Effect of Curing Method on Peanut Seed Quality[1]

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ABSTRACT

Moisture removal is a major function of the peanut (**Arachis hypogaea** L.) curing process. While commercial peanut production in the United States has become largely mechanized, peanut breeders must often resort to the stackpole method of curing. This two year study evaluates the effects of alternative curing methods on seed quality of experimental peanuts. Three cultivars were harvested at two maturities, and after 0, 1 or 2 days exposure in inverted windrows, fruit from each treatment were then cured on stackpoles or in circulating air ovens at 38°, 54° or 66°C. Analyses were made on weight/seed and percentages of moisture, shelling, shrivels. germination, and extra large kernels.

While year of production affected seed weight and germination, harvest date within years did not affect the characteristics studied. Days in the windrow affected moisture content. Drying temperatures affected shelling, shrivels and germination percentages.

Harvesting a week earlier than optimum resulted in more shriveled seed but better germination. This indicates that it may be advantageous to dig a crop used for seed earlier than that dug for edible use.

The % shriveled seed increased somewhat with increased drying temperatures. Stack curing had the lowest % of shriveled seed. Peanuts that were not placed in windrows had heavier seed if stack-cured than if oven-dried, indicating that the seeds continue to mature while attached to the vine.

Seed from pods cured in ovens at temperatures below 54°C, especially when left in windrows a day or more, germinated as well or better than those stack-cured. At high oven temperatures, germination increased with number of days in windrows indicating that viability is impaired at high temperatures when moisture content is high.

The results indicate that peanut researchers could improve their harvesting efficiency by picking from the windrow and utilizing mechanical dryers adjusted to a somewhat higher temperature than that recommended for edible peanuts. The stackpole method results in high quality seed with less risk of loss than from windrow curing.

Additional index words: Harvest maturity, seed drying, seed germination.

It is important to cure peanuts (*Arachis hypogaea* L.) in a way that will maintain or enhance their quality, both for processing and for seed. Curing is a term used to describe the physical and biochemical changes that occur in peanuts following their removal from the soil and prior to storage or processing. Moisture removal, whether by curing in stacks, windrows, or mechanical dryers, is a major function of the curing process.

Freshly harvested peanuts have 30 to 60% moisture which must be reduced to a safe storage level of 8 to 11%. The methods used to dry seed to this moisture level have significant effects on flavor and quality. Too rapid drying and overdrying impair the flavor (5, 11, 12) and increases the undesirable tendency of peanuts to skin and split during subsequent shelling and handling (2, 5, 7, 10, 12). Other effects concern seed size, weight, brittleness, and hardness (3,5, 10).

Early studies by Woodroof et. al. (12) suggested holding the drying temperature below 54°C to prevent subsequent splitting and the development of off-flavors. Later studies revealed that curing temperatures above 38°C impaired flavor (5, 11). Bailey et. al. (1) and Pickett (10) found that seed viability was reduced when freshly harvested peanuts were cured at 49°C or higher.

Dickens and Beasley (3) found that both a rapid drying rate and a high cured moisture content increased proportions of extra large kernels (ELK) in 'NC-2' peanuts and caused the whole peanuts to have a lower density. Presumably, rapid drying distorted the cotyledons and increased the void space between the cotyledons.

Field emergence for machine inverted and combined 'NC-5' peanuts in North Carolina was found to be slower but comparable to stackpole cured peanuts picked with a carding type picker (13). Relatively low emergence was obtained however, from the peanuts picked green. The earlier of three digging dates gave the best field emergence.

Dickens and Khalsa (4) obtained fewer loose shelled kernels and damaged pods, better milling quality, better seed germination, and less aflatoxin contamination when peanuts were combined from inverted windrows than from a random orientation. The percent germination decreased with an increase in moisture content of the pods and seed when combined. Loose shelled kernels and pod damage decreased with an increase in moisture, except for moisture contents above 35%.

Pearman and Butler (9) found seed moisture reductions of 12 and 21%, respectively for 'Early Runner' and 'Florigiant' following three-day exposure in inverted windrows after a rain. Moisture reductions were 32 and 28% for the same cultivars following inversion in the windrow over dry periods. Seven day exposure did not reduce the moisture appreciably more than the three day exposure if the weather remained dry.

During a good curing season artificial curing reduced germination of peanuts which were placed in dryers at higher than 20% moisture, whereas, during a poor curing season, artificially dried peanuts germinated better than those cured in the field (2). Age of peanut plants and peanut yield had no relationship to seed germination. These investigators also noted that peanuts dug before or after a designated 11-day optimum harvest period gave reduced germination percentages. Samples of seed with increased shrivels also were found to have reduced germination even when shrivels were removed. Woodroof et. al. (12)

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found that a moisture content of 5% was most satisfactory for maintaining flavor of peanuts. Peanuts stored with higher moisture content tend to have higher free fatty acid content (2).

There is an ever-present risk of field losses and mold damage caused by adverse weather while the peanuts are naturally curing in the windrow. A combination of natural curing and mechanical drying is therefore currently the recommended procedure for commercial production of peanuts in the United States (5, 6, 7, 8). Mills and Samples (7), recommend initial curing in windrows, and combining from the windrow when the kernel moisture content is from 20 to 25%. After combining, the pods are placed in a curing facility where low humidity air is forced through the mass. Air temperature and humidity is controlled to prevent the kernel temperature from exceeding 35°C and to keep the drying rate from exceeding 0.5% per hour. The application of drying air is terminated sufficiently early to achieve a final moisture content of 7 to 10%.

Although commercial peanut production in the United States has become almost completely mechanized, peanut researchers, especially those involved in breeding programs still resort to the stackpole method of peanut curing to prevent mechanical mixtures of the different lines. The objectives of this study were to evaluate the effects of alternative curing methods on the planting quality of seed peanuts.

Materials and Methods

Ten rows of each of three peanut cultivars, 'Dixie Runner', Early Runner and Florigiant were hand planted May 3, 1966 and May 9, 1967 at 30 cm plant spacings in rows 91 cm apart on a sandy soil at Gainesville, Florida. The average number of days required from planting to maturity at Gainesville is 145 days for Dixie Runner and 135 days for Early Runner and Florigiant. The cultural practices followed during the growing season corresponded to those commonly employed in the commercial fields of the region.

The peanuts were harvested by machine and inverted by hand in windrows on two dates 131 and 138 days after planting in 1966, and 135 and 142 days after plantin 1967. The peanuts were dug between 8 and 9 A. M. each day. The harvesting schedule was such that prior to drying, one-third of the peanuts had been in the windrows, 0, 1, or 2 days.

Rainfall during the peanut growing seasons (early May through early September) totaled 66 cm in 1966 and 85 cm in 1967. The rainfall distribution pattern, however, was considerably more favorable during the 1966 season.

The peanuts from both harvests in 1966 received rain while in the windrow, whereas in 1967 no rainfall occurred during either harvest. The first harvest peanuts held in the windrow for two days in 1966 received 9.5 cm of rain the first day and none the second day. The second harvest peanuts in 1966 received 0.36 cm rain each day they were held in the windrow. The maximum air temperature at a height of 152 cm above ground surface averaged 30.6°C and 32.2°C in 1966, and 28.3°C and 32.2°C in 1967 for the first and second harvests, respectively.

The peanuts were cured either by placing the plants on stack poles or by removing the pods from the vines by hand, weighing them, and placing them in circulating air ovens following 0, 1 or 2 days in the windrow. In the stack pole method the peanut plants were shaken to remove the soil and placed around the poles with the tap root and fruit inward. The peanuts cured in ovens were dried at 38°C (100°F), 54°C (130°F) or 66°C (150°F) and left in the respective drying ovens until no further weight loss was detected.

The basic experimental design was a 2 x 3² x 4 factoral. The data from each of the 72 possible treatment combinations were taken each year on five 2-plant samples selected at random. Statistical analyses were carried out on six responses: % moisture, shelling %, % shrivels, seed weight, % germination, and % extra large kernels (ELK). Since the green weight of the stack-cured peanuts was not obtained, their % moisture could not be calculated. The shriveled seed were those that did not ride a screen with 38/163 x 1.9 cm (15/64 x 3/4 inch) slots for the two runner cultivars and 38/163 x 2.5 cm (15/64 x 1 inch) slots for Florigiant. The % ELK was measured for Florigiant only and consists of those seed that rode a screen with 54.6/163 x 2.5 cm (21.5/64 x 1 inch) slots. The germination tests were made with treated seed 5 months after harvest each year. In performing the combined years analyses, the experiment was considered a split-plot with years taking the role of the main plot treatments and harvest dates within years the role of replicates. Separate error terms were obtained for testing each factor and its interaction with years.

Results and Discussion

Analyses of variance are given in Table 1. Year of production had a significant effect on the weight/seed and the % germination while harvest dates within years did not significantly effect any of the characteristics studied. Cultivars had highly significant effects on all the factors studied but did not respond similarly to the different years or drying temperatures. Drying temperature significantly affected shelling %, % shrivels, and %

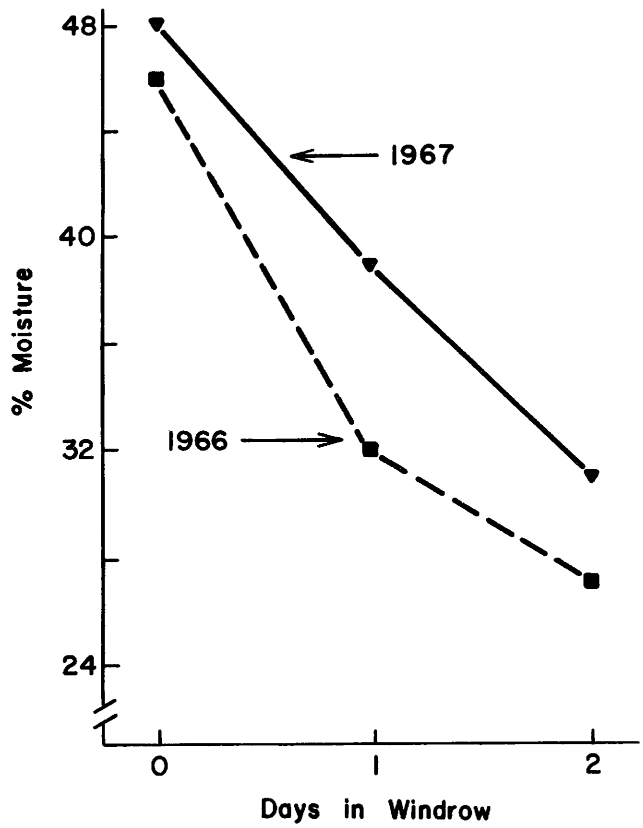

Fig. 1. Effect of days in an inverted windrow on the moisture content of peanuts.

Table 1. Mean squares and levels of significance from the analyses of variance of shelling %, % shrivels. weight/seed and % germination of peanuts as influenced by year, days in windrow, cultivar, and drying temperature.

Source of Variation	DF	Shelling %	% Shrivels	Wt./Seed	% Germination
Years (Y)	1	3289	4940	2.2590*	164893*
Harvests/Years (H/Y)	2	231	528	0.0641	2554
Days in Windrow (DW)					
Linear	1	113	90	0.0006	1442
Quadratic	1	70	41	0.0031	2151
Y x DW	2	81	50	0.0230	951
DW x H/Y	4	31	71	0.0217	1941
Cultivar (C)	2	3381**	7749**	21.4605**	26002**
C x Y	2	6	496	0.3709**	5847*
C x H/Y	4	86	232	0.0076	446
DW x C	4	20	11	0.0074	414
Y x DW x C	4	5	18	0.0030	259
DW x C x H/Y	8	26	37	0.0024	965
Drying temperature (DT)					
Stack vs. Oven	1	922*	886**	0.0014	43776**
Linear	1	418*	174**	0.0010	251988**
Quadratic	1	1	20	0.0009	151698**
Y X DT	3	37	151**	0.0035	11818
DT x H/Y	6	69	7	0.0021	3181
DW x DT					
Linear x Linear	1	22	2	0.0011	5140**
DW x (Stack vs. Oven)	2	15	19	0.0039*	327
Remainder	3	5	2	0.0008	50
Y x DW x DT	6	38	14	0.0005	241
DW x DT x H/Y	12	18	11	0.0007	128
C x DT	6	31	51**	0.0027	4357**
Y x C x DT	6	22	44**	0.0013	1570*
C x DT x H/Y	12	31	6	0.0019	442
DW x C x DT	12	21	11	0.0011	286
Y x DW x C x DT	12	19	12	0.0012	106
DW x C x DT x H/Y	24	19	7	0.0015	285
Error	576	13	4	0.0010	84

* Significant at the .05 level;
** Significant at the .01 level.

germination. The only significant difference in the analyses of variance of % ELK for the Florigiant cultivar was due to years. These results are not presented in Table 1.

Both number of days that the peanuts remained in the windrow and the type of cultivar had highly significant effects on the moisture content of the peanuts prior to stacking or oven drying (Fig. 1). The 1966 crop peanuts were rained on in the windrow and had a 4 day shorter growing season but still averaged 4% less moisture at harvest than did the 1967 peanut crop. Apparently, the less favorable growing conditions in 1967 delayed the development and maturity of the crop more than could be compensated for by 4 extra days of growing season. Although the three cultivars lost moisture similarly in the windrow, they differed significantly in the moisture content of their fruit when harvested. The fruits of the later maturing Dixie Runner cultivar averaged 13% more moisture at harvest than those of Early Runner and 7% more than Florigiant.

The mean effect of season, days in the windrow, cultivar, and drying temperature on seed quality factors is presented in Table 2. As compared to the 1966 season the less favorable 1967 growing season resulted in significantly lighter and smaller seeds and lower germination.

The number of days the plants remained inverted in windrows did not have a significant effect on any of the seed quality characteristics shown in Table 2, except as related to drying temperature effects on % germination.

The type of cultivar had a highly significant influence on the expression of all the characteristics. Dixie Runner had the lightest seed (0.42g/seed compared to 0.54 for Early Runner and 0.99 for Florigiant), but the results were not consistent for the two years (Fig. 2). The less favorable growing conditions in 1967 compared to 1966 had

Table 2. Mean influence of year, days in windrow, cultivar, and drying temperature on the shelling %, % shrivels, weight/seed, % germination and % extra large kernels (ELK).

Main Effect		Shelling %	Shrivels %	Wt./Seed g.	Germination %	ELK[1] %
Year	1966	71.1	5.9	.70	70	63
	1967	75.3	11.1	.59	40	44
Days in Windrow	0 days	72.5	9.1	.64	55	52
	1 day	73.6	8.2	.65	53	55
	2 days	73.5	8.2	.65	58	53
Cultivar	Dixie Runner	69.5	14.9	.42	63	
	Early Runner	77.0	6.6	.54	59	
	Florigiant	73.1	4.0	.99	43	
Drying Temperature	Stack	71.2	6.6	.65	69	53
	38°C	72.7	8.5	.65	71	54
	54°C	74.0	9.0	.65	69	52
	66°C	74.9	9.9	.64	12	54

[1] The % extra large kernels (ELK) was obtained for Florigiant only.

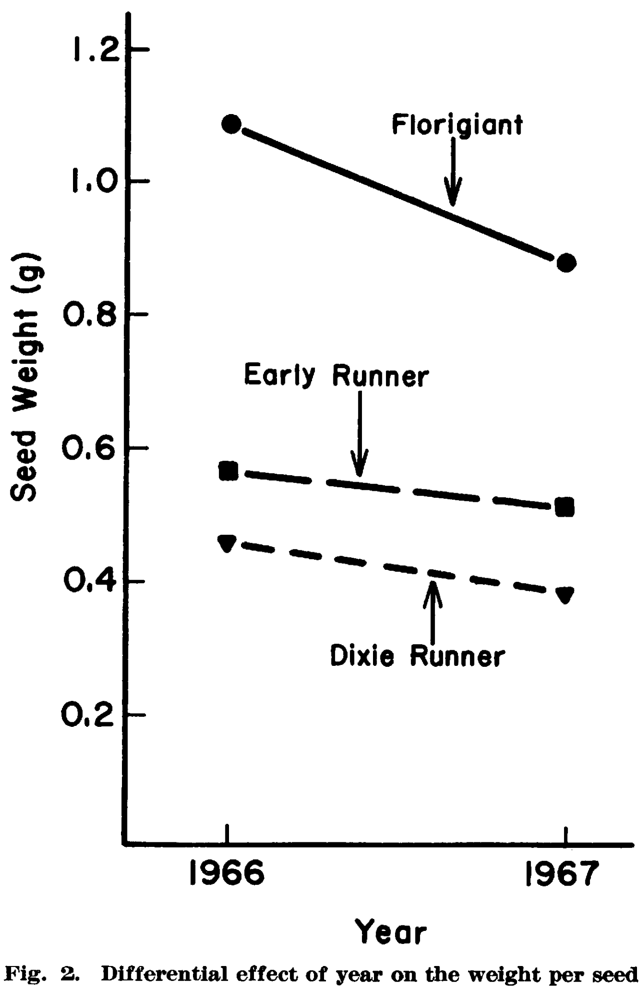

Fig. 2. Differential effect of year on the weight per seed of three peanut cultivars.

a more damaging effect on the seed weight of Florigiant than that of the other cultivars. However, the seed weight for all three cultivars was reduced in 1967. Florigiant had the heaviest seed both years and Dixie Runner the lightest. Therefore, the significance of this interaction (Table 1) may be due to the smallness of the experimental error rather than to interaction *per se*.

Dixie Runner had a significantly larger % of shriveled seed compared to Early Runner and Florigiant and a lower shelling percent, but a higher percent of the Dixie Runner seed germinated (Table 2). Since Early Runner and Florigiant were harvested at or near optimum maturity while Dixie Runner was harvested approximately a week too early, the higher seed germination for Dixie Runner was not expected. These results however confirm the findings of Young et al. (13), who supported the belief of certain seed producers that peanuts for seed should be dug early.

The artificially dried crop gave a significantly higher shelling % with the major differences at the higher drying temperature. At 38°C the increase in shelling % was only 1.5% over the stack-cured peanuts, whereas at the 66°C drying temperature the increase was 3.7% (75% compared to 71% for stack dried peanuts, Table 2).

The effects of drying temperature on the percent of shriveled seed differed for the two years and for the three cultivars (Fig. 3). In 1966, a good growing season, the percent of shriveled seed increased only 1% with the higher drying temperatures; whereas, in 1967 the increase was more than 2% when the drying temperature was increased from 38°C to 66°C. The highest drying temperature increased the percentage of shriveled seed by 5% over that obtained for the stack-dried peanuts. Stack-drying resulted in less shriveled seed for all cultivars (Fig. 3). However, for Dixie Runner and Early Runner, the percent of shrivels increased significantly with drying temperature, while with Florigiant the differences were not statistically significant; although the means for Florigiant suggest a quadratic relationship. In the present study drying temperatures did not significantly affect the % of ELK. The significant increase obtained in the % shriveled seed probably resulted in a significant reduction in the % SMK but these data were not obtained.

There were significant interactions of drying temperature with days in the windrow (Table 1).

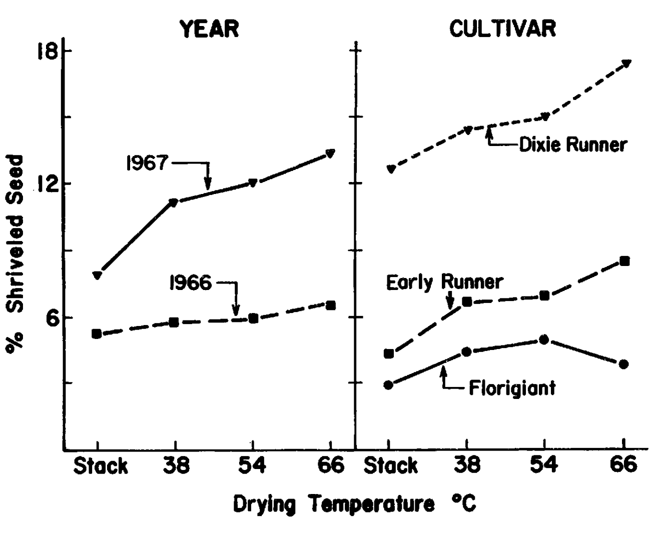

Fig. 3. Differential percentage of shriveled seed from different years and cultivars in response to different drying temperatures.

Stack-cured peanuts not placed in the windrow had significantly heavier seed than oven-dried ones, indicating that peanuts may continue to mature while attached to the vine as was suggested by Lambert (6).

Seeds from pods dried in an oven at low temperatures (54°C or less) germinated as well or better than the stack-cured peanuts (Table 2). A significant days in the windrow x drying temperature interaction exists, however, as shown in Fig. 4. At low oven temperatures the relationship between percent germination and number of days in the windrow appeared to be quadratic, passing through a minimum at one day. At the high oven temperature, the percent germination increased with the number of days in the windrow. Regardless of the number of days in the windrow, the percent of seed germinating at the high oven temperature was much lower than that for any other drying temperature. Germination decreased very rapidly for samples dried at the high oven temperatures as reported elsewhere (1, 4, 10, 13). In a preliminary test the author (unpublished) obtained almost no reduction in germination of well dried Dixie Runner and Early Runner seed by heating for several days in ovens at 54°C and 66°C. Florigiant seed, however, appeared to be susceptible to damage by these temperatures. It appears that the viability of peanut seed is much more easily impaired by high temperatures when the seed moisture content is high.

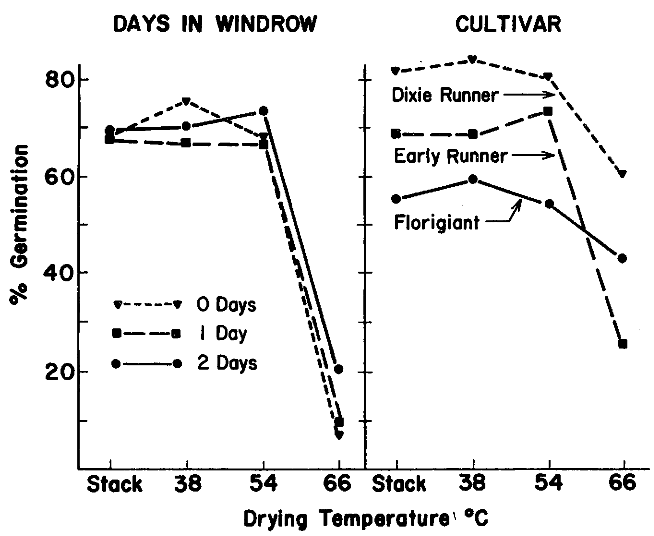

Fig. 4. Differential effect of drying temperature on the % germination of three peanut cultivars held in windrows from 0 to 2 days after harvest.

Cultivar differences in seed germination occurred for both drying temperature (Fig. 4) and years (Fig. 5). Dixie Runner had a higher percent of seeds germinating from all drying temperatures. Florigiant had the poorest germination percentage, except at the highest temperature, where the lowest germination percent was obtained with Early Runner. The cultivars maintained their relative germination position if they were stack-cured, or oven-cured at 54°C or less. While all three cultivars germinated much better

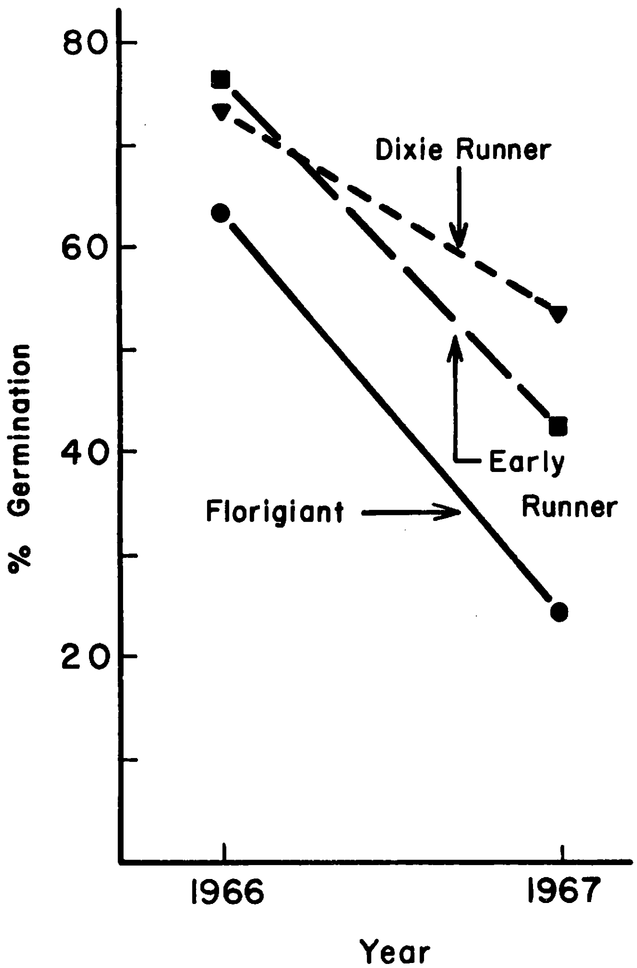

Fig. 5. Differential effect of year on % germination of three peanut cultivars.

in 1966 than in 1967, Early Runner was best in 1966 and Dixie Runner in 1967 (Fig. 5). Florigiant seed had the lowest germination in both years.

The results support the commercial curing methods of allowing peanuts to cure in windrows for one to three days (5, 7, 8), or longer in the northeast (6), prior to combining and mechanical drying. The results also indicate that for retention of high germination seed, it may be advantageous to harvest the crop earlier than when the crop is used for edible purposes. The use of temperatures above 35°C will dry the peanuts to a lower moisture level without damage more rapidly than at lower temperatures. The lower moisture level, while undesirable from the standpoint of milling quality, is advantageous from the standpoint of maintaining flavor quality (12) and germination in storage (2). Peanut researchers, could improve their harvesting efficiency and expedite the process by picking a substantial portion of their experimental material from the windrow and utilizing mechanical dryers at a somewhat higher temperature than that recommended for commercial producers. The stackpole method which generally results in high quality seed with a lower risk of loss from inclement weather should not be completely eliminated as a method of curing experimental peanuts.

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