Peanut Breeding for Drought Resistance[1]

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ABSTRACT

Because drought continues to be a major limiting environmental factor in peanut (*Arachis hypogaea L.*) production, a breeding strategy for developing drought resistance was initiated in the early 1980's at the University of Georgia, Coastal Plain Experiment Station. Crosses were made between advanced breeding lines and drought resistant germplasm. Rainout shelters were used between 60 and 120 days after planting to provide mid-season drought stress so that pedigree selection could be made within early-segregating generations. Eight pure-line selections from the GA T-2465 x Tifton-8 cross combination were first evaluation in irrigated yield trials. The Georgia selection, GA 901412 now GA T-2842, had the highest pod yield in two irrigated test during 1989 and 1990, and was found to have a 25% yield advantage over Florunner under severe drought stress during 1990. In 1991, this same drought resistant selection again had the top yield over 16 other virginia/runner type cultivars in each dryland test at two Georgia locations. Thus, progress has been made in developing adapted drought resistant Georgia breeding lines, and such a breeding approach merits consideration for developing future drought resistant candivars.

Key Words: *Arachis hypogaea* L., groundnut, water stress, pedigree selection, yield.

Drought resistance has been defined as "the ability of one genotype to be more productive with a given amount of soil moisture than another genotype"(12).Accordingly, yield produced in water-limiting environments should be considered a primary criterion for assessing genotypic performance.

The importance of full-season irrigation for peanut (*Arachis hypogaea* L.) production in the southeastern U.S. cannot be over emphasized with mid-to-late season drought being the most detrimental to pod yield (13,14). Drought resistant peanut cultivars have already been developed for the Sahelian regions of West Africa (3,4). However, yield of these cultivars have not been as high as those of U.S. cultivars when tested in Georgia (unpublished data).

Genetic variability for root (6) and shoot characters possibly associated with drought resistance (9) has been reported among cultivars, breeding lines, and peanut introductions. Likewise, genotypic differences have been found for temperature effects on vegetative and reproductive development (7), membrane thermostability (8), and various pod traits influencing calcium and water uptake (11).

Summer rainfall in southern Georgia has historically been very erratic, and long-term records suggest that while the average annual rainfall has remained relatively stable, rainfall during the peanut growing season has declined over the past decade (5). In fact, of the 15 worst Georgia droughts since 1938, eight have occurred in the 1980's (5), and the 1990 drought reduced state peanut yields by approximately 35% below the previous year (1). With over half of the southeastern U.S. peanut crop grown under dryland production, incorporation of drought resistance into adapted peanut cultivars remains a high priority. Thus, a breeding strategy for developing drought resistant candivars (candidate cultivars) was initiated in the early 1980's at the University of Georgia, Coastal Plain Experiment Station, and this paper reports the procedures and progress made toward that objective.

Materials and Methods

Crosses were made in the winter of 1983-84 between advanced Georgia breeding lines and previously reported drought resistant germplasm lines (2,3,6). The F_2, F_3, and F_4 cross populations were grown under a 60-d drought stress period imposed between about 60 to 120 d after planting during 1985, 1986, and 1987, respectively. Single plant selections were made within these early-segregating generations, and individual progeny rows were increased one year before yield trials were conducted with $F_{4:6}$ and $F_{4:7}$ (F_4-derived lines in the F_6 and F_7 generations) selections in 1989 and 1990 growing seasons, respectively.

Each yield trial consisted of two-row plots, 6.1m long, in a randomized complete block designed with six replications. Tests were conducted on a Tifton loamy sand soil type (fine-loamy, siliceous, thermic Plinthic Kandiudult) at the Agronomy Research Farm near the Coastal Plain Experiment Station, a Dothan loamy sand (fine-loamy, siliceous, thermic Plinthic Kandiudult) at the Southeast Georgia Branch Station near Midville, and a Greenville sandy clay loam(clayey, kaolinitic, thermic Rhodic Kandiudult) at the Southwest Georgia Branch near Plains. Recommended cultural practices were followed throughout the growing seasons, and individual entries were harvested according to visual above-ground maturity comparisons after shellout determinations based upon adjacent border plots.

Yield data from each test were analyzed by analysis of variance.Waller-Duncan's multiple range test (k-ratio=100) was then used for mean separations. Grade values are the average of two 1000-g samples, and were determined using federal-state inspection service standards for total sound mature kernels (TSMK), other kernels (OK), damaged kernels (DK), extra-large kernals (ELK), in addition to the weight of 100 sound mature seed.

Results and Discussion

Since drought during the summer months cannot be accurately forecast, rainout shelters are a necessity to annually screen peanut genotypes for drought resistance (10). However, shelters also have certain space restrictions which limits the number of genotypes that can be evaluated at any given time. So, priorities were established and consequently only the most promising cross combinations chosen. The advanced Georgia breeding line, GA T-2465 x Tifton-8 (2) combination was subsequently picked for this study because both parents were already know to have some drought resistance (unpublished data).

To encompass the breeding nursery, non-automated fixed shelters were temporarily built to cover the early-segregating GA T-2465 x Tifton-8 cross populations for the 60 to 120 days-after-planting stress period for each of the three generations (F_2-F_4). Drought was sufficiently uniform during this 60-d time frame to enable pedigree selection among plants and between progeny rows.

Of approximately 200 total seed which were space-planted under the rainout shelters each year (1985-87)

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with Tifton-8 as a comparative check, only about 25 individual plants were selected. These 25 selections were further reduced to approximately ten selections based upon pod and seed characteristics evaluated after shelling and grading.

In 1989, eight $F_{4:6}$ pure-line selections were first tested in an irrigated yield trial. The results suggested that differences in yield and grade did exist amongst these selections (Table 1). GA 901412 had the highest yield in this test, but it was not significantly different than four other selections or the two runner-type cultivars, Florunner and Sunrunner. Within the selections, percentage of total sound mature kernels (TSMK) ranged from 64 to 76% and from less than two to more than 12% total damage kernels (DK) with GA 901412 having the least DK. Variation in seed weight and extra large kernels (ELK) was also observed.

Sufficient seed were produced in 1989 to allow for more extensive testing the following year. Similar yield and grade results were found under irrigation for GA 901412 during 1990 (Table 2). This particular $F_{4:7}$ selection again produced the highest yield, and had one of the lowest DK percentage. The two parental lines, GA T-2465 and Tifton-8 were also included in this yield trial. Three (GA 901412, GA 901405, and GA 901407) out of the eight selections were comparable to the Georgia T-2465 parent, and all but one were significantly better than Tifton-8 in yield performance and possibly even grade. TSMK ranged from 73% to 77% among the selections with GA 901409 having the lowest percentage in both years.

In 1990, GA 901412 was also included in a dryland yield trial. Rainfall during the growing season was the lowest recorded at Tifton, Georgia since 1980 with only 36.75 cm total. Under the severe drought stress during 1990, GA 901412 was found to have a significant 25% yield advantage over Florunner, and again had fewer damaged kernels (Table 3).

Table 1. Yield and grade performance of drought resistant peanut $F_{4:6}$ selections under irrigation at the University of Georgia, Coastal Plain Experiment Station, Tifton, Georgia, 1989.

Genotype	Yield* (kg/ha)	TSMK (%)	OK (%)	DK (%)	ELK (%)	Seed (g/100)
GA 901412	4645 a	75.8	2.1	1.8	33.3	59.2
Sunrunner	4288 ab	77.0	2.0	4.8	44.0	68.2
GA 901409	4065 ab	64.0	4.1	12.3	41.0	67.1
GA 901408	4031 ab	72.9	3.0	5.8	30.0	65.6
Florunner	3980 ab	76.1	2.6	5.0	33.2	66.4
GA 901405	3923 ab	71.5	1.8	5.4	40.6	70.8
GA 901410	3894 ab	73.5	1.9	5.8	60.1	72.3
GA 901407	3653 b	66.8	2.3	10.4	27.1	66.4
GA 901411	3653 b	76.5	2.8	3.1	26.2	63.0
GA 901406	3442 b	67.1	2.9	5.5	50.2	66.9

*Yield means within the column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 2. Yield and grade performance of drought resistant peanut $F_{4:7}$ selections under irrigation at the University of Georgia, Coastal Plain Experiment Station, Tifton, Georgia, 1990.

Genotype	Yield* (kg/ha)	TSMK (%)	OK (%)	DK (%)	ELK (%)	Seed (g/100)
GA 901412	5238 a	76.2	2.3	1.2	19.2	57.1
GA T-2465	5095 ab	75.5	2.5	1.6	23.2	60.3
Florunner	4865 abc	78.6	2.3	1.4	20.2	62.7
GA 901405	4694 abcd	75.8	2.3	2.6	31.9	67.1
GA 901407	4513 bcd	75.4	2.3	2.6	20.6	63.2
Sunrunner	4253 cd	77.7	2.1	1.8	32.6	66.7
GA 901411	4209 d	76.6	4.0	1.2	15.4	59.7
GA 901408	4122 d	77.4	2.4	2.4	21.6	63.8
GA 901406	4065 d	75.6	1.7	2.9	49.2	68.2
GA 901410	3384 e	76.3	2.2	2.8	49.5	67.8
GA 901409	2922 ef	73.5	2.6	3.7	37.7	66.6
Tifton-8	2671 f	69.8	1.4	5.1	57.8	102.9

*Yield means within the column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 3. Yield and grade performance of the drought resistant Georgia peanut selection, GA 901412 and the Florunner cultivar in a dryland test at the Coastal Plain Experiment Station, Tifton, Georgia, 1990.

Genotype	Yield (kg/ha)	TSMK (%)	OK (%)	DK (%)	ELK (%)	Seed (g/100)
GA 901412	3890*	73.4	1.8	3.3	19.6	57.7
Florunner	3059	74.9	2.2	5.0	19.0	59.8

*Significantly different from Florunner at $P \leq 0.05$.

Table 4. Yield performance of drought resistant selection GA 901412 in comparison to 16 peanut cultivars under dryland production in Georgia, 1991.

Cultivar	Yield (kg/ha)* at two Georgia locations: Midville	Plains
†GA 901412	4842 a	5024 a
Georgia Runner	4818 ab	3839 cde
GK-3	4672 abc	4371 bc
Florunner	4614 abc	3156 fg
Tamrun 88	4549 abc	2963 g
AgraTech VC-1	4506 abc	4584 ab
Sunrunner	4301 abcd	3700 def
GK-7	4243 abcd	3906 cde
NC 7	4218 abcd	4545 ab
Florigiant	4180 abcd	3436 efg
Okrun	4132 abcd	2896 g
AgraTech 127	4023 abcd	3855 cde
Southern Runner	4023 abcd	4193 bcd
NC-V 11	4000 bcd	4817 ab
NC 10C	3863 cd	3765 cdef
Marc I	3860 cd	3902 cde
NC 9	3485 d	3842 cde

†Advanced Georgia breeding line: GA T-2842.

*Yields within the same column followed by the same letter do not differ significantly at $P \leq 0.05$.

In 1991, GA 901412 was likewise evaluated in dryland yield tests at two Georgia locations, Midville and Plains (Table 4). Drought stress occurred toward the latter part of the growing season this year, and was relatively worse at the Plains location. Under these test conditions, GA 901412 again had the top ranking yield in both tests over 16 other virginia/runner cultivars. It was significantly higher in yield than all but three cultivars (NC-V 11, AgraTech VC-1, and NC 7) at Plains, but was only significantly higher in yield than four cultivars (NC-V 11, NC 10C, Marc I, and NC 9) at Midville.

Thus in conclusion, progress has been made in developing adapted drought resistant peanut selections by the aforementioned method, but additional testing is still continuing. GA 901412 has now been entered in the National Uniform Peanut Performance Tests (UPPT) as GA T-2842. It has a similar maturity, spreading-runner growth habit, and slightly taller and thicker canopy appearance with narrower-looking leaves in comparison to the check cultivar, Florunner.

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