Physiology of Oil Seeds. X. Seed Quality of Peanut Genotypes as Affected by Ambient Storage Temperature[1]

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ABSTRACT

Proper storage of peanut (*Arachis hypogaea* L.) pods following drying is a critical step in maintenance of seed quality for the next planting season. The objective of this study was to examine the effect of ambient storage temperature (similar to farmers stock peanuts stored in warehouses) on seed germination and seedling vigor of selected peanut genotypes. Peanuts were grown in the field for three successive seasons. Pods were harvested, dried, and shelled. Seed samples were taken for storage under ambient conditions, humidity effects were eliminated by storing the seeds in plastic freezer bags in sealed containers. Seasons were: (1) 1986, 19 months storage at ambient temperature, (2) 1987, 7 months storage at ambient temperature, and (3) 1988, seeds without storage. When comparisons were made among genotypes *within* seasons, exposure to Season 1 conditions resulted in the least germination and seedling growth, but a wide range of genotype diversity occurred. Germination of seeds from Seasons 2 and 3 ranged from 81 to 98%, and significant differences in seedling growth occurred among genotypes. When comparisons were made *across* Seasons, the data indicated a significant storage effect, which resulted in different seed quality for individual genotypes. Usually field emergence was significantly different among genotypes and was highly correlated with germination for all seasons. Generally, emergence was negatively correlated with slow seedling growth and positively correlated with rapid seedling growth. Thus, for seeds of lower vigor (Seasons 1 and 2), rapid seedling growth was particularly critical for early, uniform emergence (10 DAP) in the field. Genotypes were significantly different in extent of seed quality reduction and field emergence both *within* and *across* storage periods. Genotype diversity to ambient storage conditions suggests there is genetic potential to improve longevity of seed quality during storage and enhance stability of field emergence.

Key Words: *Arachis hypogaea* L., groundnut, germination, seedling vigor, genotype, field emergence.

Good seed quality (germinability and vigor) is essential to establish uniform plant stands for crop production. Seed quality can be affected by environmental conditions that occur while seeds are maturing on the plant, during harvest or processing, and in post-harvest storage (Heydecker, 1977; Maguire, 1977). During post-harvest storage, exposure of peanut seeds to high relative humidity causes deterioration in quality (Ketring, 1971, 1973). With few exceptions, the rate of decrease in germination is proportional to the increase in relative humidity and temperature above optimum (Baskin and Delouche, 1971). The quality of peanuts in storage can best be kept high by maintaining proper temperature and moisture content, but controlling these factors is difficult with farmers stock peanuts stored in ambient warehouses (Smith and Davidson, 1982). Ideal conditions for normal storage periods of farmers stock peanuts are about 10 C and 65% relative humidity (Smith and Davidson, 1982; Navarro *et al.*, 1989). Moisture content of peanut seeds under these conditions is about 6%. The commercial peanut seed industry stores peanuts annually under ambient conditions of temperature and relative humidity. These conditions are not always conducive for maintenance of high quality seeds and severe monetary losses can occur if seeds do not germinate or seedlings emerge poorly under field conditions.

The objectives of this study were: 1) to store peanuts under ambient conditions, similar to commercial seed storage environment, except to exclude excessive relative humidity from stored seeds, and thus determine the combined effect of storage time and ambient temperature on peanut seed quality, and 2) to determine any genotypic differences that occurred under these conditions.

Materials and Methods

General

Peanuts were grown in the field on a Teller sandy loam soil (fine, mixed, thermic, Udic Argiustoll) at the Agronomy Research Station, Perkins, OK (35°59'N, 97°03'W). Seeds were planted 5-cm deep in 0.91-m wide rows with five seeds per 0.3-m intrarow spacing using standard agronomic practices. Cultivars, germplasm (Simpson and Smith, 1986), and breeding lines (designated BL) were used in the tests, but not all of them every year (Table 1). However, a group of six genotypes (Pronto, SN 55-437, and BL-1, -2, -3, and -4) were used throughout the study. Except insufficient seeds of BL-2 were available for field emergence tests in Season 1. Breeding lines 1 and 4 were selections of the author. Breeding lines 2 and 3 were obtained by courtesy of Dr. O. D. Smith, Soil and Crop Sciences Dept., Texas A&M Univ., College Stn., TX. Peanuts were grown in three successive seasons under irrigated conditions (1986, 1987, 1988). Pods were threshed in the fall, collected in mesh sacks, and dried while hanging in flowing air at ambient temperature. Pods were left in the sacks until shelled. After shelling, seeds were cleaned and sized. Only seeds with intact, smooth seed coats and riding at least 5.95 x 19.05 and 6.75 x 19.05 mm slotted screens were used for tests of spanish- and runner- type genotypes, respectively. Seed samples taken for storage of each genotype were placed in separate plastic freezer bags inside individual closed containers. The seeds were thus protected from ambient relative humidity while being subjected to only ambient temperature during storage.

Season 1, 1986 Seeds

Plots were planted 6 June and harvested 28 October 1986, 144 days after planting (DAP). Seeds were processed as described above, samples planted in spring 1987, and seed containers placed in storage in a large metal, uninsulated building. This type of structure is common in the southeastern and southwestern peanut-producing areas of the United States for storage of farmers stock peanuts (Smith *et al.*, 1985). These seeds remained in storage during the remainder of 1987 and all of 1988, for a total of 19 months. The seeds were subjected to ambient temperatures both years, but relative humidity was excluded by the storage method.

Season 2, 1987 Seeds

The plots were planted 11 June from seeds produced in 1986 and were harvested 28 October 1987, 135 DAP. Wet conditions delayed planting in 1987. Seeds processed in 1987 were stored in a separate insulated metal building that provided cooler ambient temperatures than the uninsulated building. These seeds remained in storage for 7 months and were subjected to 1988 ambient temperatures.

Season 3, 1988 Seeds

The plots were planted 6 June from seeds produced in 1987 and were harvested 18 October and 24 October 1988 for spanish- and runner-types, 134 and 140 DAP, respectively. The 1988 pods were processed as described for Season 1 and 2, but were kept at cool temperature (10 - 16 C) until

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shelled for seed germination and vigor tests beginning in January 1989. These seeds are designated "no storage" since they were used immediately after shelling. The sequence of Season 3 was similar to that of commercial seed processing, i. e., fall harvest, winter storage of farmers stock pods, and spring shelling with fungicide treatment for planting. Field emergence evaluations in comparison with stored seeds from Season 1 and 2 were conducted in 1989. Planting for field emergence used the same procedure as described above.

Seed Moisture and Germination

Previous experience with the drying procedure mentioned above has shown seeds contain 6% or less moisture after drying. This is a safe storage moisture content (Smith and Davidson, 1982). Seed moisture content was substantiated when samples for moisture determination were taken at the opening of the sealed containers for the first germination and vigor test. Seed moisture content was determined (fresh weight basis) by drying duplicate samples of 50 seeds of each cultivar at 80 C for 72 hours. A constant weight was attained by 72 hours of drying.

Germination and vigor were determined by placing 50 seeds in 2-L flasks fitted with two sheets of 15.0-cm diameter Whatman No. 5 filter paper moistened with distilled water and incubated at 29±1 C. The flasks were closed with cotton stoppers for air exchange and aerated with a rapidly flowing air stream for one minute twice daily between 0800-0900 and 1600-1700. Germination and vigor were evaluated at 72 hours from start of imbibition. Percentage germination was based on number of seeds with protrusion of the hypocotyl-radicle through the seed coat at least 2 mm. Vigor was defined by categorizing the percentage of seedlings (percentage was based on number of seeds that germinated) that attained hypocotyl-radicle lengths of <5, 5 to 10, 10 to 20, 20 to 30, and >30 mm (Ketring 1971, 1973; Ketring *et al.* 1978). The latter two growth categories were added in these studies. Fungicide, Captan, N-[(trichloromethyl) thio]-4-cyclohexene-1-2-dicarboximide, 50% WP, was applied to seeds used for field emergence tests, but no seed treatment was used in laboratory experiments.

Data Analysis

Germination and vigor tests were begun in January and concluded in April 1989. Seeds from each genotype *within* seasons were tested simultaneously. Seasons were tested sequentially beginning with Season 1. Total number of days from digging until tests began were 803, 438, and 82 for Seasons 1, 2, and 3 respectively. At least two laboratory germination and vigor experiments with two replicates each (four data values) were obtained for each genotype from each season. The six-genotype group was tested in five consecutive experiments. Field plots were randomized block design with three replicates. Each replicate was 50 seeds per 3.0 x 0.91 m row spacing. Data were analyzed using the PROC GLM procedure of SAS (1985). The AOV indicated significant differences among genotypes, and mean separations were made by LSD at $P<0.05$ unless otherwise indicated.

Results and Discussion

Since seeds in cold storage retain their original viability for up to 21 months (Ketring, 1973) it was considered that cold temperatures during the storage period would not be of major significance in causing deleterious effects to seed germination and vigor. However, ambient outside high temperatures for the summer storage seasons in 1987 and 1988 were 38 and 39 C in August, respectively. Periodic measurements taken adjacent to and at the same level of the peanuts inside the storage buildings during the hottest months (July and August) indicated that temperatures were 5 to 10 C and 2 to 5 C higher than ambient outside temperatures for the uninsulated and insulated building, respectively. Relative humidity ranged from 20 to 100%, but the seeds in sealed containers were protected from this exposure. Smith *et al.* (1985) concluded that changes in the stored peanut environment were mainly affected by changes in the mean ambient outside and overspace temperature and relative humidity. In this study only ambient temperature would apply, particularly the mean high outside summer temperatures that elevated the storage building internal temperatures.

Seed Moisture Content

Moisture contents of the stored peanut seeds were sufficiently low (Table 1) that internal relative humidity of the containers was not a factor in affecting seed quality. At moisture contents of 3 to 5%, seeds equilibrated at 20 to 50% relative humidity at 32 C (Beasley and Dickens, 1963), which is a safe storage relative humidity. Peanut seeds with a moisture content of 5 to 6% and stored in sealed containers at 2 to 5 C deteriorated very little after 10 years (Norden, 1981) Also, seeds of genotypes in this study with moisture content in the 3 to 4% range had high percentages of germination and of vigorous seedlings (hypocotyl-radicle lengths of 20 to 30 and >30-mm in length). Seeds with moisture content of about 4% and stored in moisture-barrier packages remained viable for 3 years, even with temperatures in the 20 to 30 C range (Bass, 1968). Thus, in this study only internal building temperature plus length of storage time would be the combined variables affecting seed quality. Temperature and storage time are inseparable under commercial conditions.

Table 1. Percent seed moisture content of stored peanut genotypes.

	Season grown		
Genotypes	1986	1987	1988
Cultivars			
Tamnut 74	4.54±0.03[1]	-	-
*Pronto[2]	4.88±0.08	4.62±0.00	3.52±0.02
Pronto (5 C)[3]	3.08±1.35	-	-
Comet	5.24±0.01	-	4.19±1.06
Florunner	-	4.59±0.09	3.31±0.03
Okrun	-	4.61±0.01	3.46±0.02
Germplasms			
*SN 55-437[4]	4.92±0.01	4.85±0.00	3.62±0.04
TxAG-1	3.89±1.40	4.70±0.02	-
TxAG-2	4.92±0.01	4.79±0.08	-
TxAG-1 (5 C)[3]	4.80±1.42	-	-
TxAG-2 (5 C)[3]	4.16±0.19	-	-
Breeding Lines			
*BL-1	4.38±0.02	4.65±0.03	3.38±0.05
*BL-2	-	4.81±0.03	3.73±0.02
*BL-3	5.24±0.05	4.68±0.01	3.54±0.05
*BL-4	3.96±0.00	5.19±0.01	3.58±0.03

[1] Percent ±SD.
[2] Asterisk indicates a genotype included in all tests.
[3] Seeds simultaneously stored at 5 C.
[4] Line introduced from Senegal, West Africa.

Seed Quality

To insure that good quality seeds entered storage, they were tested each successive year by field emergence, which ultimately is the most important factor for both the seedsman and grower. Seeds grown in 1986 (Season 1) and placed in storage were tested for emergence in 1987 (Season 2). Emergence was 85±4, 80±9, 84±6, 88±6, and 92%±4 SD for genotypes Pronto, SN 55-437, BL-1, TxAG-1, and TxAG-2 at 10 DAP, respectively. All plots had similar uniform stands. Thus, the 1986 seeds were of good quality when placed into storage. Similarly, seeds grown in 1987 (Season 2) were

tested for field emergence in 1988 (Season 3). Emergence was 95±4, 89±6, 75±3, and 66%±5 SD for Comet, Pronto, Okrun, and Florunner at 14 DAP, respectively. The runner types were typically slower in emergence than the spanish types, but uniform stands were attained in all plots. Also, Okrun and Florunner germinated 95 to 88.5% in laboratory tests. Thus the 1987 seeds were of good quality when placed into storage. The 1988 (Season 3) seeds were generally of good quality but some genotype differences occurred.

Seed Germination and Vigor—*Within Seasons*

To comprehend the full effects of ambient storage conditions on seed quality, seeds of some genotypes grown in Season 1 (1986) also were placed in cold storage. Seeds from genotypes kept in cold storage (5 C, Table 2) compared with those from ambient conditions indicated the potential of low temperature and low relative humidity to retain the inherent quality of peanut seeds (Ketring, 1973; Norden, 1981). Seeds of genotypes from cold storage had higher percentages of germination and vigorous seedlings than seeds from ambient storage conditions (Table 2). However, the commercial peanut seed industry, because of the bulk of farmers stock peanuts, must store them under ambient conditions on a seasonal basis. Therefore, these studies were conducted on a seasonal basis, which would of necessity include different lengths of time in storage.

Table 2. Percent germination and percentage of seedlings within each hypocotyl-radicle length range of peanut genotypes grown in Season 1, (1986). Seeds were stored for 19 months either in cold storage or ambient conditions.

		Percentage of seedlings				
	Percent	Hypocotyl-radicle length				
Genotypes	Germination	<5	5-10	10-20	20-30	>30mm
		Season 1, 1986 Seeds				
Pronto (5 C)[1]	99.5[2]a	1.01e	0.5d	5.0c	45.2a	48.2a
TxAG-2 (5 C)	91.5a	17.3de	11.4cd	22.9a	34.0b	14.5b
TxAG-1 (5 C)	90.0a	25.2d	13.8bcd	21.9a	27.0b	12.1b
TxAG-2	74.5bc	57.4bc	25.4abc	17.2a	0.0c	0.0c
TxAG-1	65.5c	51.8c	34.9a	13.3bc	0.0c	0.0c
Pronto	24.5d	84.2a	9.2cd	6.7c	0.0c	0.0c

[1] Seeds simultaneously stored at 5 C.

[2] Mean values in each column with different letters were significantly different, $LSD_{0.05}$.

Within Season 1 (1986) germination and seedling vigor differed among genotypes tested (Table 3). Genotypes BL-2 and BL-3 had the highest, Tammut 74, TxAG-1 and TxAG-2 were intermediate, and the remainder of the genotypes had low percent germination and percentage of vigorous seedlings, respectively (Table 3). These seeds produced in 1986 were stored 19 months and exposed to temperatures approaching 50 C in the summers of both 1987 and 1988. This may seem an inordinate length of time for peanuts to be stored under ambient conditions, but was the only season where pronounced genotypic differences occurred in both germination and hypocotyl-radicle growth.

Within Season 2, (1987) all genotypes had a high percentage of germination and were not significantly different (Table 3). Significant differences occurred among genotypes in the percentage of least and most vigorous seedlings (Table 3). However, the data indicate the seeds of all genotypes were of good quality. These seeds produced in 1987 were stored 7 months and exposed to temperatures approaching 44 C in the summer of 1988.

Within Season 3, two genotypes (BL-3 and BL-4) were significantly lower in germination than the other genotypes (Table 3). There were no significant differences among the genotypes in percentage of the most vigorous seedlings (>30 mm category). But some of the genotypes, such as SN 55-437 and BL-3, had a high percentage of slow growing seedlings (<5 mm category) (Table 3). These seeds produced in 1988 were shelled and immediately tested.

Table 3. Percent germination and percentage of seedlings within each hypocotyl-radicle length range of peanut genotypes analyzed *within* Seasons 1, 2, and 3 after 19, 7, and 0 months of storage, respectively.

		Percentage of seedlings				
	Percent	Hypocotyl-radicle length				
Genotypes	Germination	<5	5-10	10-20	20-30	>30mm
		Season 1, 1986 Seeds				
*BL-3[2]	93.0a[1]	10.3e	19.4abc	33.7a	32.4a	4.2a
*BL-2	83.0ab	17.2e	21.3abc	32.9a	23.8a	4.7a
Tamnut 74	75.0b	69.4bcd	16.3bc	14.3bc	0.0b	0.0a
TxAG-2	74.5b	57.4cd	25.4abc	17.2b	0.0b	0.0a
TxAG-1	65.5c	51.8d	34.9ab	13.3bc	0.0b	0.0a
*Pronto	24.5d	84.2ab	9.2c	6.7cd	0.0b	0.0a
*BL-1	24.5d	78.1abc	20.6abc	1.4d	0.0b	0.0a
*SN 55-437	21.0de	71.3bcd	28.8abc	0.0d	0.0b	0.0a
*BL-4	13.0de	61.9bcd	38.1a	0.0d	0.0b	0.0a
Comet	11.0e	100.0a	0.0d	0.0d	0.0b	0.0a
		Season 2, 1987 Seeds				
TxAG-2	98.0a	2.5c	6.1a	12.2d	39.3a	39.8a
TxAG1	96.0a	5.3bc	6.9a	20.8c	41.5a	25.6bcd
BL-4	95.5a	5.2bc	7.4a	38.7a	32.5a	16.3d
BL-1	95.2a	6.9bc	8.6a	24.8bc	33.7a	25.5bcd
Pronto	94.9a	8.4ab	9.5a	19.6c	35.2a	27.1bc
BL-2	94.5a	13.8a	8.9a	23.2c	25.2a	28.9b
SN 55-437	94.4a	5.7bc	11.9a	30.8b	33.0a	18.6cd
BL-3	93.5a	10.1ab	12.3a	24.1bc	26.7a	26.7bc
		Season 3, 1988 Seeds				
Pronto	97.4a	24.9ab	8.0bc	16.8a	26.9abc	23.5a
BL-1	96.6a	26.4ab	10.5bc	23.5a	23.4bc	16.2a
BL-2	96.5a	10.9c	6.0bc	25.1a	36.0a	22.0a
SN 55-437	94.8a	30.0a	9.7bc	22.4a	26.8abc	1.1a
Comet	94.5a	21.2abc	4.2c	19.6a	34.9ab	20.1a
BL-3	83.5b	31.1a	23.2a	16.7a	15.1c	3.9a
BL-4	81.0b	16.1bc	14.8ab	24.9a	23.9abc	20.2a

[1] Mean values in each column within seasons with different letters were significantly different, $LSD_{0.05}$.

2 Asterisk indicates genotypes included in all tests.

In Table 4, data are given for three presently grown cultivars Okrun, Florunner, and Pronto, runner- and spanish-types, respectively. Only Seasons 2 and 3 involved the runner types while Pronto was included for comparison. Within Season 2, Florunner had the least percentage of germination and seedlings in the >30 mm category. Within Season 3, Pronto had the highest and lowest percentages of seedlings in the <5 and >30 mm categories, respectively. Differences in germination and seedling growth capability among genotypes within Season 1 (Table 3) and Season 2 (Table 4) indicate genotypic differences in stability of seed quality during storage. The data for Season 3 (Tables 3 and 4) suggest a seasonal influence on seedling growth even though genotypes were grown at the same location. These comparisons indicate the seasonal effect was minor compared to the storage effect, which can be shown by analyzing the date across Seasons for individual genotypes.

Table 4. Percent germination and percentage of seedlings within each hypocotyl-radicle length range of three peanut genotypes analyzed only *within* Seasons 2 and 3 after 7 and 0 months of storage, respectively.

Genotypes	Percent Germination	Percentage of seedlings Hypocotyl-radicle length <5	5-10	10-20	20-30	> 30mm
		Season 2, 1987 Seeds				
Okrun	95.0a[1]	6.3a	8.4a	23.1a	41.1a	21.1a
Florunner	88.5b	13.7a	10.9a	32.9a	36.4a	6.1b
Pronto	94.9a	8.4a	9.5a	19.6a	35.2a	27.1a
		Season 3, 1988 Seeds				
Okrun	95.5a	2.6b	4.2a	14.5a	40.7a	38.0a
Florunner	89.0a	12.2b	10.2a	22.3a	22.9b	32.4a
Pronto	97.4a	24.9a	8.0a	16.8a	26.9b	23.5b

[1] Mean values in each column within seasons with different letters were significantly different, $LSD_{0.05}$.

Seed Germination and Vigor—*Across Seasons*

When comparisons were made across seasons for individual genotypes, Season 1 had the most damaging effect on germination and seedling growth (Table 5). However, genotypes BL-3 and BL-2 retained germinability and higher percentage of more rapidly growing seedlings than other genotypes when comparing Season 1 with Seasons 2 and 3 for individual genotypes (Table 5). Genotypes TxAg-1 and TxAG-2 were intermediate in this respect when comparing Season 1 with Season 2 (Table 5). Although small compared to the storage effect, there apparently was a genotype X season interaction that resulted in lower seed quality for some genotypes. For instance, seeds of BL-3 and BL-4 were somewhat lower quality (lower germination) from Season 3 (no storage) than those from Season 2 (7 months storage). Thus, germination and seedling growth were more stable to storage environment from some cultivars than for others, but some genotypes also were affected by growing season environment more than others (Ketring *et al.* 1978). This can be overcome by selecting genotypes that show stability of germination and growth across seasons and locations.

Field Emergence

In 1989 field emergence was determined simultaneously for all seasons. Generally, emergence was higher than

Table 5. Percent germination, field emergence, and percentage of seedlings within each hypocotyl-radicle length range of individual peanut genotypes analyzed *across* Seasons 1, 2, and 3 after 19, 7, and 0 months of storage, respectively. Seeds for field emergence planted in June 1989.

Genotypes and Seasons	Percent Germination	Percent Emergence 10 DAP	Percent Emergence 42 DAP	Percentage of seedlings Hypocotyl-radicle length <5	5-10	10-20	20-30	>30 mm
*SN 55-437[1]								
1	21.0b[3]	51.3a[2]	66.0b	71.3a	28.8a	0.0c	0.0b	0.0c
2	94.4a	60.0a	87.3a	5.7c	11.9b	30.8a	3.30a	8.6a
3	94.8a	71.3a	96.0a	30.0b	9.7b	22.4b	26.8a	11.1b
*BL-3								
1	93.0a	44.0b	48.7b	10.3b	19.4a	33.7a	32.4a	4.2b
2	93.5a	70.7a	92.7a	10.1b	12.3a	24.1ab	26.7ab	26.7a
3	83.5b	72.7a	91.3a	31.1a	23.2a	16.7b	15.1b	13.9ab
*BL-1								
1	24.5b	72.7b	87.3ab	78.1a	20.6a	1.4b	0.0c	0.0c
2	95.2a	62.0b	82.0b	7.4c	8.6a	24.8a	33.7a	25.5a
3	96.6a	92.0a	94.0a	26.4b	10.4a	23.5a	23.4b	16.2b
*BL-2								
1	83.0b	-	-	17.2a	21.3a	32.9a	23.8b	4.7b
2	94.5a	69.3a	84.0a	13.8a	8.9b	23.2b	25.2b	28.9a
3	96.5a	64.0a	97.3a	10.9a	6.0b	25.1b	36.0a	22.0a
*Pronto								
1	24.5b	58.7c	70.7c	84.2a	9.2a	6.7b	0.0c	0.0b
2	94.9a	70.7b	84.0b	8.4c	9.5a	19.6a	35.2a	27.1a
3	97.4a	92.0a	94.7a	24.9b	8.0a	16.8a	26.9b	23.5a
*BL-4								
1	13.0c	39.3a	58.7b	61.9a	38.1a	0.0b	0.0b	0.0b
2	95.5a	70.0a	84.0a	5.2b	7.4b	38.7a	32.5a	16.3a
3	81.0b	47.3a	86.0a	16.1ab	14.8ab	24.9a	23.9a	20.2a
TxAG-1								
1	65.5b	55.3a	82.0a	51.8a	34.9a	13.3a	0.0b	0.0b
2	96.0a	79.3a	91.3a	5.2b	6.9b	20.8a	41.5a	25.6a
3	-	-	-	-	-	-	-	-
TxAG-2								
1	74.5b	68.7a	82.0a	57.4a	25.4a	17.2a	0.0b	0.0b
2	98.0a	80.0a	90.7a	2.5b	6.1b	12.2a	39.3a	39.8a
3	-	-	-	-	-	-	-	-
Okrun								
1	-	-	-	-	-	-	-	-
2	95.0a	68.0a	86.0a	6.3a	8.4a	23.1a	41.1a	21.1b
3	95.5a	72.7a	90.7a	2.6a	4.2a	14.5a	40.7a	38.0a
Florunner								
1	-							
2	88.7a	58.3a	85.3a	13.7a	10.9a	37.9a	36.4a	6.1b
3	89.0a	62.0a	86.0a	12.2a	10.2a	22.3a	22.9b	32.4a

[1] Asterisk indicates genotypes included in all tests. All available 1986 seeds of BL-2 were used in the germination tests.

[2] At 42 DAP, plants were dug by hand and tap roots counted.

[3] Mean values in each column across seasons for individual genotypes with different letters were significantly different, $LSD_{0.05}$.

expected for Season 1 (Table 6) considering the germination and growth of the seedlings shown in Table 3. Except for genotypes BL-1 and BL-3, the trend of field emergence (Table 6) was the same as for germination and seedling growth in Season 1 (Table 3). For Seasons 2 and 3 where germination ranged from 81.0 to 98.0% and there were high percentages of seedlings in the two fastest growing categories (20 to 30 and >30 mm) (Table 3), emergence ranged from 58.7 to 80.0% and 47.3 to 92.0% for Seasons 2 and 3, respectively, at 10 DAP (Table 6). There were significant genotype differences at both 10 and 42 DAP for Season 1, but only at 10 DAP for Seasons 2 and 3 (Table 6). The initial rate of emergence (10 DAP) was apparently more genotype dependent than plant stands at 42 DAP. Thus, rapid emergence capability of some genotypes was more stable to storage environment than others. It is most likely that early emergence capability is being emphasized in the germination and vigor tests.

Table 6. Percent field emergence of peanut genotypes analyzed *within* Seasons 1, 2, and 3 after 19, 7, and 0 months of storage, respectively. Seeds planted in June 1989.

	Percent emergence							
GENOTYPE	10 DAP	42 DAP[1]/	GENOTYPE	10 DAP	42 DAP[1]/	GENOTYPE	10 DAP	42 DAP[1]
	Season 1, 1986 Seeds			Season 2, 1987 Seeds			Season 3, 1988 Seeds	
*BL-1[2]	72.7a[3]	87.3a	TxAG-2	80.0a	90.7a	BL-1	92.0a	94.0a
TxAG-2	68.7ab	82.0ab	TxAG-1	79.3a	91.3a	Pronto	92.0a	94.7a
*Pronto	58.7bcd	70.7bc	BL-3	70.7ab	92.7a	Comet	84.0a	88.7a
TxAG-1	55.3cde	82.0ab	Pronto	70.7ab	84.0a	BL-3	72.7ab	91.3a
*SN 55-437	51.3def	66.0cd	BL-4	70.0ab	84.0a	Okrun	72.7ab	90.7a
*BL-3	44.0ef	48.7e	BL-2	69.3ab	84.0a	SN 55-437	71.3ab	96.0a
*BL-4	39.3f	58.7cde	Okrun	68.0ab	86.0a	BL-2	64.0ab	97.3a
			BL-1	62.0b	82.0a	Florunner	62.0ab	87.3a
			SN 55-437	60.0b	87.3a	BL-4	47.3b	86.0a
			Florunner	58.7b	85.3a			

[1] At 42 DAP plants were dug by hand and tap roots counted.

[2] Asterisk indicates genotypes included in all tests. All available 1986 seeds of BL-2 were used in the germination tests.

[3] Mean values in each column within seasons with different letters were significantly different, $LSD_{0.05}$.

When comparisons of emergence were made across seasons for individual genotypes, Season 1 had the most damaging effect on emergence (Table 5). However, three genotypic scenarios seem to be shown by the emergence data in Table 5 when comparisons are made across seasons: (1) No significant season effect on early emergence (10 DAP), but a reduced plant stand (42 DAP) depicted by SN 55-437 and BL-4; (2) Significant reduction in both early emergence and plant stand depicted by BL-3, BL-1, and Pronto; and (3) No significant season effect on either early emergence or plant stand depicted by BL-2, TxAG-1, TxAG-2, Okrun, and Florunner. Except for BL-3, both (1) and (2) can be explained by low germination and lack of vigorous seedling growth (Table 3). Number (3) is explicable by intermediate (TxAG-1 and TxAG-2, Table 3) and good stability (BL-2, Okrun and Florunner, Tables 3 and 4) of the seeds in the environments to which they were exposed. For TxAG-1 and TxAG-2, Season 3 (fresh seeds) was lacking, but their tolerance to storage Seasons 1 and 2 is a remarkable attribute (Tables 3 and 5). Similarly, emergence data for Season 1 was lacking for BL-2, Okrun, and Florunner, but tolerance to Season 1 and 2 (BL-2, Tables 3 and 5) and Season 2 (Okrun and Florunner, Tables 4 and 5) indicates an important capability. Wynne and Sullivan (1978) studied seedling emergence for several cultivars over locations and years. Although there were interactions among years, locations, and cultivars, there also was a range of cultivar stability for seedling emergence across environments. A high heritability estimate (0.76) indicated that breeders could select cultivars that produce a high percentage of emerged seedlings across environments and thereby improve planting seed quality of peanuts. The diversity in germination, hypocotyl-radicle growth, and field emergence among genotypes examined in this study, indicates that selection can be made to improve longevity of peanut seeds in storage.

Correlation coefficients for field emergence with germination and seedling growth by season are shown in Table 7. Germination was highly correlated with emergence for all treatments except 42 DAP in Season 2. Emergence was negatively correlated with slow growing and positively correlated with rapidly growing seedlings for both Season 1 and 2, (Table 7). None of the growth categories were significantly correlated with emergence for Season 3. Thus, for seeds of good quality (high percentage germination and rapid seedling growth), germination was correlated with field emergence (Table 7). But for seeds of lower viability (Seasons 1 and 2), rate of seedling growth also was critical for field emergence, particularly for rapid emergence (10 DAP, Table 7).

Table 7. Correlation coefficients of germination, and hypocotyl-radicle length category with field emergence. All seasons tested simultaneously for emergence in 1989.

		Hypocotyl-radicle length[1]		
	Germination	<5 + 5-10	10-20	20-30 + >30 mm
Season 1[2]				
Emergence				
10 DAP	0.858***[3]	-0.702*	0.884***	0.557
42 DAP	0.976***	-0.835***	0.972***	0.701*
Season 2				
Emergence				
10 DAP	0.702**	-0.608*	-0.641**	0.770**
42 DAP	0.198	-0.181	-0.403	0.387
Season 3				
Emergence				
10 DAP	0.685**	0.184	-0.435	-0.056
42 DAP	0.681**	0.111	0.055	-0.119

[1] Percentages for the two slowest and two most rapidly growing categories were summed.

[2] N=8, N=10, N=9 for Seasons 1, 2, and 3, 19, 7, and 0 months of storage respectively. N values were different for each season because of lack of sufficient seeds for emergence data for some genotypes.

[3] Symbols *, **, and *** represent significance of the correlation coefficient at the 10%, 5%, and 1% levels of probability, respectively.

Conclusions

It is very encouraging that Season 3, which is the general processing procedure used by the peanut industry, resulted in peanut seeds with good quality (high percentage germination, seedling growth, and field emergence). However, care was taken in these experiments to ensure that the pods and seeds were not exposed to high relative humidity that can damage peanut seeds at either low or high temperature (Ketring 1971, 1973; Baskin and Delouche 1971). In addition: (1) In the absence the high relative humidity, a few genotypes tolerated, to some degree, 19 months of storage with ambient maximum temperatures that raised internal building temperatures nearly to 50 C (Season 1). With a 7 month's storage time and a lower maximum temperature (44 C, Season 2), peanut seeds were not appreciably damaged as shown by their germination and growth. Also, emergence potential was at least more than 80% as indicated by plant sands at 42 DAP. Thus, peanut seeds were remarkably tolerant of high temperature in the absence of high relative humidity. Controlling relative humidity in storage buildings appears more critical to maintaining seed vitality than controlling temperature. (Bass, 1968; Baskin and Delouche, 1971; Ketring, 1971, 1973; Smith and Davidson, 1982). Studies using properly ventilated (mechanical or natural) miniature warehouses indicated that quality of farmers stock peanuts can be maintained if initial peanut moisture content was 10% or less. Relative humidity declined from an initial 70 to 80% to 40 to 50% and was less than ambient relative humidity for a majority of the storage period (Smith, et al. 1989). (2) Although peanut seeds were tolerant of high temperature, differences occurred among genotypes and seedling growth was more adversely affected than germination. (3) Peanut genotypes were significantly different in extent of reduction of both seed vitality and field emergence within storage seasons. (4) Some genotypes were more stable than others across seasons, indicating less influence of annual environmental variables on seed quality during storage. (5) Genotype diversity to ambient storage conditions suggests that genetic potential exists even in this small sample of peanut germplasm to improve longevity of seed quality during storage and enhance stability of field emergence. Wynne and Sullivan (1978) found greater stability of seedling emergence across years and locations for some cultivars than for others and indicated seedling emergence could be improved by selecting for this trait.

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