Polygon Breeding: Old Hat or New Trick?

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'Polygon breeding' can be described as a multilocalional breeding method with complete and continued sharing of populations and selections. It was first applied in eastern Africa for the breeding of Phaseolus vulgaris beans, and was then called 'Diversified Bulk Population Breeding' (van Rheenen and Muigai 1984). In the present terminology it would be called 'Pentagon Breeding', as five locations participated in the program. It somewhat resembles 'Shuttle Breeding', used for wheat improvement by the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), but the difference between polygon breeding and shuttle breeding is comparable to the difference between a line and a polygon, the simplest being a triangle and next a tetragon (Fig. 1). If we have three locations (A,B,C), and if we denote F4 population, that was grown, for example as F4 at A, as F3 at B, and as F3 at C by F (ABC), 3-years' shuttle and triangle breeding starting from an F2 would yield the following populations:

<table>
<thead>
<tr>
<th>Shuttle breeding</th>
<th>Triangle breeding</th>
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<tbody>
<tr>
<td>F4 (ABA)</td>
<td>F4 (AAA)</td>
</tr>
<tr>
<td>F4 (BAB)</td>
<td>F4 (BAA)</td>
</tr>
<tr>
<td>F4 (AAB)</td>
<td>F4 (BAB)</td>
</tr>
<tr>
<td>F4 (AAC)</td>
<td>F4 (BAC)</td>
</tr>
<tr>
<td>F4 (ABA)</td>
<td>F4 (BBA)</td>
</tr>
<tr>
<td>F4 (ABB)</td>
<td>F4 (BBB)</td>
</tr>
<tr>
<td>F4 (ABC)</td>
<td>F4 (BBC)</td>
</tr>
<tr>
<td>F4 (ACA)</td>
<td>F4 (BCA)</td>
</tr>
<tr>
<td>F4 (ACA)</td>
<td>F4 (BCB)</td>
</tr>
<tr>
<td>F4 (ACA)</td>
<td>F4 (BCC)</td>
</tr>
</tbody>
</table>

The number of populations for shuttle breeding will be two after 3 years, and for triangle breeding 32. If the

Figure 1. Shuttle breeding and polygon breeding. A, B, C, D are different locations.
polygon has \( n \) angles, the number of populations after 3
years will be \( n^2 \), and after \( x \) years \( n^x \).

An example is wheat improvement, that partly resembles
shuttle breeding, and partly pure location breeding
at two places in Canada, where various combinations of
locations over years or “pathways” were used.

The Tamil Nadu GD Naidu Agricultural University,
Coimbatore, the Agricultural Research Station, Bad-
napur, and ICRISAT Center collaborated in an adjusted
tetragon breeding program for four different chickpea
cross populations during 1985-90.

Provisionally, some interesting conclusions can be
drawn. There has been a controversy among breeders
over the choice of environment for selection purposes:
should breeders use an optimal environment; a stress
environment; a good, normal environment; or an environ-
ment as close as possible to farm conditions for their
breeding and selection work? The results of the tetragon
breeding program showed that selection in one environ-
ment was significantly more effective than in another
environment. At each of the four locations =300 plants
were selected from the same \( F_5 \) base populations and the
=1200 progenies from these were tested at all four loca-
tions. The top 10% of these =1200 progenies consistently
contained more selections from Coimbatore (C: low pro-
ductivity) and Patancheru 2 (P2: high productivity) than
from Patancheru 1 (P1: low productivity) and Badnapur
(B: medium productivity). Obviously the differences
cannot be explained in terms of quality of environment,
and it is difficult to predict the best environments for
selection (Table 1).

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**Figure 2. A proposed scheme for an interna-
tional breeding program, with regional subpro-
grams (I_2, P_2, etc.).**

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Consequently the Polygon Breeding method has some
attractive features:
- it is less restrictive in selection environment than ‘one
  location breeding’;
- it enhances national and international collaboration
  and interaction (Fig. 2);
- it leaves options for wide-to-narrow adaptation (e.g.,
  ABC and AAA); and
- it may help to avoid competition between breeding
  programs.

Finally, returning to the question raised in the title of
this paper, Polygon breeding: Old hat or new trick? ... the
hat is not brand new, but has been worn very little; and
the trick of systematic close interaction of different
breeding programs, we believe, is relatively new.

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### Table 1. Origin of top 10% selected chickpea pro-
genies (120) after testing at Badnapur (B), Coimbatore
(C), Patancheru—nonirrigated (P1) and Pa-
tancheru—irrigated (P2) during 1989/90.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>45</td>
</tr>
<tr>
<td>P1</td>
<td>9</td>
</tr>
<tr>
<td>P2</td>
<td>52</td>
</tr>
<tr>
<td>HO(^1)</td>
<td>30</td>
</tr>
<tr>
<td>(x^2)</td>
<td>46.87</td>
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<tr>
<td>(P)</td>
<td>&lt;0.01</td>
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\(^1\) HO: Each location has been equally effective as a selection site.

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Reference