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Heterosis of Apparent Photosynthesis Rate in *Arachis hypogaea* L.[1]

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ABSTRACT

Complete diallel crosses were made among three parental peanut (*Arachis hypogaea* L.) genotypes to gain a better understanding of photosynthetic inheritance. Highly controlled environmental conditions were used throughout the study to determine apparent photosynthetic rates. Results indicated significant differences among parents and F_1 hybrids. Reciprocal differences were also observed between certain cross combinations. Dominance and overdominance effects were found under these test regimes which suggest a heterotic response for this important characteristic.

Key Words: Peanut, groundnut, dominance, overdominance.

Peanut (*Arachis hypogaea* L.) photosynthesis plays an obviously important but presently obscure role in the reproductive capability of plants. If such a physiological mechanism could be genetically manipulated within a breeding program, then overall performance might be increased.

Variation has been noted previously in apparent photosynthetic rates (APR) among genotypes for potentially improving photosynthesis. Pallas and Samish (5) revealed a CO_2 range of 0.9452 - 1.4456 mg m^{-2}-s^{-1} for Tifton-8 and NC 4, respectively. Likewise, Bhagsari and Brown (1) demonstrated an average CO_2 range of 0.6672 - 1.0286 mg $m^{-2}s^{-1}$ over three experiments for thirty-one cultivated lines, and they also found that the wild species generally had lower APR as compared to *A. hypogaea.* Recently, Pallas (4) identified additional diversity among peanut germplasm for APR ranging from 0.5838 for Spanhoma to 1.1954 mg CO_2 $m^{-2}s^{-1}$ for Florunner and Florigiant at a 1400 μmol $m^{-2}s^{-1}$ photosynthetic photon flux density (PPFD). In another study by Bravdo and Pallas (2), NC 4 had the highest APR, and Spanhoma had the lowest rate.

The authors were unable to find any literature on the inheritance of peanut photosynthesis. The objective of this research was to gain a better understanding of peanut genetics for APR.

Materials and Methods

Two pure-line cultivars, NC 4 and Spanhoma, and one germplasm line, Chico, were selected because of their known wide variation in APR. Photosynthetic capability was determined on an individual plant basis. A complete diallel crossing of these three parental lines was made to generate six F_1 hybrid combinations. The cultivar, Argentine, was also included as an internal check to constitute a total of ten entries.

Because of capacity limitations, only two samples could be analyzed at a given time. Thus, the experimental design consisted of a pseudo-incomplete block arrangement. Entries were assigned at random among each of four replications. Six runs with two entries per run comprised a replication. Runs were conducted in consecutive order, and no entry was included more than once in any replication, except for the internal triplicated check.

Staggered plantings were made to enable similar growth stage comparisons throughout the experiment. Each seed was germinated and transferred to 1.4-L containers filled with Jiffy Mix for further development. These seedlings were grown in water-cooled chambers programed for 25C, 60% RH, and 350 μL CO_2L^{-1} air for 50 400 s (14 hr) photoperiods, and 20C, 90% RH, and 400 μL CO_2L^{-1} for 36 000 s (10 hr) nyctoperiods. The primary light source consisted of a bank of VHO coolwhite fluorescents supplemented with incandescents giving a total of 195 J $m^{-2}s^{-1}$ radiation at the soil surface as measured by a Beckman-Whitley model H188-01 total radiometer.

All APR were made on the youngest fully expanded unshaded leaves of three to four-week old plants as previously described (5). APR measurements were determined in two semi-closed compensating systems where air was circulated through a plexiglass water-cooled chamber at 0.42 m s^{-1}. The air temperature and vapor pressure deficits were controlled by bringing humidified air to the desired dewpoint temperature and reheating before entrance into the leaf chamber. The CO_2 content of the chamber was monitored by a model 315 NDIR Beckman IR CO_2 analyzer and held at steady-state 300 ± 2 μL CO_2L^{-1} by the system. A constant day-night temperature of 25C was maintained with 60% daytime RH and a 90% nighttime RH. Actual APR readings were made at a 1400 μmol $m^{-2}s^{-1}$ PPFD. Several light sources were used in combination to provide for an evenly distributed high illuminance as follows: a) background fluorescent-incandescent light bank, b) 625 and 1500-W quartz iodine lamps, and c) a carbon arc burning high intensity photo 88 rods which simulates the spectral composition of sunlight.

Data were subjected to a general linear model procedure for analysis of variance. Means were compared by the Duncan's multiple range test. Comparison of high and midparent versus F_1 values was made by linear contrasts.

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Results and Discussion

The first analysis using just the check cultivar showed no significant replication, chamber, or replication x chamber interaction effects. A subsequent complete entry analysis likewise showed no significant chamber or run differences. Thus, a randomized complete block analysis was deemed appropriate for testing variation among the ten entries. Argentine had an average APR of 1.0279 mg $CO_2 m^{-2} s^{-1}$ which was not significantly different from NC 4.

Highly significant differences were found among parents and some F_1 hybrids (Table 1). The relative APR of the parents were in agreement with previous results (2). NC 4 had a significantly higher APR as compared to Spanhoma and Chico. Yet, NC 4 appeared to have a lower rate than that observed by Pallas and Samish (5).

Table 1. Mean apparent photosynthetic rates of three parental peanut lines and six F_1 hybrids from diallel cross combinations.[a]

Parent: ♂	Chico	Spanhoma	NC 4
♀	---------- (mg CO_2 $m^{-2}s^{-1}$) ----------		
Chico	0.7445 e	0.8948 cd	0.9851 bc
Spanhoma	1.0554 b	0.8141 de	1.0324 b
NC 4	1.0146 bc	1.2053 a	1.0036 bc

[a] Values followed by the same letter are not significantly different at the 0.01 level of probability.

Reciprocal differences were noted among F_1 plants from Chico x Spanhoma and Spanhoma x NC 4 cross combinations, but not between NC 4 x Chico. This suggests some maternal or extrachromosomal influence, probably chloroplastic, is also involved in the inheritance of photosynthesis.

All F_1 hybrids were significantly greater in APR than their respective midparental mean and equalled or exceeded the high parent (Table 2). These results indicate that dominance plays an important role in the inheritance of APR among these peanut genotypes under such experimental test regimes.

Overdominance was not observed among crosses with the widest parental range. However, it was detected for crosses involving parents of closer photosynthetic rates, but only when the higher parent was used as the maternal line. Thus, for heterotic increase in APR, two crosses appeared as better nicks, particularly NC 4 x Spanhoma which produced the highest rate.

Our findings regarding F_1 expression of apparent photosynthetic rates agrees with those found in *Zea mays* L. (3) and *Triticum aestivum* L. (6). Hybrid vigor has long been noted among peanut crosses (7). Because high APR appears to be conditioned by dominant alleles, it theoretically would be very difficult to select a homozygous plant in the early generations. An option would be to practice some form of bulk, mass, single-seed descent, or recurrent selection, and delay pure line selection until the cross populations have reached a larger degree of homozygosity.

Table 2. Mean comparison between F_1 peanut hybrids versus midparent (MP) and highparent (HP) for APR.[a]

F_1	MP	HP
Chico X Spanhoma	**	NS
Chico X NC 4	**	NS
Spanhoma X Chico	**	**
Spanhoma X NC 4	**	NS
NC 4 X Chico	**	NS
NC 4 X Spanhoma	**	**

[a] NS Nonsignificant at the 5% level.

** Significant at 1% level.

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