Breeding/Genetics

Polygon Breeding: Old Hat or New Trick?

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'Polygon breeding' can be described as a multilocational 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 Maíz 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 F_4 population, that was grown, for example as F_2 at A, as F_3 at B, and as F_4 at C by F (ABC), 3-years' shuttle and triangle breeding starting from an F_2 would yield the following populations:

Shuttle breeding	Triangle breeding		
F_4 (ABA)	F_4 (AAA)	F_4 (BAA)	F_4 (CAA)
F_4 (BAB)	F_4 (AAB)	F_4 (BAB)	F_4 (CAB)
	F_4 (AAC)	F_4 (BAC)	F_4 (CAC)
	F_4 (ABA)	F_4 (BBA)	F_4 (CBA)
	F_4 (ABB)	F_4 (BBB)	F_4 (CBB)
	F_4 (ABC)	F_4 (BBC)	F_4 (CBC)
	F_4 (ACA)	F_4 (BCA)	F_4 (CCA)
	F_4 (ACA)	F_4 (BCB)	F_4 (CCB)
	F_4 (ACA)	F_4 (BCC)	F_4 (CCC)

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

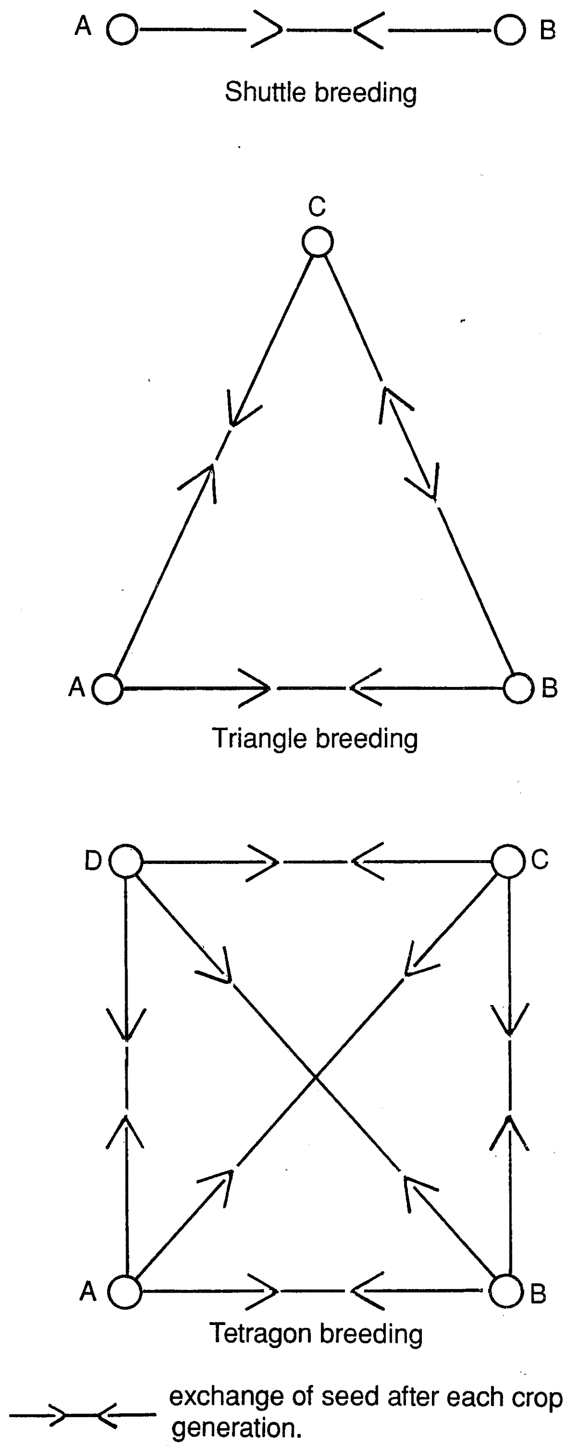

Figure 1. Shuttle breeding and polygon breeding. A, B, C, D are different locations.

polygon has n angles, the number of populations after 3 years will be n^3, 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, Badnapur, 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 environment 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 environment 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 locations. The top 10% of these ≈1200 progenies consistently contained more selections from Coimbatore (C: low productivity) 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).

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

Origin of selected progeny	Test location (1989)				
(1988/89)	B	C	P1	P2	B,C,P1,P2
B	14	12	16	26	11
C	45	42	38	35	48
P1	9	25	16	12	5
P2	52	41	50	47	56
HO[1]	30	30	30	30	30
x^2	46.87	20.47	28.5	21.80	61.36
P	<0.01	<0.01	<0.01	<0.01	<0.01

1. HO: Each location has been equally effective as a selection site.

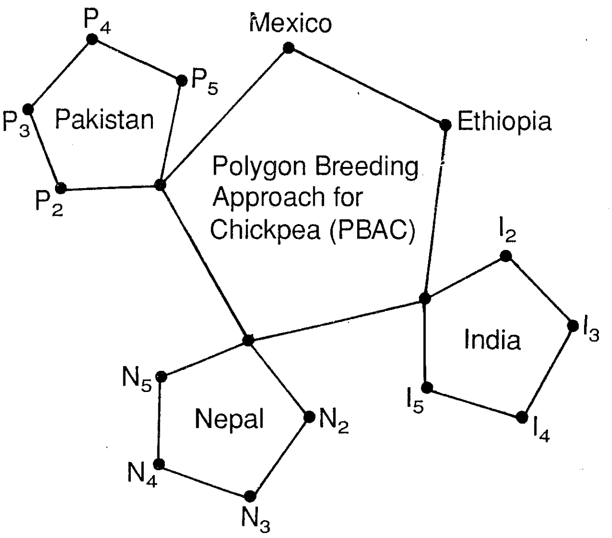

Figure 2. A proposed scheme for an international breeding program, with regional subprograms (I_2, P_2, etc.).

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.

Reference

van Rheenen, H.A., and **Muigai, S.G.S.** 1984. Improvement of field beans by diversified bulk population breeding. Annual Report of the Bean Improvement Cooperative 27:129–130.