.</td>
<td>Miscellaneous (inbred lines)</td>
<td>15</td>
</tr>
<tr>
<td>16.</td>
<td>Male sterile lines:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. A1 A2 and A3 sources</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>ii. Downy mildew 'resistant' B lines from Dr. G.W. Burton</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>Wild species of <em>Pennisetum</em></td>
<td>11</td>
</tr>
<tr>
<td>18.</td>
<td>Interspecific crosses (probable)</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 3: Distribution of wild *Pennisetum* species maintained at ICRISAT

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. orientale</em></td>
<td>2 n, 4 n, Western Himalaya, Concan, Bihar, West wards to Arabia, Iraq, North America.</td>
</tr>
<tr>
<td><em>P. villosum</em></td>
<td>2 n, 4 n, Nileland, in Eritria and in Arabia.</td>
</tr>
<tr>
<td><em>P. massaicum</em></td>
<td>Nileland to East Arabia, introduced into India.</td>
</tr>
<tr>
<td><em>P. ruppellii</em></td>
<td>Ethiopia</td>
</tr>
<tr>
<td><em>P. polystachyon</em></td>
<td>Tropics of the old world</td>
</tr>
<tr>
<td><em>P. purpureum</em></td>
<td>Tropical Africa, but now introduced into many other tropical countries.</td>
</tr>
<tr>
<td><em>P. Squamulatum</em></td>
<td>Tropical Africa</td>
</tr>
<tr>
<td><em>P. alopecuroides</em></td>
<td>Burma, through Meghalya, Polynesia.</td>
</tr>
<tr>
<td><em>P. setosum</em></td>
<td>Tropical America and Africa.</td>
</tr>
<tr>
<td><em>P. pedicellatum</em></td>
<td>Rajasthan, Eastern Ghats &amp; Madhya Pradesh.</td>
</tr>
<tr>
<td><em>P. divisum</em></td>
<td>Rajasthan.</td>
</tr>
<tr>
<td><strong>Hybrid Napier</strong></td>
<td>X <em>P. squamulatum</em></td>
</tr>
<tr>
<td><em>P. typhoides</em></td>
<td>X <em>P. purpureum</em> (Hybrid Napier)</td>
</tr>
<tr>
<td><em>P. orientale</em></td>
<td>X <em>P. typhoides</em></td>
</tr>
</tbody>
</table>
6. **Problems of maintenance:**

For objectives I and eventually III, since Pearl millet is protogynous and cross-pollinated, there is a problem in maintaining the collected or aggregate diversity within each accession when several hundreds have to be grown simultaneously. Because of allogamy it is prone to be contaminated and modified (Harlan, 1973). Selfing leads to inbreeding depression (Pokhriyal et al. 1966) and the appearance of new phenotypes. Hand sibbing even if it includes the bulking of pollen is laborious and should involve large numbers of plants for each accession. Additionally, while opening the bag on the female head, free pollen may also enter with the selected pollen causing contamination.

6.1 **Cluster bagging method to maintain the variability within individual accessions:**

To overcome these problems, we have developed a method which is a compromise between the need to produce seed from a large number of accessions, while yet allowing some measure of cross-pollination within each accession.

6.1.1. **Planting:** Planting is done in clusters as shown in Fig.1. Each cluster is spread 45 cm along and 25 cm across the ridge with one cluster per meter on the ridge. Each cluster consists of 10 equally spaced plants around the perimeter. Recent experience has shown that it is better to plant 6 hills
in a cluster, but leave two plants per hill which gives
better control over tillering. Four ridges of 5 m length
are used for each accession. Thus more than 200 plants
are grown for each accession.

6.1.2. Bagging: At the time of flowering, one ear from each plant
in the cluster is enclosed in a single large kraft paper bag.
Bags of 80x25x10 cm and 60x25x10 cm are used for the African
types which have long ears, and 40x20x8 cm for other types
with smaller heads. The stems in a cluster are tied with a
string near the base of the bag to give stability, and the
bags are shaken once a day to create pollen movement within
the bag. From an ear pollen is shed over a period of 4 to
6 days (Burton and Powell, 1968) making cross-pollination
possible.

6.1.3. Harvesting: An equal quantity of seed from each plant in
the plot should be bulked to reconstitute the accession.

This method has been put to field test at ICRISAT on about
1200 accessions planted in November 1977 and found to have
no major difficulties in practice. Seed set has been better
under the large bags as compared to selfing, indicating that
cross fertilization is occurring. Experiments are planned
to determine the amount of cross-pollination.
6.2 **Selfing:**

To meet the demand from breeders and other interested scientists bulk S₁ seed is supplied. For the tillers not used in cluster bagging one ear from each hill is selfed, and at least 50 heads are selfed per accession. An equal quantity of seed from all the selfed heads is bulked to constitute the S₁ bulk seed. These S₁ seeds retaining all genes in the plants selfed with recessive genes separated from their dominant alleles will be the most useful form of the ecotype for the plant breeder (Burton, 1976).

6.3 **Germplasm pools:**

To minimise gene erosion many scientists advocate constituting of germplasm pools, although loss of genes was reported while advancing germplasm pools of Pearl millet (Burton, 1976), nevertheless germplasm pools have their own significance as a practical solution. Hence, we are planning to constitute germplasm pools. After evaluation, accessions of similar morphology and from the same geographic region which represent samples of the same population will be mixed in equal quantity, to form germplasm pools for a particular race or cultivar group. For instance Maiwa and Gero races from West Africa, Jakhrana from Rajasthan, Pittaganti from Andhra Pradesh, the photosensitive group from Eastern Ghats etc. The best way to minimize gene loss and population shift in a germplasm pool will be to advance the population with equal numbers of seeds from each plant in the pool as suggested by (Burton, 1976).
Acknowledgements:

I am grateful to Mr. D.J. Andrews, Dr. L.J.G. van der Maaten and Mr. K.E. Prasada Rao for their suggestions while developing the cluster bagging technique.

REFERENCES:


