Peanut Science (1978) 5, 109-111

Effect of Environment and Cultivar on Peanut Seedling Emergence[1]

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ABSTRACT

The influence of the environment and the cultivar on field emergence of peanut (*Arachis hypogaea* L.) seedlings was investigated by determining the percentage of emerged seedlings for eight cultivars planted in replicated tests at five locations in North Carolina for a 3-year period.

Both years and locations influenced the percentage of emerged seedlings although neither source of variation was significant because of a large and significant location x year interaction. The percentage of seedlings that emerged was also influenced by the cultivar. 'NC 17' averaged only 63% emerged seedlings while both 'Florigiant' and 'NC-Fla 14' averaged over 80% emerged seedlings.

The year x cultivar and year x location x cultivar interactions were significant. The cultivars differed in stability over environments for the percentage of emerged seedlings when the data were analyzed by regression. Florigiant and NC-Fla 14 had greater stability over environments than the remaining six cultivars for the percentage of seedlings that emerged.

Broad-sense heritability for seedling emergence was estimated to be 0.76.

These results indicate that peanut breeders can improve seed quality by selecting for both a greater percentage of emerged seedlings and cultivar stability over years and locations.

Key Words: Stability, genotype-environment interactions, heritability, seed quality, *Arachis hypogaea* L.

Peanut (*Arachis hypogaea* L.) seed can account for approximately 20% of the cost of production for a Virginia-North Carolina grower. In general, excessive seeding rates are required to produce the plant stands necessary for high yields. With improvement in seed quality growers could reduce seeding rates and thus production costs.

Although improvement of peanut seed quality requires effort during many phases of seed production, the possibility of improving the inherent quality of seed through breeding exists. Grabe and Metzer (1969) classified 25 soybean [*Glycine max* (L.) Merr.] cultivars according to their ability to emerge from different planting depths. Distinct cultivar differences in emergence ability were evident and appeared to be genetically controlled. Fehr (1973) demonstrated that selection for differences in soybean hypocotyl length during germination at 25 C was possible. Mixon (1971) found that seeds from lots of 'Early Runner' peanuts which produced radicles during the first and second day after imbibition of water gave a greater percentage of emerged seedlings than seeds from lots which produced radicles on the third and subsequent days. Superiority was expressed during germination at low temperatures or after seeding at depths deeper than normal.

Whittington (1973) analyzed data on field emergence of four sugar beet (*Beta vulgaris* L.) cultivars at three locations for 4 years and found that cultivar variation was significant but of less importance than the effects of locations or years. The genetic variation was highly significant despite a significant year x location interaction. The differences between cultivars were greater in years or at locations when seedling emergence was poor because of adverse environmental conditions.

The significant cultivar x environment interactions indicated that seeds from different cultivars did not perform consistently over a range of environments. Seed from cultivars that perform well even when marked fluctuations of climatic conditions occur would be advantageous. General adaptability of cultivars grown in several environments has been measured by several workers using variety x environment interactions as the basic measure of adaptability. Finlay and Wilkinson (1963) used a linear regression of yield on the mean yield of all cultivars in an environment to measure variety adaptation. Their analysis was used to identify cultivars specifically adapted to good or poor environments as well as to identify those with general adaptability. Wright (1976) summarized the various methods of regression analysis for selection for general and specific adaptation to the environment.

This study was conducted to determine the potential for improving peanut seed quality by selecting for seedling emergence under field conditions. The objectives of the research were (a) to investigate the influence of environment and cultivar on field emergence of peanut seedlings; (b) to determine if some cultivars produce higher plant stands over a range of environments; and (c) to determine the heritability of peanut seedling emergence.

Materials and Methods

Seeds from eight Virginia peanut cultivars were planted in replicated tests at five locations across the North Carolina peanut production area during the 3-year period from 1975-1977. All seeds were produced at the Upper Coastal Plain Research Station, Rocky Mount, and the Peanut Belt Research Station, Lewiston, NC. Seeds were produced using recommended cultural practices. Seeds were dried using the conventional stackpole method. A single lot of less than 4.5 kg of seed for each cultivar was produced by thoroughly mixing equal quantities of the seeds from the two locations. The eight cultivars ('NC 2', 'NC 5', 'Florigiant', 'Va 72R', 'NC-Fla 14', 'NC 17', 'Avoca 11', and 'Shulamit') studied are all large-fruited Virginias currently grown in North Carolina.

Each test was replicated four times with a plot consisting of two rows of 100 seeds each. The number of plants that emerged for each plot was counted 3-4 weeks after planting. The locations selected were considered random within a section of the North Carolina peanut-producing area (Table 1). Date, method of planting and spacing between plants within rows varied slightly from test to test but the planting methods used allowed an accurate count of emerged seedlings.

A combined analysis of variance over years and locations was conducted. Years, locations, and cultivars were considered random, allowing the calculation of variance components for each effect and interaction. The data were further analyzed by the regression technique of Finlay and Wilkinson (1963). The mean percentage of emerged seedlings for each cultivar was plotted against the mean

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Table 1. Location and date of planting for seedling emergence studies.

Location	Production area	Date of planting (days from May 1) 1975	1976	1977
1	Western Coastal Plain	+7	+11	+12
2	North central	+5	+4	+11
3	South central	+6	+11	+2
4	Northeastern	+8	+6	+11
5	Southeastern	+1	+4	-8

of all cultivars at a location with the overall mean being the independent variable and the individual cultivar means being the dependent variable. Finally, broad-sense heritability, H, was estimated using the ratio formed by dividing the genotypic by phenotypic variance (Allard, 1960).

Results and Discussion

The year of planting (and perhaps the year of seed production) had an influence, although not significant at the 5% probability level, on the percentage of peanut seedlings that emerged. Five percent more seedlings emerged in 1976 than in either 1975 or 1977 (Table 2). The location at which the seeds were planted, although not significant at 5% probability level, had a greater influence on the percentage of emerged seedlings (Table 2). The mean for the percentage of seedlings that emerged at the Western Coastal Plain location over the 3-year period was 68% while more than 80% of the seedlings emerged at the southeastern location. However, locations were not consistent in seedlings emergence from year to year, producing a significant and large location x year interaction (Table 3). Neither years nor locations were significant because of this large location x year interaction.

Table 2. Influence of year and location on the average percent peanut seedling emergence for eight cultivars.

Year/location	Percent seedling emergence 1[a]	2	3	4	5	Year average
1975	72.9[b]	75.1	73.6	61.4	88.6	74.3
1976	67.5	87.1	82.2	85.2	75.2	79.4
1977	63.5	76.9	79.2	72.3	76.9	73.8
Location average	68.0	79.7	78.3	72.9	80.2	

[a]Refers to locations in Table 1.

[b]$LSD_{(.05)}$ for testing individual year-location means = 4.2.
$LSD_{(.05)}$ for years = 9.9; for locations = 14.3.

Table 3. Mean squares and components of variance from analysis of variance of seedling emergence.

Source	d.f.	Seedling emergence: Mean squares	Variance components estimates
Year (Y)	2	1558.59	0
Location (L)	4	2649.65	67.74
Y x L	8	1836.82**	442.07
Rep/Y x L	45	68.55	68.55
Cultivar (C)	7	2165.21**	27.60
Y x C	14	507.01**	20.09
L x C	28	107.20	0.17
Y x L x C	56	105.14**	21.57
Error	315	18.88	18.88

**Mean squares significant at 1% level of probability.

The percentage of emerged seedlings was also significantly influenced by the cultivar. Seeds of NC 17 consistently produced the fewest seedlings averaging only 63% seedlings emerged, while both Florigiant and NC-Fla 14 averaged over 80% seedlings emerged for the 3-year period (Table 4). The cultivars did not produce a consistent percentage of emerged seedlings each year resulting in a significant year x cultivar interaction (Table 3). The cultivar x year x location interaction was also significant since cultivars did not produce consistent percentage of seedlings over years at a location.

Table 4. Percent seedling emergence for eight peanut cultivars for 3-year period (1975-77).

Cultivar	Percent seedling emergence 1975	1976	1977	Cultivar average
NC 2	76.1	86.3	70.4	77.6
NC 5	69.3	79.2	74.6	74.4
Florigiant	84.7	85.9	79.0	83.2
Va 72R	75.2	78.5	72.2	75.3
NC-Fla 14	86.5	75.6	80.0	80.7
NC 17	55.4	67.5	66.3	63.1
Avoca 11	80.0	81.4	72.6	78.0
Shulamit	67.6	81.1	75.1	74.6
Average	74.3	79.4	73.8	75.8

$LSD_{(.05)}$ for individual cultivar-year mean = 6.5.
$LSD_{(.05)}$ for years = 9.9; for cultivars = 8.8.

Cultivars responded differentially to the range of environments when response was measured by the regression of the percentage of emerged seedlings for a cultivar on the overall mean seedling emergence for an environment (Table 5). The regression coefficients for the eight cultivars ranged from .716 to 1.281. Cultivars NC-Fla 14 and Florigiant had regression coefficients less than 1.0. These small regression coefficients indicated that these two cultivars had a greater resistance to environmental change or above average stability for seedling emergence across environments. Conversely the large regression coefficient above 1.0 for the cultivar Shulamit indicated that seedling emergence for this cultivar was sensitive to environmental change; *i.e.*, low stability over environments. NC 5, NC 17, and NC 2 all showed average stability. However, since both NC 2 and NC 5 had average stability associated with high or average seedling emergence, these cultivars showed general adaptability. NC 17 had average stability associated with a low mean for seedling emergence. NC 17, therefore, was poorly adapted to all environments. The above average stability of NC-Fla 14 and Florigiant associated with a high mean seedling emergence indicated that these two cultivars performed well in both poor and good environments. In general, genotypes that perform well across both good and poor environments are advantageous and should be selected by the peanut breeder. The differences in sensitivity to the environment displayed by NC 17 and NC-Fla 14 are interesting. These two cultivars are sister lines selected from a cross of F334A-3-5-5-1 and Jenkins Jumbo made in Florida in 1951. NC-Fla 14 appeared to be well buffered against environmental changes while NC 17 was more sensitive.

Table 5. Regression estimates (b) of stability and the test of homogeneity of pairs of b estimates.

Cultivar	b	NC-Fla 14	Florigiant	Va 72R	Avoca 11	NC 2	NC 17	NC 5	Shulamit
		b							
		.716	.873	.899	.955	1.090	1.092	1.094	1.281
Shulamit	1.281	6.018**[a]	8.390**	2.543*	6.337**	3.024**	2.243*	3.25**	--
NC 5	1.094	4.835**	6.708**	1.452	3.892**	.090	.040	--	--
NC 17	1.092	3.567**	3.640**	1.192	2.173*	.020	--	--	--
NC 2	1.090	4.452**	5.600**	1.362	3.249**	--	--	--	--
Avoca 11	.955	3.305**	3.030**	.437	--	--	--	--	--
Va 72R	.899	1.067	.204	--	--	--	--	--	--
Florigiant	.873	2.260*	--	--	--	--	--	--	--
NC-Fla 14	.716	--	--	--	--	--	--	--	--

[a]Pairs of b estimates tested for homogeneity by t test where:

$$t = \frac{b_i - b_j}{\left(\frac{SSE_i + SSE_j}{n_i + n_2 - 4}\right)\left(\frac{1}{\Sigma x_i^2} + \frac{1}{\Sigma x_j^2}\right)}$$ with degrees of freedom = $n_i + n_j - 4$.

*,**indicates that regression coefficients are significantly different from each other at 5 and 1% probability levels.

Furthermore, a high percentage of seedlings of NC-Fla 14 emerged while a low percentage of NC 17 seeds produced seedlings. The significant difference between stability estimates for cultivars NC2 and Avoca 11 was also interesting. Avoca 11 was developed through mass selection from NC 2. However, although the average percentage of seedlings that emerged for the two cultivars was similar, Avoca 11 showed greater stability across environments than NC 2. Greater stability occurred although Avoca 11 is obviously less diverse than NC 2, which was derived from an F_4 selection.

The heritability for seedling emergence computed as the ratio of the genotypic and phenotypic variance was 0.76. Heritability estimates of this magnitude indicate that selection for percentage of seedling emergence over environments should be effective and should improve planting seed quality of peanuts.

In conclusion, the results from this study demonstrate that, although under genetic control, the percentage of seedling emergence for seeds of peanut cultivars is clearly influenced by the environment. Heritability estimates and estimates of stability infer that peanut breeders can select cultivars that produce a high percentage of emerged seedlings in both good and poor environments and thereby improve the planting seed quality of peanuts.

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Accepted August 2, 1978