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A Comprehensive Breeding Procedure Utilizing Recurrent Selection for Peanuts[1]

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ABSTRACT

A comprehensive breeding procedure for peanut (*Arachis hypogaea* L.) consisting of three stages — the development of a genetically broad-based virginia-type population, recurrent selection without extensive crossing for continued population improvement, and isolation of pure lines from high yielding families at each cycle of selection was initiated in 1974. Forty S_1 families in S_3 generation were selected from each cycle of selection. Only five families from cycle 0 outyielded the check cultivar, Florigiant, whereas yield of all selected families from the next two cycles exceeded the yield of Florigiant. Pure lines isolated from high yielding cycle 0 families have yielded more than Florigiant in advanced yield trials. Use of this procedure provides a systematic approach in developing higher yielding peanut cultivars with a broad genetic base.

Key Words: *Arachis hypogaea* L., recurrent selection, breeding methods, groundnut.

Plant breeding consists of creation of genotypic variability in a population of plants, selection of genotypes that possess the desired combination of genes, and release of the best genotypes as cultivars for production (3). Several comprehensive breeding systems have been proposed to systematically develop and exploit the variability in plant populations (2, 4, 6). Comprehensive breeding systems proposed for cross-pollinated crops such as maize (*Zea mays* L.) consist of three phases: (a) the development of two or more breeding populations from diverse genetic sources, (b) continuous intrapopulation improvement using a recurrent selection procedure, and (c) the development of superior cultivars (hybrids or synthetics) from each cycle of selection (2).

Since population improvement is applicable to both outcrossing and self-pollinating species and is a powerful procedure for breeding programs (3), a procedure similar to the maize comprehensive program can be used with self-pollinated crops such as the peanut (*Arachis hypogaea* L.). However, the objective of the procedure for peanuts would be the production of homozygous lines instead of hybrids. The major objections of a comprehensive breeding system using recurrent selection for a self-pollinated crop are the amount of labor required to make the large number of pollinations required during the recombinational stage and the length of time involved for each cycle of selection. A recurrent selection procedure proposed by Compton (1) and adapted to peanuts by Wynne (7) reduces the number of required pollinations per cycle of recombination and, with the use of greenhouse and winter nurseries, also reduces the time for each cycle.

The objective of this paper is to describe the application of a comprehensive peanut breeding system which allows for intrapopulation improvement of a broad genetic-based population. Furthermore, the system requires little crossing and results in the isolation of inbred lines with potential for cultivar release.

Materials and Methods

Development of Breeding Population

The breeding population was initiated in 1974 by randomly crossing 40 diverse virginia-type (*A. hypogaea* ssp. *hypogaea* var. *hypogaea*) cultivars or breeding lines selected to represent a broad genetic base (Table 1). One hundred single crosses were made using each of the 40 lines as a parent in five crosses. Only one seed per cross was needed so the number of pollinations per cross and for the recombination phase was minimized.

Recurrent Selection

The first cycle (C_0) of recurrent selection was completed as described in Table 2. A single F_1 seed from each original selection (S_0 plant) was used to produce the first selfed generation (S_1 plant and F_2 seed) in the greenhouse. Each S_1 plant, representing a single cross, was harvested in bulk and grown for seed increase in a winter nursery in Puerto Rico. Enough F_3 seed was provided from the increase for testing in replicated yield trials. Lines from cycle 0 were tested in 1976 in the $S_{1,3}$ (S_1 family in S_3) generation with two replications at the Peanut Belt Research Station at Lewiston, NC. Forty of the 78 $S_{1,3}$ families tested were selected on the basis of high fruit yield and were used to initiate the recombinational phase of the next cycle. Cycle 1 lines were tested in 1979 in a four-replicate yield test at the Peanut Belt Research Station and the Upper Coastal Research Station at Rocky Mount, NC. Forty of the 92 $S_{1,3}$ families tested were selected on the basis of high fruit yield as parents for the next cycle. The next cycle (C_2) was tested in 1982 in four-replicate yield tests at the Rocky Mount and Lewiston locations. Forty of the 80 $S_{1,3}$ families tested

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Table 1. Identification and source of origin of parents used to initiate recurrent selection for fruit yield.

Parent	Identity	Source	Parent	Identity[a]	Source
1.	NC 7 (NC 5 x Fla 393)	North Carolina	21.	NC 5	North Carolina
2.	GP-NC 343 x Va 61R	"	22.	Florigiant	Florida
3.	Florigiant x NC Ac 342	"	23.	NC-Fla 14	North Carolina
4.	NC 6 (GP-NC 343 x Va 61R)	"	24.	NC 17	"
5.	GP-NC 343 x NC 5	"	25.	Florunner	Florida
6.	NC 5 x Florigiant	"	26.	B_2 x NC 5 F_3 selection	North Carolina
7.	NC 2A N78	"	27.	B_2 x NC 5 F_4 bulk	"
8.	NC Ac 6333 x NC 5	"	28.	B_1 x NC 4 F_4 bulk	"
9.	NC 2 x Florigiant	"	29.	B_1 x NC 5 F_4 bulk	"
10.	Florigiant x NC 5	"	30.	B_2 x NC 4 F_4 bulk	"
11.	NC 5 x NC Ac 9088	"	31.	Florigiant x Florunner F_4	"
12.	Va 72R	Virginia	32.	Florigiant x Valencia F_4	"
13.	Va 70 Composite	"	33.	Florigiant x Spanhoma	"
14.	Au 2	Alabama	34.	Frost Resistant	"
15.	Georgia 194R	Georgia	35.	PI 170236 (Yer. Fistik)	Turkey
16.	UF 439-16-6	Florida	36.	PI 152122 (Schwarz)	Brazil
17.	Early Bunch	"	37.	PI 138870 (Badamizamine)	Iran
18.	UF 714021	"	38.	Taylor 16	North Carolina
19.	UF 73307	"	39.	PI 162858 (Ashford)	Sudan
20.	GK 3	Gold Kist	40.	PI 158850	China

[a] B_1 (PI 262090) and B_2 are primitive Bolivian cultivars of var. hypogaea.

were selected for high fruit yield to initiate a fourth cycle of recurrent selection (C_3 population).

Isolation of Inbred Lines

Fifty-six randomly selected seeds from each of the 40 selected families from cycle 0 were used to plant an unreplicated nursery which was in the S_4 (selfed) generation. Progeny from single plants selected for appearance and apparent high yield were evaluated in preliminary two-replicate yield tests with plots consisting of two rows of 28 plants each spaced 25 cm apart within the row at the Lewiston location. Selected lines were increased and entered into advanced breeders yield trials with four replicates and a plot consisting of two 28-plant rows at Rocky Mount and Lewiston, NC for two years. Promising lines were then submitted for regional testing at two digging dates at each of four locations in North Carolina and Virginia in the Virginia-North Carolina Peanut Variety and Quality Evaluation Program (5).

Table 2. Outline of procedure for one cycle of recurrent selection without extensive crossing.

40 Parents for first cycle (C_0)
↓ (100 random-paired matings)
100 S_0 plants grown in greenhouse
↓ (single seed descent)
100 S_1 plants grown in greenhouse
↓ (bulk harvested each S_1 plant)
100 S_1 families in S_2 --→ Winter nursery
↓ (bulk harvested each family)
100 S_1 families in S_3 --→ Replicated yield test (cycle 0)
↓
40 Family selections [parents for next cycle (C_1)]

Results and Discussion

Only 78 $S_{1,3}$ families from cycle 0 were evaluated for yield at a single location in 1976 due to poor seed increase in Puerto Rico. Yields ranged from 1885 to 4786 kg/ha for the 78 $S_{1,3}$ families compared to 4250 kg/ha for Florigiant. Five of the 78 families outyielded, although not significantly ($p = 0.05$), the check cultivar Florigiant (Table 3). Of the original parents, only three (P28, P30, and P40) were not represented in the pedigrees of the lines used as parents for the next cycle.

Yields of the 92 $S_{1,3}$ families of cycle 1 ranged from 2781 to 4290 kg/ha for the 92 families compared to 3012 kg/ha for Florigiant. All 40 families selected as parents for cycle 2 yielded more than Florigiant (Table 3). An additional four original parents (P1, P3, P16, and P24)

Table 3. Yield of C_0-C_2 populations, selected lines, and check cultivar Florigiant.

Year	Yield of Florigiant (kg/ha)	Cycle	Range of yields (% of Florigiant)	
			Total lines	Selected lines
1976	4250	0	44.4-112.6	80.5-112.6
1979	3012	1	92.3-142.4	106.2-142.4
1982	3359	2	55.9-168.8	123.2-168.8

were excluded from the pedigrees of the selected families used as parents for the next cycle of recombination.

Yields of the 80 $S_{1,3}$ families of cycle 2 ranged from 1867 to 5669 kg/ha for the second cycle compared to 3359 kg/ha for Florigiant. Of the 40 families selected to initiate a fourth cycle of selection (C_3 population), all again outyielded Florigiant (Table 3).

The increased yields for the 40 highest yielding families from cycles 1 and 2 compared to the yield of Florigiant suggest that recurrent selection has been effective in increasing yield of the population. The improvement in yield occurred in spite of a very low selection intensity, where almost half of the population was selected for each cycle. The low selection intensity was planned since it reduces the chance of discarding high yielding families which are tested in only one or two environments. The low selection intensity should also retain genetic variability in the population for several cycles of selection.

Although seven of the 40 original parents were eliminated from the pedigrees of the selected families after three cycles of selection, 33 of the original parents were still represented in the population (Fig. 1). Several of the parents such as P6 (NC 5 x Florigiant), P8 (NC Ac 6333 x NC 5), P12 (Va 72R), P19 (UF 73307), and P32 (Florigiant x Valencia) appear frequently in the pedigree of the cycle 3 parents; however, these parents occur in numerous new combinations which is one of the major advantages of recurrent selection in a self-pollinator such as peanuts.

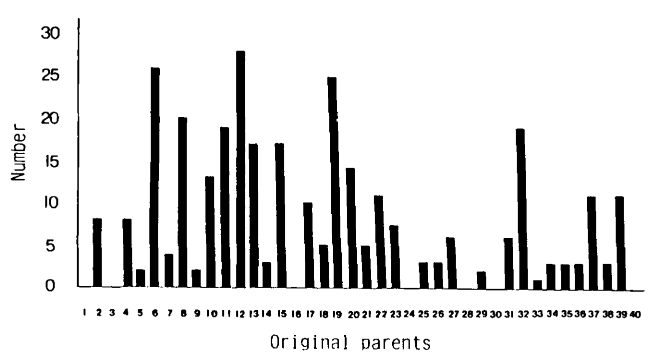

Fig. 1. Number of times that original parent occurs in pedigree of third cycle selections (see Table 1 for identification of original parents).

The final phase of a comprehensive breeding scheme for a self-pollinator is the isolation of inbred lines. All seven inbred lines tested in the Virginia-North Carolina Peanut Variety and Quality Evaluation Program had higher average yields over locations than Florigiant at the first digging date. However, only four of the lines had significantly higher (p = 0.05) yields than Florigiant (Table 4). For the second digging date, yields of all lines except one exceeded the mean yield of Florigiant with three of the lines yielding significantly better (p = 0.05). From cycle 1, 22 lines from 15 different crosses outyielded Florigiant in breeders yield trials during 1984. Yields of an additional 56 lines from 22 crosses from cycle 2 exceeded the yield of Florigiant in a preliminary yield test at a single location.

These results indicate that the proposed comprehensive breeding scheme utilizing single seed descent, a broad-based population, and a low selection intensity is effective for peanuts. The results also suggest that inbred lines developed from a broad-based population improved through recurrent selection can be selected that have yields superior to cultivars presently grown. Furthermore, these findings suggest that peanut breeders can utilize recurrent selection as part of an early generation testing scheme to systematically develop higher yielding populations that can be exploited for cultivar release.

Table 4. Yield of pure line genotypes selected from cycle 0 evaluated in 1984 at four locations with two digging dates each.[a]

Variety or line	Digging I		Digging II	
	Yield[b] (kg/ha)	Value ($/ha)	Yield (kg/ha)	Value ($/ha)
Va 780839	4591a	2890a	4797abc	3075a-d
NC 82-1P	4062efg	2450e-h	4576a-g	2875c-i
NC 18401	4025fg	2413e-h	4367d-h	2726gh
Va 790815	4226c-g	2534d-g	4498b-h	2811e-j
NC 18406	4306b-e	2591de	4801abc	3011a-f
NC 18407	4321b-e	2640cd	4527a-g	2887c-i
NC 18411	4640a	2907a	4897a	3167ab
Florigiant	3984gh	2337hi	4369d-h	2722g-j

[a]Means with different letters significantly different at p = 0.05 according to Duncan's new multiple range test. Data excerpted from annual report of Virginia-North Carolina Peanut Variety and Quality Evaluation Program (5).

[b]Means averaged over four locations with three replicates/location.

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