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ADDRESSES

PAPERS

ABSTRACTS

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ADDRESS

PEANUT EXPORTS - POTENTIAL, PROBLEMS, PROFIT

by

Don Sands

Gentlemen, Mr. Mills and Mr. Dickens have given me a very challenging and currently a very important topic for presentation here today. So, before launching into the subject of peanut exports specifically, we should first set the background for exports in general. Today the subject of exports is currently in the news as never before. You can hardly pick up a newspaper or a magazine without reading something about the importance of exports to the U.S. economy and the balance of payment problem. The President is quite concerned and is quoted regularly on this subject. Recently, we had bad news hitting us all at once that was somewhat confusing and certainly dismal - in that Germany had defiantly stopped supporting the dollar; the Japanese were refusing the devaluation of the yen; and in addition the U. S. balance of payments had taken a turn for the worse. The immediate cause of our trouble was a deficit in our balance of payment for the first quarter of the fiscal year in an amount of 5.5 billion dollars. This meant that for the first three months of this year we sent out 5.5 billion dollars more than we took in, which turned loose 5.5 billion of additional free dollars in the world market. The President left no doubt about which of these facets of the news concerned him most. The problem at the bottom, he believes, is not the dollar but the deteriorating U. S. position in world trade. The Administration is less interested in monetary measures per se than in finding ways to bolster U. S. exports. Ten years ago no such problem existed for this country because we imported annually 14 billion dollars worth of goods but exports were in the 20 billion dollar range, giving us a comfortable balance of trade of some 6 billion dollars to offset other balance of payment factors, notably foreign aid, maintaining troops abroad, corporate foreign investment, foreign security purchases, and the hundreds of millions of dollars spent annually by American tourists overseas.

This picture has changed drastically in a decade, although today exports exceed 40 billion dollars annually, which is double ten years ago. Imports are rising above that figure and have recently started to accelerate with a tremendous influx of foreign cars, electronic equipment, textiles, shoes, etc. Already the combined sales of two Japanese automobile makers sell more cars in this country than does American Motors. So it appears that the Administration is on a solid footing, with their contention that our problems are not primarily the result of an over-valuation of the dollar or an undervaluation of such strong currencies as the German mark or the Japanese yen - it is a matter of our spending too much abroad and not being able to earn enough abroad - it is that simple. To put it another way, an American drives home in a German car from a French movie, slips off his Hong Kong suit and Italian shoes, puts on an English robe and Mexican slippers and sips Brazilian coffee from Dutch china while sitting on Danish furniture. Then to the soft music of a Japanese tape player, he writes a letter to his Congressman on Canadian paper with a Belgian pen demanding that something be done about all of the gold that's leaving this country. So, there is no doubt that our overall balance of payment situation is reason for concern, but in agriculture, we can be proud of our position of being the great stabilizing industry of this country and every farmer ought to be proud of

the record. It is a far better record than any other industry in this nation. In agriculture, we have been increasing our productivity per farmer at the rate of approximately 8% per year, whereas the industrial worker in our country was only increasing his productivity at the rate of 2.5% a year. The American farmer can be more than happy about his contribution in the field of exports, because he is benefiting directly from the trend. U. S. exports of farm products in the fiscal year that recently ended are expected to hit a record of 7.5 billion, up 11% from the previous record of 6.8 billion. According to Secretary Hardin, the massive rise in agricultural exports has largely eliminated U. S. farm surpluses. So gentlemen, in summary exports - at the present time have never been more important. With the first quarter balance of payment deficit of 5.5 billion and our exports for the first five months of this fiscal year being virtually a standoff with imports, we are going to have to place great emphasis on improving this position through exports. So, with this atmosphere, I think that we can state with confidence that the opportunity in agricultural exports in general and peanut exports in particular never looked brighter. As we look at the potential food demand of the world, it seems that we are looking at a bottomless barrel. With the rapidly increasing world population and the improving economic conditions around the world, the demand for food has never been greater. In spite of great efforts of the countries of the world to increase food production by themselves, the ability of most countries to do so is quite limited and will not keep pace with the increased demand. For instance, in Japan, Sweden, Germany, Switzerland, Ireland and England the farm land has been losing ground to various non-agricultural uses such as houses, roads, airfields and factories. These countries can add very little to their productive capacity so far as land is concerned. In fact, they will not be able to hold their own. Three countries, Pakistan, India and China, where there is well over one-third of the world's population there is little new land that can be brought into cultivation. At the present time, it appears that some of the smaller Asian countries will be able to add additional farm land such as Burma, Thailand and the Philippines. Certainly Africa and South America have the potential for greater agricultural endeavorment but at the same time those countries with additional land available are some of the areas that are going to have the largest population increases, which could continue to require most of their additional output. We are all aware that agricultural technology has and will increase rapidly, but in spite of our vast store of scientific knowledge and the research developments yet to come, there is still no practical substitute for land in the production of food. As new land becomes increasingly scarce and as large needs can only be met by raising yields, there will come a time when exporting of food products will become a day to day business. A time when all processors and handlers of agricultural products will necessarily have to familiarize themselves with world trade. So, when we look at the increasing population, the increasing affluence around the world, the pitifully low edible peanut consumption in many areas of the world, we can certainly say that the potential for the peanut is enormous. We can take advantage of this situation by bringing the nutritional value, the flavor and the vast array of peanut products to the attention of the foreign consumer, thus cultivating their taste and desire to include peanut products in their normal food fare. We need to create heavier usage and acceptance throughout the world by attending trade fairs, seminars and lend a helping hand to foreign countries in the establishment of their own National Peanut Councils. We should encourage knowledgeable marketing and proper advertising geared to the mode of the

various countries. We can help create change and if we are successful, we will truly be looking at a bottomless barrel.

Certainly, we are not without our problems with peanut exports. Our production is built around a support program of controlled acreage and our ability to export depends on surplus production from these acres. Therefore, it is to be expected that at times our supplies will be erratic and, therefore, we cannot truly be considered as a reliable foreign supplier at all times. The peanut surplus for export is made available by the government through their weekly sales and our greatest problem is that this creates a cost to the government. Although peanuts help tremendously, our balance of payment position - to the tune of some 25 million dollars per year on edible peanuts alone - we are also aware that we are receiving approximately 30% to 40% less for these peanuts than our domestic market. We find that our ability to get higher prices is somewhat limited due to world competition. After all, we have only about 300,000 tons of surplus from which to produce an exportable edible peanut while the world production of peanuts totals 17,346,000 metric tons. So, you can see we are not without competition in the world markets and, of course, this presents us problems. But, we are making progress every year and the key to U. S. competitive success lies in the quality of the peanuts we export. We have two areas of control that have enhanced the esteem of the U. S. peanut immeasurably in world markets. One is the controls limiting undesirable peanuts from entering the export trade, such as proper sizing, U. S. grade standards, and improved sheller attitude in shipping quality. The other and probably the most important for the future is our testing and control procedures for aflatoxin. As nations become more familiar with the uniformity and reliability of these tests, our position will be greatly enhanced. If we will continue our research for additional controls in this area, it can be the single most important thing in helping us secure higher and higher prices in the world market. Trips like the one made recently by Mr. Bill Dickens and Dr. Ruark at the request of the National Peanut Council and U. S. D. A., during which they visited Germany, Holland, Denmark, Belgium, Ireland and England will be of great benefit to U. S. exports. This helps foreign countries to become aware of the reliability of our testing and sampling procedures, which without a doubt are the best in the world today. As countries tighten their standards and enforce them, the U. S. position will be greatly enhanced. It seems that a world seminar inviting all interested nations to attend in order to discuss sampling, analysis and controls of aflatoxin in peanuts could be of great benefit in establishing uniformity on a world level.

Now, in regard to profits, we have to review this from two angles - one, from the standpoint of the growers and the other from the standpoint of the companies operating in the export field. The peanut growers encouragement to support export market development is not on the basis of profitability today, but more on the basis of future potential. He recognizes that his ability to participate in the world markets at the present time is limited, but may be a very needed and necessary avenue for disposal of his production in the future. The grower has faith that the cost of food products will rise throughout the world and that he will be in a position to capitalize on this situation. His assumption is certainly valid because the cost of food is rising throughout the world. England shows an average price increase of 10½% on agricultural commodities above year ago levels. In France, commodity prices have increased 2.7% since January; in Germany, prices increased last year approximately 5%; in Italy, an ice cream peddler now charges 16 cents for the same size cone that he sold for 8 cents only six

months ago. In Buenos Aires, long home of the cheap but succulent steak, a platter of beef has doubled in price in most restaurants over the past year. There is no doubt that food prices are increasing. Hopefully, the nutritious, flavorful peanut will someday be able to secure a price in world markets compatible with the price in the U. S. On profits in regard to industry, it is important that U. S. D. A. must recognize that companies competing in the export market are entitled to a profit on such transactions. Bidding is competitive enough in our free enterprise system without U.S.D.A. rejection of bids which do not meet a preconceived idea of market. Last year they utilized such an approach in accepting bids on the disposal of their peanut surplus, which resulted in our failure to be competitive in all of the world markets. In Europe, we were just above the market, but we did move a tremendous volume of peanuts into Canada and Japan. The point I am making is that we must be reasonably competitive throughout world markets rather than limit our outlets by price. U. S. D. A. must recognize that every company who is working in the export field has several responsibilities which are vital to its success and to the success of its operation. The most important of these, of course, is the ability to make an adequate profit. Without profit, nothing positive happens since the atmosphere is such that nothing positive can happen. In the case of export peanuts, it also affects our national balance of payment when we are unable to compete with other nations of the world for the peanut market. So as we think, talk and act on the potentials of exports, the problems to be solved, we must recognize that business profit is the single most important ingredient that makes it all possible. This past Tuesday, I attended an exports meeting called by U. S. D. A., which was attended by a full cross section of the industry. I think this was one of the best meetings on exports that I have had the privilege of attending. The Industry had a chance to speak forth on the problems which confront them, hear the problems facing the government and express possible solutions. All discussions were received with an apparent open mind, with an attitude to seek the fairest solutions and yet at the same time, avoid excess cost to either of the parties. It seems to me with this type of concern, that our export program will have the atmosphere to develop as never before. So, I think we can conclude that export opportunities have never been so good, that we do have problems but they can be solved and that the profit potential is there. The only thing we must do is make things happen, not wait on them to happen.

POLLUTION AND THE PEANUT INDUSTRY

by

Gerald T. Weekman

**Spec. in Charge, Entomology Ext. N. C. State University
Raleigh, N. C.**

I have been requested to speak to you on the subject of pollution and more specifically on how pollution effects the peanut industry. By virtue of training and experience I am an entomologist. I will direct my remarks to the subject of pesticides and their impact on the peanut industry.

Pesticides are and will continue to be essential in peanut production in the United States for as long as I can see in the future. Unfortunately for you and for me the very essentiality of pesticides in peanut production is creating problems that we must identify and strive to minimize.

Among these problems are excessive pesticide residues in the raw agricultural product.

Ten years ago many peanut growers suffered excessive losses from rootworms that quite suddenly were resistant and seemingly immune to aldrin poisoning. What have we learned from these last twenty years of experience? We still depend on highly persistent pesticides to control insect pests in other crops. Pesticides that remain in the soil and in the water not only cause inconvenience in the production of root crops, but they threaten some vital life systems in our lakes, rivers, sounds and oceans. A pesticide that persists beyond its useful life or drifts beyond the place where it is needed must be called a pollutant and the ugly connotation that goes with this word applies.

The problem that is even more sinister to us in agriculture is pest resistance to poisons. Aldrin and its relatives were used from 1950 to 1960 and in this time we selected a highly resistant strain of rootworms that survives today.

We have used diazinon, Thimet and their phosphate relatives from 1960 to the present. How long will it be before another outbreak of a resistance occurs? Will the chemical industry that must now spend 10 million dollars to develop a product for use be standing by to play a new one into the system? Even if the new chemical is there, how long will it last and what will take its place?

I suggest that it is time for us to get off the merry-go-round and take note of the problems that face us and begin to plan for the future.

Nothing is more difficult or more confusing to an agriculturalist today than trying to make a decision on pesticides. Much of his confusion results from fear that he will lose an essential pesticide. Just as the conservationist fears the harm pesticides may do to our environment, this fear coupled with an attitude that the future is beyond control and an apprehension that the worst is sure to happen has led to the confusion. Developed nations around the world are committed to impose controls on the use of all pesticides, and in particular to eliminate all nonessential uses of highly persistent pesticides. These controls may well relieve the environmental impact of pesticides by reducing the use of potential environmental polluting pesticides and eliminating misuse. As an example of the kinds of control we can expect I call to your attention what has happened in North Carolina.

On July 12 the North Carolina General Assembly enacted the "North Carolina Pesticide Law of 1971" following detailed committee review in both Houses

of the assembly. As stated in its full title this law is: "An Act to provide for the protection of the quality of the environment and for the protection of the public health through regulation of the use, application, sale and disposal of pesticides and the registration of pesticides". This legislation does provide for regulations on use, sale, storage, disposal and application of all pesticides and repeals the "North Carolina Insecticide, Fungicide and Rodenticide Act of 1947" (CS 3, Article 4 A, Chapter 106) and the "North Carolina Aerial Crop-Dusting Law" (CB Article 4 B, Chapter 106) effective October 1, 1971.

There are many significant provisions of this law that affect all of us. The creation of a North Carolina Pesticide Board which is responsible with the Commissioner of Agriculture to carry out the provisions of the Act.

The Board is to be appointed by the Governor and shall consist of seven members.

1. A representative of the North Carolina Department of Agriculture.
2. A representative of the North Carolina Board of Health.
3. A representative of a State Conservation Agency.
4. A representative of the Agricultural Chemicals Industry.
5. A person engaged in agricultural production.
6. A citizen at large who is a non agricultural conservationist.
7. A citizen at large not associated with agricultural production or the chemical industry.

This board may adopt regulations and set policy following one or more public hearings with four concurring votes.

The Commissioner of Agriculture is charged to enforce and administer the law.

Powers of the Pesticide Board

The Pesticide Board is authorized to appoint a Pesticide Advisory Committee to assist the Board and the Commissioner in an advisory capacity. The Pesticide Board may, after hearing, adopt and revise a list of restricted pesticides if in the judgment of the Board such action is necessary. The restriction may include the time and condition of sale, distribution or use; may include prohibition of use for designated purposes; may require the purchaser to certify use as labeled; or may require a use permit issued by the Board.

The Board may adopt regulations concerning handling, transport, storage, display and disposal of pesticide wastes as well as restricting or prohibiting certain types of packages and containers and may apply to their strength and/or size to alleviate danger of spillage, breakage or misuse.

All brands or grades of pesticides must be registered by the Board prior to sale or offer to sell requires an annual fee of \$25.00.

The Board to prevent an imminent hazard to the public or to a nontarget organization or segment of the environment may suspend registration immediately.

Dealers and Manufacturers

All persons in the business of distributing, selling, offering for sale or holding for sale restricted use pesticides are to be licensed by January 1, 1972 for each outlet or location for an annual fee of \$25.00. Qualifications for license include two years of experience or suitable education or a college degree.

A written and/or oral examination prescribed by the Board must be satisfactorily completed prior to January 1, 1974 and renewal examinations shall be prescribed by the Board at intervals of not less than four years.

Names of employees of dealers must be submitted to the Board at each renewal and each dealer is responsible for the actions of his employees.

Revocation of dealers license: provisions for revocation of licenses by the Board for violation by the act by licensee or employee of licensee for not more than two years.

Applicators and Consultants

Any person who owns or manages a pesticide application business who applies pesticides on lands of another except persons who apply pesticides on their own land with ground machine or for the accommodation of his neighbors or is licensed under the North Carolina Structural Pest Control Act must be licensed by January 1, 1972. An annual license fee of \$25.00 is required. Each piece of ground equipment is to be licensed, the fee is \$10.00. Each piece of aerial equipment is to be licensed, the fee is \$25.00.

Qualifications for an applicators license include two years experience or suitable education or a college degree.

A written and/or oral examination prescribed by the Board must be satisfactorily completed prior to January 1, 1974 and renewal examinations shall be prescribed by the Board at intervals of not less than four years.

The names of all solicitors, salesmen and operators must be furnished to the Board at each renewal and applicators are responsible for the actions of their employees.

Revocations of Applicator's License

Provision is made for revocation of licenses by the Board for not more than two years for violation of the act by the applicator or his employees.

Reporting Volumes of Pesticides

Persons selling pesticides to the consumer shall report to the Board all purchases, sales and shipments of restricted use pesticides and other pesticides designated by the Board.

Inspect

The Board may for purposes of enforcing the act may inspect all equipment and premises subject to the act, inspect lands on which pesticides are used, inspect storage and disposal areas, inspect complaints of injury to humans, lands or plants and sample pesticides being applied or to be applied.

Interim Licenses

The Board is authorized to issue provisional or interim licenses to all categories of licenses or to waive particular requirements or to provide for phasing of license requirements but no interim or provisional license shall be valid later than December 31, 1973.

These controls will not solve the problem of pest resistance to pesticides. Based on present knowledge, as long as man continues to use pesticides to control a pest he must recognize and be prepared to deal with pesticide resistance. An insect in its infinite variety and with its myriad of mechanisms to assure survival is well prepared to meet and overcome any effort by man to destroy it. By using an insecticide to control rootworms we add only a single additional obstacle to the thousands of hurdles that the rootworm already faces in its struggle to survive. As has been demonstrated repeatedly, it only takes 10-15 generations for an insect population to overcome a pesticide.

The world's agricultural industry must reorient itself in the use of pesticides. We will continue to use pesticides and we will use more of them in the next ten years than we have used in the last ten. But pesticides can never be our sole defense against pests and they should be no more than one of several tools used to manage pest problems.

Today when an insect appears on a crop the farmers automatic reaction is to use a poison. This is a reaction that must be altered to one in which the farmer says: "What pest do I have? How many are there? What damage will they cause? Of the several means of control available to me, which one offers the best return for my investment?" He must also recognize the hidden costs of environmental pollution and eventual pest resistance.

Research can provide the answers we need to the hundreds of unanswered questions and research can provide the tools to combat our problems.

The solutions to many pest problems may well come from:

(1) The development of more pest specific chemicals, that is, chemicals toxic only to the target species.

(2) More specific forecasting of pest outbreak conditions eliminating the need for routine preventive use of chemicals.

(3) Utilization of plants resistant to disease and insect attack which raise the threshold of economic damage to minimize the need for pesticides.

By continuing all available resources, whatever they may be, we can arrive at what is now referred to as pest management, a complex but highly efficient means to alleviate pest problems and hence prevent "pollution" resulting from peanut production.

INFLUENCE OF PEANUT HARVESTING AND CURING METHODS ON AFLATOXIN CONTAMINATION

by

Wilbur A. Parker and Daniel Melnick
Best Foods Research Center, CPC International Inc.,
Union N. J.
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INTRODUCTION

During the fall of 1963, experiments were conducted in order to evaluate a new method of harvesting and curing peanuts with the hope that the method would eliminate the aflatoxin problem. This new approach involves leaving the peanut plant in the soil until low temperatures stopped nut maturity development; this requires approximately 30 days beyond normal harvesting date. The vines are cut at the soil level two days prior to digging and the harvesting is completed in one additional step. In the following text and tables, the term "New Concept Method" and its abbreviation, NCM, will be used to identify this new method of harvesting when coupled with subsequent forced air drying in bins.

The objectives of the New Concept Method are (a) to allow the kernels to go to full maturity by extending the harvest date, (b) to protect the kernels from time of harvest until the completion of curing, i.e., during the period of moisture reduction, (c) to increase the peanut yield by extending the growing period, and (d) to minimize or prevent the growth of *Aspergillus flavus* and thereby eliminate aflatoxin formation. The early literature indicates that the most vulnerable period for fungal development is immediately after digging, when the kernels contain very high moisture contents and are exposed to the extremes of weather conditions while in the windrows. Likewise, the most susceptible period for aflatoxin contamination is believed to occur during field drying (1, 2).

Although the method of field curing is still used in many countries of the world, the popular present method of harvesting in the United States involves partially drying the peanuts and vines in windrows, with subsequent drying and curing in bins, utilizing forced air which may be heated to reduce the humidity (3). In the present study, both of the above mentioned methods of curing (i.e. during field drying and artificially drying in bins) were also used in order to provide control samples. The new concept method of harvest is actually a combination of "new and old", in that once the peanuts are harvested, the curing and moisture reduction is completed in bins using dry forced air.

In the course of this study, a method was developed to allow shipment of high moisture peanuts to distant locations for subsequent evaluation without fear of having the sample change as a result of mold propagation. This method of peanut preservation has interesting possibilities in preventing aflatoxin contamination of peanuts harvested in areas having limited drying facilities.

MATERIALS, METHODS AND RESULTS

Seed Types and Soil Treatment

The peanuts comprising the test sample and the two controls were of the Early Runner variety. The test plot for the NCM peanuts involved a 20 acre plot

TABLE I
SUMMARY OF PEANUT SEED TYPES AND PLANTING CONDITIONS

<u>Method of Harvest</u>	<u>Seed Type</u>	<u>Planting Date</u>	<u>pH of Soil Prior to Planting and Treatment</u>	
			<u>Field #20*</u>	<u>Field #5^ø</u>
New Concept	100% Certified Early Runners	April 23 & 24, 1963	5.8	5.4
Field Curing	50% Certified Early Runners and 50% from previous year New Concept harvest	April 23 & 24, 1963	5.8	-
Artificial Curing	100% Certified Early Runners	April 23 & 24, 1963	5.8	-
<p>* A ton of lime and 200 pounds of N-K-P (6-12-12) were applied to this field prior to planting date.</p> <p>ø About 1.5 tons of lime and 300 pounds of N-K-P (6-12-12) were applied to this field prior to the planting date.</p>				

test. Very good weather conditions prevailed during the growing period. During the period from mid-June through the middle of August, the crops were dusted at two-week intervals with a mixture of 80% sulfur, 3% copper salt, and 5% DDT, at a rate of 20 pounds/acre.

Experimental test equipment was developed and used in this study, which enabled the actual digging and separation of the soil and extraneous material from the kernels in a one-step harvest method, i.e., digging, combining and cleaning.

Harvesting

The two control peanut crops remained in the soil for 139-140 days, after which digging occurred. The NCM lot remained in the soil for at least one month longer than the time allowed the two control samples; the latter was typical of that in current practice prior to regular harvesting.

The analyses for moisture content (gravimetric weight loss procedure) of the kernels at the time of digging are shown in Table II. The results of these moisture tests show a significant difference (lower) in the moisture content of the kernels

TABLE II

PEANUT HARVESTING AND CURING DATA				
<u>Method of Harvest</u>	<u>Harvest Date</u>	<u>Number of Days In Soil</u>	<u>---- % Moisture ----</u>	
			<u>Initial</u>	<u>After 7 Days</u>
New Concept	October 4 to 23, 1963	164 days at start of harvest, 183 days upon completion of harvest	20	6.5
Field Curing	September 10, 1963	140	37	9.5
Artificial Curing	September 9, 1963	139	37	7.0

from the NCM lot, which remained in the soil 30-40 days beyond the normal harvest date.

Peanut yield obtained by the New Concept Method was disappointingly low; the low yield was due, in part, to the fact that the experimental harvesting equipment was in the early design state, and thus only partially developed. Consequently extra handling of the nuts thru auxiliary cleaning equipment was required. Although the actual harvest of the NCM peanut was relatively low, approximately 13,000 pounds of farmers' stock nuts were harvested from the 20 acres. The two control plots, 5 acres each, produced 8,740 pounds in the case of the field cured peanuts, and 11,650 pounds in the case of the control field which provided peanuts for the artificial bin curing.

Prior to starting the harvest of the test plot for the NCM peanuts, 24 soil samples were taken in sterilized jars to test for the presence of *Aspergillus flavus*; later culturing of these samples revealed one sample positive with *Aspergillus flavus*. Samples of the high moisture nuts were also sent to our New Jersey Laboratory for independent critical evaluations; these samples were protected under an atmosphere of chloroform according to the procedure to be described later in this report.

Curing

Subsequent to the digging and combining operation in the NCM program, curing was completed by transferring the pods to bins utilizing unheated forced air at the rate of 17,000 cubic feet per minute until the moisture level was reduced to about 8%. The ambient temperature during the curing period ranged between 52° F and 82° F.

During the time the field cured control nuts were in the windrows, the weather conditions were almost ideal to permit windrowing for 14 days. Two rainfalls occurred during this period; the first on September 13, when the rainfall measured 0.25 inches, and again on September 14, when the rainfall measured 0.6 inches. Relative humidity recorded during the 14 days averaged 63%, with a range of 32 to 85%.

With respect to the second control lot, digging was started during the morning of September 9; during the afternoon of this date, the peanut pods from one-half of the plot were combined and the pods moved to bins for artificial curing. The remaining 2½ acres were combined two days later and the resulting pods transferred to the drying bins; the pods were placed on top of those previously harvested to complete the curing process. This latter method provided ideal protection to the control nuts, since the kernels were protected almost from the time of harvest until the time of shelling. Studies (4, 5) have shown that reducing the relative humidity and seed moisture as rapidly as possible during the curing process provides good protection against the propagation of *Aspergillus flavus*. McDonald and Harkness have found (6) that at least five days are required before there is measurable formation of aflatoxin on the high moisture kernels removed from the soil.

Shelling

After the curing of the three lots was completed, each sample was shelled through the cooperation of the USDA's Pilot Plant Shelling Plant located at Dawson, Georgia. The results of the farmers' stock gradings obtained on the

peanuts from the NCM test plot and also the gradings for the field cured and bin cured control peanuts are shown in Table III. These data show an abnormally high percentage of hull breakage in the nuts obtained from the NCM lot, and confirm our observations made on the same pods at the time of digging. In addition to finding a high percentage of broken hulls, the hulls were badly discolored (black) and exhibited signs of serious deterioration. It was obvious the kernels had lost much of their natural resistance to mold contamination. Other investigators have confirmed the natural protection which is provided by unbroken, intact hulls against insect infestation, microbiological spoilage, and aflatoxin contamination (7, 8).

In fact, at the time of digging, many kernels were already exhibiting heavy mold contamination, even when present several inches below the surface of the soil! The excessive degree of hull breakage experienced in the New Concept Method was further demonstrated by the high percentage of loose shell kernels, as much as 16.16% for the New Concept Method. This compares to 4.74% for the field cured and a low 2.36% for the bin cured samples.

During the shelling operation, interest was centered upon the amount of damage exposed once the peanuts were shelled. The discharge rate during processing of peanuts for the U. S. No. 1 grade was at the rate of 1200 pounds per hour. Table IV shows the damaged kernels removed in the reject stream for each lot as well as the aflatoxin content found in the reject stream during the removal of the damaged nuts and foreign material. The high percentage of rejects reported for the NCM peanuts (viz. 1.65%) was three times that experienced for the field cured rejects, and four times the figure reported for the bin cured rejects.

The damaged nuts were sorted from each of the reject streams and tested for the presence of aflatoxin. Aflatoxin was determined at that time by the early method developed by Broadbent et al (9) and involved only measurement of aflatoxin B₁. Most investigators are in agreement with Coomes et al (10) in concluding that measurement of the B₁ compound (the principal and most toxic component) is normally adequate to define the magnitude of toxicity of a given sample with respect to total aflatoxin toxicity.

The extremely high level of aflatoxin reported in the damaged nuts removed from the reject stream from the New Concept Method (110,000 ppb B₁) is evidence of the high degree of mold contamination associated with the damaged kernels from this new type of harvest. It is worth emphasizing that the contamination occurred with peanuts in the ground until time of "instant" subsequent curing, i.e., curing by forced air ventilation as promptly as possible after harvesting.

Raw Peanut Gradings

Following the shelling operation, kernels from the U. S. No. 1 grade were evaluated by the U. S. Department of Agriculture and also by our Portsmouth (Va.) Laboratory to confirm that No. 1 grade was, indeed, obtained. The data from the grading analyses are shown in Table V.

It is significant to note that the value for damaged kernels in the NCM lot were on the average four times higher than the values obtained with the two control samples. Furthermore, the aflatoxin test results show an unsatisfactory level of 270 ppb B₁ for the NCM peanuts. The figures for the two control peanut lots were typical of what could be obtained at that time (1963).

TABLE III

FARMERS STOCK (UNSHELLED) PEANUT GRADINGS			
<u>Grading Category</u>	<u>New Concept</u>	<u>Field Cured</u>	<u>Bin Cured</u>
Hull Breakage, %	95.00	41.50	31.20
Total Over 16/64 X 3/4 Screen, %	66.08	57.76	62.66
Sound Mature Kernels, %	64.56	57.30	62.12
Sound Splits, %	8.30	10.94	4.74
Other Kernels, %	3.54	7.08	9.32
Hulls, %	21.64	23.54	22.98
Loose Shell Exposed Kernels, %	16.16	4.74	2.36
Damage, %	1.74	0.76	0.54
Foreign Material, %	7.39	12.46	2.69
Moisture, %	6.21	5.87	6.02

TABLE IV

ANALYSIS OF PEANUTS REJECTED AT SHELLING PLANT			
<u>Grading Category</u>	<u>New Concept Rejects</u>	<u>Field Cured Rejects</u>	<u>Bin Cured Rejects</u>
% Foreign Material	9.58	1.42	0.98
% Unshelled	10.70	20.24	5.76
% Damage	32.60	16.78	21.76
% Good Kernels	2.74	0.68	3.60
% Machine Injury	4.24	8.20	14.76
% Skin Discoloration	40.02	51.92	52.52
Pounds of Rejects	110.0	20.0	26.5
Pounds of No. 1's	6562	3685	6540
% Rejects	1.65	0.54	0.40
Aflatoxin Concentration in Damage (ppb B ₁)	110,000	2,500	17,500

TABLE V

RAW PEANUT GRADINGS - NUMBER ONE GRADE						
Grading Category	New Concept		Field Cured		Bin Cured	
	Plant	USDA	Plant	USDA	Plant	USDA
% Other Varieties	0.00	0.03	0.00	0.00	0.00	0.00
% Split	5.96	2.04	5.56	0.69	1.95	0.44
% Thru Screen	1.44	0.91	2.36	1.18	1.79	0.54
% Major Damage	0.77	0.74	0.19	0.16	0.13	0.04
% Minor Defects	0.89	0.50 ^g	0.28	0.07	0.13	0.42 [*]
Total Damage	1.66	1.24	0.47	0.23	0.26	0.46
% Moisture	5.75	5.77	5.19	5.97	5.96	6.06
Aflatoxin Concentration (ppb B ₁) ^h	270	-	25	-	5	-
^g Consist of 0.25% skin discolorations. [*] Attributed to mechanical injury. ^h The aflatoxin values listed are calculated from analyses of pick-outs, obtained in a simulated peanut butter plant-operation, with allowance made for 50% destruction of the aflatoxin during the roasting process (11).						

Simulated Peanut Butter Processing

Following the shelling and sorting operations, the U. S. No. 1 peanuts from each lot were processed in simulated plant operation duplicating actual peanut butter operations at that time in order to ascertain the quality parameters and aflatoxin levels of the three lots available for critical study. Prior to processing, a portion of each sample was roasted for flavor (CLER)* evaluation, with the following results obtained as shown in Table VI.

TABLE VI

RESULTS OF CLER (FLAVOR) SCORE EVALUATIONS OF ROASTED PEANUTS			
Flavor Category	New Concept	Field Cured	Bin Cured
% Bad Off Flavor	0	5	0
% Slight Off Flavor	0	20	10
% Low Peanut Flavor	20	20	25
% Good Peanut Flavor	80	55	65
CLER Score	92	71	82

**Critical Laboratory Evaluation of Roast, a method developed in the Best Foods Skippy Laboratories and in general use today throughout the industry.*

The peanuts derived by the New Concept Method proved to have the best peanut flavor among the three samples; the test samples consisted for the most part of undamaged, mature kernels. As a point of reference, a CLER score of 50 is considered borderline. Thus, a CLER score of 92 indicates an exceptionally good flavor; and, the respective scores of 71 and 82 for the field cured and bin cured samples also indicates a very satisfactory flavor quality.

One kilogram aliquots from each of the three test samples were removed prior to the simulated peanut butter processing, and analyzed for fatty acid composition (12). The results obtained in the present investigation are shown in Table VII. These data indicate a decrease in ratio of oleic acid to linoleic acid for the NCM peanuts. Young (13) had reported lower oleic to linoleic acid values for immaturity, just contrary to what we had found. Possibly the NCM peanuts in the present study were over-mature; Young had also reported a decrease in oleic acid as maturity was exceeded; viz., "studies on over-mature peanuts indicate that the germination cycle was essentially a reversal of maturity". The mean Iodine value (94.7) for the samples tested in the present study was slightly higher than expected for oils obtained for runner varieties. In any case, differences in fatty acid composition among the three test lots are regarded to be too small to be of direct practical significance, i.e., insofar as affecting nutritional value or flavor stability.

The simulated plant processing conditions allowed us to preserve the identity of the samples throughout processing. Special arrangements were made to permit complete recovery of the pick-outs from the hand picking operations and also complete recovery of the "acceptable" peanuts discharging as the main stream. These "acceptable" lots of peanuts were recovered by collecting in toto the discharge from the picking tables in large drums with covers subsequently applied; the peanuts were held for manual sorting.

The damaged roasted peanuts in the rejected pick-outs were tested for

TABLE VII

ANALYSES OF PEANUT OILS PRESSED FROM RAW PEANUTS			
	New Concept	Field Cured	Bin Cured
Iodine Value (Wijs)	95.4	94.0	94.6
Saponification Value	188.7	188.4	188.9
% Oil	52.6	52.3	51.6
<u>Fatty Acid Composition*</u>			
% Fatty Acids in Tri-glycerides (95.6% Basis)			
Linolenic	0.0	0.0	0.0
Linoleic (L)	29.2	26.4	27.0
Oleic (O)	47.3	51.3	50.8
Saturated	19.1	17.9	17.8
Ratio O/L	1.62	1.94	1.89
* Obtained by spectrophotometric method; no preconjugated diene or triene were found.			

TABLE VIII

ANALYSES OF PEANUT REJECTS (PICKOUTS) DURING SIMULATED PEANUT BUTTER PRODUCTION			
Category	New Concept	Field Cured	Bin Cured
Pounds of No. 1's (Roasted Basis)	5,247	3,510	6,232
Blancher Pickouts (lbs.)	22	9.5	18.5
% of Process Rejected as Pickouts	0.42	0.27	0.30
% Damage in Pickouts	44.9	14.6	11.0
Aflatoxin Content of Damage in Rejects; (ppb B ₁)	50,000	12,500	2,500
Aflatoxin (B ₁) Removed; mg. per 100 lbs. of peanuts processed	4.25	0.23	0.04

aflatoxin as well as the main stream mentioned above. The results from these analyses are shown in Table VIII. These data also include the percentage of nuts which were rejected from the total lots processed, as well as the percentage of the damaged nuts in the rejected peanuts. The grading analysis from the NCM pick-outs revealed almost 50% damage, which is a very high level of damage considering the nuts had already been upgraded at the shelling plant. In addition, the damage was very severe. The aflatoxin content of this damage component was 50,000 ppb B₁. This is an extremely high concentration of aflatoxin. Additional tests revealed the aflatoxin level found in the rejects from the field cured lot was five times that of the rejects from the bin cured samples. Furthermore, the amount of aflatoxin removed per unit weight from the NCM peanuts was almost 20 times that removed from the field cured peanuts.

In Table IX, there is a summary of the fate of aflatoxin during the simulated

TABLE IX

FATE OF AFLATOXIN DURING SIMULATED PEANUT BUTTER PRODUCTION			
	New Concept	Field Cured	Bin Cured
<u>Reject Stream</u>			
Damaged Peanuts Removed (%)	0.19	0.04	0.03
Aflatoxin Concentration of Damaged Peanuts (ppb B ₁)	50,000	12,500	2,500
Total Aflatoxin Removed (ppb B ₁)	95	5	1
<u>Main Stream</u>			
Total Aflatoxin Remaining (ppb B ₁)	39	Negative	Negative
Total Aflatoxin in Roasted Peanuts Combined Reject and Main Stream Nuts (ppb B ₁)	134	5	1

peanut butter productions. These data show not only the aflatoxin levels in the rejected peanuts but also those in the main streams which were collected in drums. The extremely high level of aflatoxin contamination found in the main stream from the New Concept Method after the hand picking operation shows this stream to have contained a higher level of aflatoxin than even the starting samples of either the field cured or bin cured samples prior to roasting and rejection of objectionable nuts. The main streams from the two control samples tested negative with respect to aflatoxin contamination.

Since the above study was conducted with the hand picking operation used at that time to remove the aflatoxin contaminated kernels, it is possible that the aflatoxin contamination (39 ppb B₁) in the main stream of the NCM peanuts might have been significantly less had present methods for plant sorting of peanuts been used. Hand picking operations have obvious limitations related to rate and fatigue factors, when compared to electronic sorting in current use today (14). All of our plants have long since installed electronic sorting machines that have an unlimited capacity to reject off color (mold contaminated) nuts and foreign materials.

Protection of Raw Peanuts High in Moisture Content

In the course of the present studies, samples of high moisture peanuts were sent to our research laboratory in New Jersey for critical analyses and evaluations. Fifty pound quantities of freshly dug peanuts were sealed in metal containers in the presence of the chloroform vapors. The latter was produced by pouring chloroform (viz. 70 ml.) on a wad of absorbent cotton (viz. 50 gm.) and depositing the treated cotton on top of the peanuts in the containers. Laboratory studies had demonstrated that chloroform not only prevents propagation and aflatoxin production by *Aspergillus flavus* but is also fungicidal.

In Figure 1, there are shown two Petri dishes demonstrating the effectiveness



Figure 1. Effectiveness of chloroform vapor from cotton wad reservoir (plate on right) in preventing the propagation of *Aspergillus flavus*, N.R.R.L. 2999, following direct inoculation of ground raw peanuts containing 27% moisture content; plate on left was not so protected.

of chloroform vapors (i.e. chloroform not in direct contact with the ground raw peanuts of 27% moisture content) in preventing propagation of *Aspergillus flavus* (N.R.R.L. 2999) following direct inoculation. The test sample and control were incubated at 30°C for a period of four days and the Petri dishes were sealed airtight with pressure sensitive tape at the periphery. Even on Difco potato-dextrose agar, propagation of the mold was inhibited by the chloroform vapor. This inhibitory effect was not just fungistatic but fungicidal. When a portion of the inoculated ground raw peanuts, after four days' exposure to the chloroform was subcultured on potato-dextrose agar (now in the absence of chloroform), no mold growth at all was observed.

The exposure-to-chloroform vapor technique, as used in the present study, permits one to have the resources of a distant laboratory available for the study of freshly harvested peanuts as though the laboratory itself adjoined the growing fields. Studies reported by others (15, 16, 17, 18, 19) with known established

fungicides have shown only limited success in protecting high-moisture peanuts in the field and under conditions of laboratory exposure. Chemical (pesticide) treatments have been known to cause off-flavor in food products not only because of the off-flavor imparted by certain chemicals but also because of the interference by same in the normal metabolic changes occurring in the food prior to and after harvesting. The same risks are involved in using chemicals for protecting peanuts just after harvesting and during curing. In our studies, chloroform has proven to be an effective fungicide for postharvesting applications, with proper precautions taken against inhalation. Properly cured peanuts, following even immersion in chloroform, to the point of measurable oil extractions, even up to 2% absolute oil removal, produce no off-flavors during roasting. The chloroform is sufficiently volatile to be completely removed during the roasting process and leaves behind no detectable residuum. The latter has been demonstrated organoleptically and is being further evaluated by sensitive analytical procedures; additional studies are also in progress on the influence of chloroform vapor on the post-harvesting treatment (curing) of peanuts. A closed chamber, holding peanuts protected by chloroform vapor, must obviously be thoroughly aerated before a person enters the chamber.

CONCLUSIONS

It is evident from the result of the present study that the New Concept Method, as conducted, is not a solution to the aflatoxin problem. Some very positive findings have been noted:

1. Peanuts left in the soil 30 to 40 days beyond the regular harvest date lose natural protection to mold contamination due to serious hull deterioration and subsequent hull breakage; i.e., strong, sound hulls are good protection against mold contamination.

2. One of the desirable features of the New Concept Method is that of moving peanuts directly from harvesting to curing bins. This completely eliminates the possibility of rain on the peanuts during curing.

3. It has been clearly established that peanuts can and do become contaminated with mold while in the soil and this mold can proliferate while in the soil; with the proper mold present, aflatoxin is produced.

4. Artificially bin cured peanuts can be produced that are of good quality and flavor when processed properly.

5. Mature NCM peanuts, free of damage, have exceptionally good flavor. However, with greater maturity obtainable by the New Concept Method, hull deterioration occurs to a greater degree with a resulting greater contamination with aflatoxin.

6. Fatty acid composition data revealed no differences of practical significance among the peanut lots provided by the three different methods of harvesting and curing. However, the ratio of oleic to linoleic acid would seem to indicate that the NCM peanuts are over-mature in the physiological sense.

7. Exposure of peanuts of high moisture content to chloroform vapor is an effective means for preventing aflatoxin contamination until drying will have reduced the moisture level to less than 8%. This is attained without the introduction of organoleptic defects.

SUMMARY

A critical evaluation of different methods of harvesting and curing peanuts was conducted with respect to the incidence of aflatoxin content and overall peanut quality. The peanuts were harvested in bulk according to both the conventional method and according to a New Concept Method advanced at that time, September of 1963. Those peanuts harvested by the conventional procedure were either subjected to field drying and curing or by artificial means in bins using forced air. The New Concept Method involved deliberately allowing the peanuts to remain in the soil about one month beyond the ideal harvesting date and then cutting and removing the vines two days prior to digging. The freshly dug kernels were then immediately subjected to artificial curing, employing the same procedure as used for one lot of control peanuts.

Microbiological tests demonstrated the presence of aflatoxin producing strain of *Aspergillus flavus* in damaged nut samples obtained by the new harvesting method. Heavy mold contamination was noted on many kernels which remained in the soil. A new chloroform preservation technique was employed to permit shipment of samples of peanuts of high moisture content to a distant laboratory location to provide in essence "on the spot" critical evaluation.

The percentage of rejected (damaged) kernels from the new harvesting method was about four times that experienced with the two control samples after conventional harvesting, those field cured and those artificially cured. Many of the kernels remaining in the soil after the ideal harvest date showed serious hull deterioration and this no doubt contributed to loss of natural protection against mold spoilage. A significant increase in aflatoxin content was associated with the increase in mold damage. The artificially cured peanuts were superior in quality characteristics than those field cured, following conventional harvesting. The mature and damage-free peanuts, obtained by the New Concept Method, were scored higher in good peanut flavor after roasting than the control peanuts obtained by the other two methods. This was attained with no change of direct practical significance in fatty acid composition. However, the advantage of superior flavor of good peanuts obtained by the New Concept Method was wiped out by the high incidence of mold contamination in the overall crop, associated with increased aflatoxin content (30 to 40 times higher). The standard harvesting procedure, with properly controlled artificial curing thereafter, still offers the best way to obtain quality peanuts with the least aflatoxin contamination.

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SPANISH PEANUT YIELD RESPONSE TO NEMATICIDE - SOIL FUNGICIDE COMBINATIONS

by

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Infestations of the Northern root-knot (*Meloidogyne hapla*) and root lesion (*Pratylenchus brachyurus*) nematodes have been found in many peanut fields in Oklahoma. Limited surveys of peanut fields indicate the infestations of root-knot nematodes occur in small irregular areas scattered across the field, while the root lesion nematode infestations are usually more uniform. Crop rotation with non-susceptible crops is a practical method of controlling nematodes; however, many growers cannot rotate and nematicides offer an effective means of control. Many soil organisms capable of causing seedling blight, root and pod rot are found in the Oklahoma peanut soils. Common soil inhabiting fungi found in the peanut soils include *Rhizoctonia solani*, *Fusarium* spp. *Sclerotium rolfsii*, *Aspergillus niger*, and *Pythiaceae* fungi. It would be difficult to overemphasize the importance of the problems caused by the various soil inhabiting pathogens. In recent years our appreciation of the severity of these problems has increased. Continued observation of peanut losses in the growers' fields has stimulated the development of a research program in this area. In order to effect an immediate relief of the grower's problem, field research studies were carried out in heavily infested growers' fields.

1968 STUDY. Peanut nematicide-soil fungicide trials in Caddo County were carried out on the (irrigated) Grover Skaggs, Jr. farm. Two fumigants (DD and Vorlex) and a soil fungicide (Terraclor) were applied to Starr Variety Spanish type peanuts. Plots were four single row beds, 1130 feet long on 36 inch centers with check rows on either side of each material. All nematicides were injected at an eight inch depth with one 45° "L" shank chisel per row, prior to planting. Terraclor 10G (PCNB) was applied in-furrow at planting. Soil samples for nematode analysis were taken before nematicides were applied, at mid-season and at harvest. Yield and pod-lesion index was determined at harvest October 23.

RESULTS

Increased yields were obtained from all treated plots. Yield increases of 981 pounds per acre were obtained in the Terraclor-Vorlex treatments. The added increased yield obtained from the nematicide-fungicide treatments indicated the need for such a practice. Qualitative observations of pods indicated a reduction of pod rotting disease when nematicide-soil fungicide combinations were used. Treatments and results are given in table one.

1969 TESTS. Nematicide-soil fungicide trials were located on Grover Skaggs, Jr. farm (irrigated) Caddo County and Dee Keeton farm (dryland) Marshall County. Combinations of a fumigant nematicide (DD) and soil fungicides (Terraclor 30G and Polyram 80W) were applied to Argentine Variety Spanish type peanuts. The fumigant was injected in two single-row beds on 36 inch centers, at an eight inch depth with a 45° "L" shank chisel prior to planting. Terraclor 30G was applied by the in-furrow blending method at planting. Polyram 80W was applied in a 14 inch band as a spray and incorporated into the bed at planting. Soil samples for nematode analysis were taken during the season

and yields were taken in the field at harvest.

Yields in the nematicide-soil fungicide combinations produced increased yields similar to those obtained in 1968. The greatest increase in yield of 2276 lbs/acre was obtained in the DD-Terraclo treatments the response obtained from the fungicide-nematicide treatments further emphasizes the importance of the nematode-soil fungus disease complex. Treatments and results are given in table two.

Table 1. PEANUT NEMATOCIDE & SOIL FUNGICIDE TRIALS
Skaggs Farm, Caddo County, 1968

Treatment ¹ Nematicide-Fungicide & Rate (Acres)/acre	Yield lbs/acre	difference ² lbs/acre	% of check
DD 100%, 10 gal	4079	+423	112
DD 100% +PCNB 10G 1, 10 gal 10 gal	4439	+783	121
Vorlex 100%, 3.40 gal	4058	+402	111
Vorlex 100%, 3.40 gal +PCNB 10G -I, +30	4666	+983	127
PCNB 10G-I, 10 lbs	4204	+410	111

¹I= application at planting

² Difference in yield is the increase or decrease compared to an average of nontreated plots (checks) adjacent to each chemical treatment.

Table 2. NEMATOCIDE-SOIL FUNGICIDE TRIALS 1969

Treatment ¹ Nematicide-Fungicide & Rate in Ac./Acre Per Acre	Yield lbs/acre	difference ² lbs/acre	% of check
Geover Skaggs, Jr. Farm (Trt.), Caddo County			
DD 100% 10 gal	3013	658	138
DD 100%, 10 gal & Terra 30 G. 10 lbs I	5631	2276	201
Terraclo 30G 10 lbs	3627	544	118
DD 100%, 10 gal & Polyras 80 WP, 10 lbs-I 3920		1635	170
Dee Kuston Farm (Dryland), Marshall County			
DD 100% 10 gal	544	88	119
DD 100% 20 gal	538	82	118
DD 100% 10 gal & Terra 30G 5 lbs I	635	224	155

¹I= Application of soil fungicide at planting.

² Difference in yield is the increase or decrease compared to an average of nontreated plots (checks) adjacent to each chemical treatment.

CONCLUSIONS

The increased yields obtained in plots treated with the nematicide-fungicide combinations indicate a synergistic effect of the chemical combinations. These increased yields suggest the development of recommendations for nematicide-fungicide application in Oklahoma peanut fields infested with nematodes.

Parasitic soil inhabiting fungi are found in most Oklahoma peanut soils and cause damage to the developing seedling as it emerges. Standard seed treatments destroy only the fungi and bacteria on the seed and provides only a protection zone around the seed; therefore, a soil fungicide applied at planting is needed. The omnipresence of the parasitic soil fungi accent the need of adding a soil fungicide with the nematicide application. Injury caused by the nematode penetration and feeding on the peanut root system would certainly offer more infection courts for the various fungi.

Further studies using combinations of fumigants and nonfumigants and soil fungicides are needed before a general practice can be suggested.

CHEMICAL TREATMENT OF PEANUTS IN THE WINDROW TO CONTROL ASPERGILLUS FLAVUS AND AFLATOXINS 1

by

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The effect of chemicals on *Aspergillus flavus* Link and aflatoxin contamination in peanut kernels was studied on windrowed plants in the field. Cultivar Starr (Spanish type) peanuts were grown according to recommended cultural practices. Plants were dug 135 days after planting and inverted in the windrow. Digging samples were collected and kernels assayed for *A. flavus* on high salt-malt agar and for aflatoxins by TLC and the aqueous-acetone method. Background contamination with *A. flavus* averaged 15% of freshly-dug kernels and with aflatoxins 21 ppb. Aqueous solutions or suspensions of 24 chemicals (Table 1) were applied to pods immediately after sampling, and the plants were covered with polyethylene film (PEF). Pods with water applied served as controls. After 24 hours the PEF was raised, pods were inoculated with an aqueous spore suspension of an aflatoxin-producing strain of *A. flavus* (NRRL-2999), and the PEF replaced. After 6-days incubation samples were collected and kernels assayed for *A. flavus* and aflatoxins as described for digging samples. Chemicals most effective in reducing the incidence of *A. flavus* recovered from kernels were: PABA-DMSO, 99% free of the fungus; maneb and Bordeaux, each 98%; captafol-DMSO, 97%; Geigy-20-072(25), 96%; boric acid, 93%; and formaldehyde and propionic acid, each 91% as compared to 48% of the control kernels free of *A. flavus* (Table 1.) Aflatoxin contamination was not correlated with isolation frequency of *A. flavus*. No aflatoxins were recovered from 14 treatments, 20 ppb or less from eight, and 151 ppb from controls (Table 1).

1. Contribution of University of Georgia College of Agriculture Experiment Stations, supported in part by the Agricultural Research Service, U. S. Department of Agriculture, Grant No. 12-14-100-9900(34), administered by the Plant Science Research Division, Beltsville, Maryland.

Table 1. Chemicals applied to peanut pods in the windrow, *Aspergillus flavus* and aflatoxins recovered from kernels of treated pods.

Chemical	Aqueous concentration/liter	<i>Aspergillus flavus</i> ^a	Total aflatoxins, ppb ^b
p-Aminobenzoic acid (PABA) + dimethylsulfoxide (DMSO)	20 g + 50 ml	1	0
Manzate 80D ^(T) (maneb)	12 g	2	20
Bordeaux 8-8-100D	23 g	2	0
Difolatan 4F ^(T) (captafol) + DMSO	20 ml + 50 ml	3	0
Geigy 20-072(25)	40 g	4	0
Boric acid	20 g	7	0
Propionic acid	50 ml	9	7.5
Formaldehyde	75 ml of 40%	9	2.5
Potassium azide	10 g	10	0
Gentian violet	200 mg	15	5
Captafol 4 lb. a. i./gal	20 ml	23	0
Benlate 50 WP ^(T) (benomyl)	5 g	26	0
DMSO	50 ml	27	0
PABA	20 g	31	1.2
Sodium m-bisulfite	50 g	32	0
Sodium hypochlorite	5.25 g	35	5
Calcium hypochlorite	50 g	38	0
Crystal violet	200 mg	46	2.5
Nutonex sulfur 94W ^(T)	50 g	48	0
Malachite green	200 mg	54	0
Sodium bisulfite	50 g	64	39
Acetic acid	50 ml	65	5
Lime sulfur 30L	225 ml	67	22.5
Brilliant green	200 mg	76	0
Control	-0-	52	151

^a Mean of four 100-kernel replicates.

^b Mean of four 25-g replicates.

INHIBITION OF AFLATOXIN PRODUCTION IN LIQUID CULTURE BY BIOLOGICAL DYES 1

by

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A number of biological dyes were evaluated for their inhibitory effects on growth, sporulation, and aflatoxin production of a known aflatoxigenic isolate of *Aspergillus flavus* Link (NRRL-2999) in liquid medium. The dyes were evaluated singly in concentrations of 1, 10, 100, and 500 ppm in 250-ml flasks containing 50 ml of a "20% sucrose - 2% yeast extract" medium. Non-amended medium served as controls. Flasks were inoculated with a spore suspension of the fungus and incubated for 7 days in the dark at 27 C. Visual evaluations on growth and sporulation were made and the contents of each flask analyzed separately for aflatoxins using the aqueous-acetone method and TLC. All treatments were replicated five times. Of 27 dyes tested (Table 1), four (brilliant green, malachite green, gentian violet, and crystal violet), significantly inhibited growth, sporulation, and aflatoxin production at 100 ppm or lower (Table 2). These four dyes completely inhibited growth at 500 ppm. They are being evaluated further in the laboratory and in the field as windrow treatments to control aflatoxin contamination in peanuts.

1. Contribution of University of Georgia College of Agriculture Experiment Stations, supported in part by the Agricultural Research Service, U. S. Department of Agriculture, Grant No. 12-14-100-9900(34), administered by the Plant Science Research Division, Beltsville, Maryland.

Table 1. Effects of biological dyes on visual ratings^a of growth and sporulation of an aflatoxin-producing strain of *Aspergillus flavus* in liquid culture.

Dye	Concentration, ppm									
	0		1		10		100		500	
	Gr. ^b	Sp. ^b	Gr.	Sp.	Gr.	Sp.	Gr.	Sp.	Gr.	Sp.
Azofuchsin 3B	5	5	5	5	5	5	5	5	5	5
Azofuchsin G	5	5	5	5	5	5	5	4	4	4
Bismark brown R	5	5	5	5	5	5	5	5	5	5
Bismark brown Y	5	5	5	5	5	5	5	5	5	4
Brilliant alizarin blue	5	5	5	5	5	5	5	5	5	5
Brilliant green	5	5	4	2	0	0	0	0	0	0
Brilliant yellow	5	5	5	5	5	5	5	5	5	5
Congo red	5	5	5	5	5	5	5	5	5	5
Crystal violet	5	5	4	4	3	3	1	1	0	0
Erythrosin	5	5	5	5	5	5	5	5	5	4
Gentian violet	5	5	3	3	2	2	1	0	0	0
Malachite green	5	5	5	5	5	4	2	1	0	0
Methyl green	5	5	5	5	5	5	4	4	2	1
Methyl orange	5	5	5	5	5	5	5	5	5	5
Methylene blue	5	5	5	5	5	5	4	4	3	3
Methylene green	5	5	5	5	4	3	3	3	5	5
Nigrosin B	5	5	5	5	5	5	5	5	5	5
Orange G	5	5	5	5	5	5	5	5	5	5
Orcein	5	5	5	5	5	5	5	5	5	5
Rhodamine B-O	5	5	5	5	5	5	5	4	4	3
Rose bengal	5	5	5	5	5	5	5	5	5	5
Safranin O	5	5	5	5	5	5	5	5	4	4
Safranin T	5	5	5	5	5	5	4	4	4	4
Scarlet G	5	5	5	5	5	5	5	5	5	5
Sudan II	5	5	5	5	5	5	5	5	5	5
Sudan green	5	5	5	5	5	5	5	5	5	5
Thionin	5	5	5	5	5	5	5	5	5	5

^a 0= no growth or sporulation; 5= most growth or sporulation.

^b Gr. = growth; Sp. = sporulation.

Table 2. Effects of biological dyes on aflatoxin production by *Aspergillus flavus* in liquid culture.

Dye	Dye concentration, ppm			
	1	10	100	500
Aflatoxin production, % of control ^a				
Azofuchsin 3B	33	75	100	5
Azofuchsin G	54	143	143	123
Bismark brown R	635	635	92	131
Bismark brown Y	137	104	75	151
Brilliant alizarin blue	30	54	77	100
Brilliant green	75	0	0	0
Brilliant yellow	95	86	83	65
Congo red	73	60	100	87
Crystal violet	60	36	3	0
Erythrosin	151	89	43	102
Gentian violet	59	17	1	0
Malachite green	50	66	5	0
Methyl green	52	66	50	27
Methyl orange	74	77	97	110
Methylene blue	153	144	130	5
Methylene green	243	248	67	29
Nigrosin B	185	220	220	130
Orange G	89	110	87	101
Orcein	58	79	48	48
Rhodamine B-O	104	77	93	59
Rose bengal	153	153	144	93
Safranin O	83	198	195	145
Safranin T	56	66	106	100
Scarlet G	80	70	140	180
Sudan II	136	153	110	236
Sudan green	85	85	66	84
Thionin	142	101	142	142

^a Mean of five replicates.

INVASION OF FARMERS' STOCK PEANUTS BY STRAINS OF ASPERGILLUS FLAVUS IN A CONTROLLED ENVIRONMENT IN THE LABORATORY

by

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ABSTRACT & PAPER

Farmers' stock peanuts with sound pods and with damaged pods were inoculated in two separate tests with spores of *Aspergillus flavus*; an aflatoxin-producing strain (P-70-51i) and a white-spored mutant strain (AF-2) capable of little or no aflatoxin production. After 1 week in a relative humidity of 90% at 25 C, *A. flavus* was recovered from surface-disinfected shelled kernels as follows: I. Inoculated with P-70-51i, 10% of kernels from sound pods and 62% of kernels from damaged pods. II. Inoculated with AF-2, 6% of kernels from sound pods and 78% of kernels from damaged pods. Tests of *A. flavus* isolates from I and II indicated that nearly all strains were similar to corresponding parent cultures. Species of the *A. glaucus* group became prevalent after 2 weeks in storage. *Penicillium* spp became a significant segment of the mycoflora after 4 weeks. Aflatoxins were detected in I after 2 weeks. Concentrations of the toxins remained low until 4 weeks, then reached 70 ppb in sound pods and over 7000 ppb in damaged pods. In II, aflatoxin B₁ was detected in peanuts from damaged pods after 1 week at a level of 4 ppb. After 2 weeks, 21 ppb were detected in peanuts from sound pods compared to a trace from broken pods. The moisture content of the peanuts varied from 13.0 to 14.9% in 8 determinations made after 3 and 5 weeks respectively.

Soon after the source of aflatoxin contamination of peanuts was determined, Bampton (1) investigated the growth of the causal agent, *Aspergillus flavus* Link, and production of aflatoxins in this crop. He suggested "... the shell might offer some protection as no fruiting colonies of the fungus were found in the drying heaps of unshelled nuts." A continuation of this study, reported by McDonald and Harkness (8), showed that the percentage of kernels infected by *A. flavus* was "affected markedly" by the condition of the shell. Schroeder and Ashworth (10) found significant aflatoxin concentration only in kernels from damaged pods in a hand-separated sample from a contaminated lot of peanuts.

Clearly, a sound, healthy shell or pod is an impediment to the penetration and infestation of the enclosed kernels and to the subsequent development of aflatoxin contamination. Goldblatt (6) recognized prevention of contamination as the first and best approach to control of the problem. Therefore, the production of peanuts in sound pods and the maintenance of this condition could be one of the more feasible means of preventing aflatoxin contamination. However, it must be recognized that the effectiveness of the pod or shell as a barrier to penetration by *A. flavus* can be expected to vary considerably from pod initiation, through development to maturity, and finally in the nonliving stage after harvest. Studies during all of these stages of development are essential before the role of the shell in the prevention of aflatoxin contamination can be completely assessed. This research deals with one facet of the problem; that is to determine the effectiveness of the shell as a barrier in peanuts that have been

cured and then exposed to environmental conditions favorable for the development of aflatoxin contamination.

MATERIALS AND METHODS

In-shell cured Spanish peanuts, Starr variety, were hand separated into a lot with sound pods and a lot with damaged pods (primarily mechanically cracked or broken).

Two strains of *A. flavus* were used in this experiment. Strain P-70-51i, a normal-type and highly toxigenic, produced large quantities of aflatoxins B₁ and B₂ in a standard culture test to be described later. The other strain was a non-pigmented mutant (white-spored) culture first detected as a single conidial head in an otherwise normal green colony of a non-toxigenic strain. This strain, designated as "AF-2 (white)," 1) was used as a "marker" to separate reisolations from the normal population that may have been present before inoculation.

It was essentially non-toxigenic, producing no aflatoxin in culture in initial tests. Dry spores of both strains were grown and collected by the method of Boller (2).

Both sound and damaged pods were inoculated as separate lots by dusting with large quantities of dry spores and then tumbling and mixing in a Patterson-Kelly Twin Shell Blender 2) for about 30 minutes. Spores were applied in equal volumes in sufficient quantity to insure that the amount of inoculum would not be a limiting factor in the infestation. The treated peanuts were then stored on screen trays suspended over a glycerol solution in plastic refrigerator boxes (Fig. 1). The specific gravity of the solution was adjusted and maintained at 1.082 to keep the relative humidity within the boxes at 90% (3). These containers were then stored in an incubator at 25 ± 1 C.

Subsamples of the peanuts were selected, at random from each treatment, at weekly intervals for 7 weeks. Fifty shelled kernels were surface sterilized by immersion for 1 min. in a 1% sodium hypochlorite solution and plated on malt-salt agar (7.5% NaCl) to determine the percentage of fungal infections. Also 25g of shelled kernels were assayed for aflatoxins by an adaptation of the method of Pons (9). Another 20g were weighed and hand shelled; shells and kernels were dried separately for 3 hours at 130 C (7), cooled in a desiccator, and weighed to determine the moisture content of the in-shell peanuts.

The fungi that grew from the kernels were counted after the plates had been incubated for 5 to 7 days at room temperature. *A. flavus* colonies were transferred to Czapek's agar (3% sucrose) slants. When 7-10 days old, the aflatoxin-producing capability of each culture was determined by growing it on a suspension of ground Spanish peanuts (3g in 50 ml of water) in 250-ml Erlenmeyer flasks for 7 days at 25 C. These cultures were extracted with aqueous acetone and the quantity of aflatoxins was quantified. The percentage of kernels infected by *A. flavus* that resulted from the inoculation procedure was estimated by comparing the color of each slant culture and its aflatoxin-producing ability with the corresponding characteristics of the parent strain.

1) Identification as a mutant of the *A. flavus* group was confirmed through the courtesy of Dorothy I. Fennell, U. S. Department of Agriculture, NURDD, ARS, Peoria, Illinois.

2) The use of a trade name does not imply an endorsement of this product by the U. S. Department of Agriculture or its agents.

RESULTS

Fungi isolated. Initially, storage fungi were not found in peanuts from either sound or damaged pods. Internal infection by fungi was limited to a few kernels infected by field fungi (Table 1 and 2). The number of fungus-free kernels decreased sharply in peanuts with sound pods after 1 week in storage. In contrast, fungus-free kernels in damaged pods decreased rapidly during the first week in storage. *A. flavus*-infected kernels increased in all treatments during the first week in storage. Rate of invasion, by the normal green culture, (P-70-51i) in damaged pods was about 6 times that in sound pods. The number of cultures of *A. flavus* isolated from sound pods decreased after 5 weeks but continued to increase from the peanuts from damaged pods. *A. flavus* was recovered from 100 percent of the kernels after 6 weeks.

Species of the *A. glaucus* group, although not detected after 1 week in storage, rapidly became the dominant fungi in peanuts in sound shells and a major percentage of the mycoflora of the peanuts in damaged shells (Table 1 and 2). *Aspergillus candidus* Link was found after 6 weeks in ca 60 percent of the kernels from damaged pods (Table 2) and *Penicillia* became prevalent after 4 weeks, with recovery from 74 percent after 6 weeks. Neither the *Penicillia* or other *Aspergilli* (including *A. candidus*) were recovered from an appreciable number of kernels from sound pods (Table 1).

Isolations from the peanuts inoculated with AF-2 (white) followed a similar pattern with some minor variations (Table 3 and 4). Generally, AF-2 (white) did not appear to be as capable of penetrating the sound pods as the green-spored normal-type strain, P-70-51i.

Aflatoxin contamination. A significant level of aflatoxin contamination in the peanuts in sound pods, inoculated with the toxigenic strain (P-70-51i) was not detected until after 4 weeks (70 ppb). However, in peanuts from damaged pods, concentration reached 20 ppb after 2 weeks and exceeded 7000 ppb after 4 weeks (Table 5).

Although initial tests showed that AF-2 (white) was not toxigenic, aflatoxins were detected in peanuts from both sound and damaged pods; after 2 weeks in sound pods and after 1 week in damaged pods (Table 6). The concentration never exceeded 86 ppb in either pod category. Throughout the experiments, there was no indication of a significant difference between the pod categories.

Moisture Content. Before treatment the moisture content of the in-shell peanuts averaged 5.8% (wet basis). It increased rapidly to 11-12% during the first week in storage, followed by a uniform decrease in absorption rate, to reach about 16% after 7 weeks. Initially the "in-shell" damaged were slightly drier than the "in-shell" sound-podded peanuts but the damaged tended to pick up water at a slightly higher rate during the first few weeks.

Recovery of *A. Flavus*. In the standard test previously described, the normal-type strain (P-70-51i) regularly produced about 3000 to 5000 ug of aflatoxin B₁ and from about 150 to 300 ug B₂ per flask. Strain AF-2 (white) failed to produce a detectable amount of aflatoxin when initially isolated. In later tests, small amounts of B₁ were usually detected. With both strains, the recovery of the original isolate was confirmed by color in slant culture and performance in the standard aflatoxin-production test. Cultures recovered from kernels from sound pods (Table 7) usually appeared similar to the strains used to provide the inoculum for the respective experiments. Only two green-spored cultures were found in peanuts inoculated with the AF-2 (white) mutant during the entire

experiment. Similarly, most of the cultures recovered from the kernels of damaged pods were indistinguishable from the strain applied as inoculum. (Table 8).

DISCUSSION AND CONCLUSIONS

Diener and Davis (4) reported development of aflatoxins in peanuts with sound pods stored before curing at relative humidities as low as 87 percent at 30 C. In a later study (5), also with intact pods, these authors reported the limiting values for unsterile unshelled peanuts as 85.5% relative humidity at 20 C. However, damaged and sound pods were not compared.

The optimum temperature for growth of most strains of *A. flavus*, consistent with maximum production of aflatoxin, is about 25 C. Our previous experience had shown that relative humidity of 90 percent at 25 C favored rapid development of aflatoxin contamination in peanuts. It is not unlikely that cured farmers' stock peanuts may be exposed to such conditions and thus the test data might be expected to predict the actual effectiveness of the sound-pod barrier.

The results established, both by counts of infected kernels and by the rate of accumulation of aflatoxins, that the sound pod is an effective barrier to *A. flavus* under the conditions of these experiments.

The extremely rapid and widespread development of species of the *A. glaucus* group was unexpected. Because of the excessive *A. flavus* inoculum level, other fungi were expected to be at a distinct competitive disadvantage. This proved true during the early days of storage but the effect was lost with time. Apparently, the pods do not bar penetration by the *A. glaucus* group as effectively as the *A. flavus* group. Possibly the *A. glaucus* group had penetrated prior to storage but data from the control and the first week of storage do not support this. The *A. glaucus* group not only penetrated the pod more easily but also seemed to be at a competitive advantage under the environmental conditions of this experiment.

Pods became visibly moldy after about 3 weeks in storage. Examination under the microscope showed that the *A. glaucus* group was the predominant external fungus. Many kernels were split and again species of the *A. glaucus* group were the most common fungi found growing between the cotyledons. In many cases, growth was luxuriant with conidial heads and cleistothecia visible to the unaided eye. These data suggest that a closer look at possible deterioration caused by species of the *A. glaucus* group may be advisable.

In damaged pods, kernels supported a much more luxuriant mycoflora than in sound pods. The development of numerous infestations by *Penicillia* was particularly notable; many kernels in damaged pods supported growth of two or more species. They also became obviously moldy more rapidly than kernels from sound pods.

Although AF-2 (white) originally failed to produce detectable levels of aflatoxin in the standard peanut test medium, 92 to 100 white-spored cultures reisolated from the inoculated peanuts produced aflatoxin in the standard test. Production was low, ranging from a trace to 4 ug per flask. It seems probable that aflatoxins detected in the stored peanuts may have been produced by this strain. This is supported by the extremely low rate of isolation of normal green-spored cultures.

The data from both experiments failed to indicate that multiple infection of the kernels seriously inhibited the production and accumulation of aflatoxin.

Similar experiments with both fresh-dug and fresh combined peanuts of different varieties would be desirable. However, emphasis should be placed on improvement of harvesting and handling techniques to prevent mechanical damage and perhaps on the development of varieties with pods that resist damage. Reduction of broken and damaged pods should lead to a corresponding reduction of aflatoxin contamination in kernels.

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Figure 1. Method for experimental storage of peanuts in controlled relative humidity and temperature.

Table 1. Fungi isolated from peanut kernels from sound pods after inoculation with an aflatoxin-producing strain of *Aspergillus flavus* (P-70-51i) and storage in an atmosphere maintained at 90% relative humidity and a temperature of 25 C.

Time in storage	Fungi isolated from kernels					
	None	<i>A. flavus</i> group	<i>A. glaucus</i> group	All other Aspergilli	Penicillia	Field fungi
weeks	%	%	%	%	%	%
0	92	0	0	0	0	8
1	86	10	0	0	0	4
2	0	58	100	0	2	2
3	22	18	58	0	0	16
4	20	40	60	0	6	0
5	2	40	98	0	4	2
6	0	12	100	0	0	0
7	0	6	98	0	6	0

Table 2. Fungi isolated from peanut kernels from damaged pods after inoculation with an aflatoxin-producing strain of *Aspergillus flavus* (P-70-51i) and storage in an atmosphere maintained at 90% relative humidity and a temperature of 25 C.

Time in storage	Fungi isolated from kernels					
	None	<i>A. flavus</i> group	<i>A. glaucus</i> group	All other Aspergilli	Penicillia	Field fungi
weeks	%	%	%	%	%	%
0	96	0	0	0	0	4
1	38	62	0	0	0	2
2	2	86	64	0	0	4
3	4	72	74	0	6	6
4	0	54	86	4	10	0
5	0	92	76	2	52	0
6	0	100	18	64	74	0
7	0	100	64	0	12	0

Table 3. Fungi isolated from peanut kernels from sound pods after inoculation with a white-spored mutant strain of Aspergillus flavus (AF-2 white) and storage in an atmosphere maintained at 90% relative humidity and a temperature of 25 C.

Time in storage	Fungi isolated from kernels					
	None	<u>A. flavus</u> group	<u>A. glaucus</u> group	All other Aspergilli	Penicillia	Field fungi
weeks	%	%	%	%	%	%
0	92	0	0	0	0	8
1	92	6	0	0	0	2
2	20	18	74	0	0	8
3	22	10	70	0	6	4
4	4	12	86	0	4	4
5	2	20	100	0	8	4
6	0	6	100	2	2	2
7	0	16	100	0	30	4

Table 4. Fungi isolated from peanut kernels from damaged pods after inoculation with a white-spored mutant strain of Aspergillus flavus (AF-2 white) and storage in an atmosphere maintained at 90% relative humidity and a temperature of 25 C.

Time in storage	Fungi isolated from kernels					
	None	<u>A. flavus</u> group	<u>A. glaucus</u> group	All other Aspergilli	Penicillia	Field fungi
weeks	%	%	%	%	%	%
0	96	0	0	0	0	4
1	16	78	2	0	0	6
2	18	50	72	0	10	2
3	2	64	80	2	16	0
4	0	100	60	60	24	0
5	4	100	88	0	86	0
6	0	100	56	24	64	0
7	0	100	62	14	44	0

Table 5. Aflatoxins detected in peanuts inoculated with a toxin-producing strain of Aspergillus flavus (P-70-511) after storage in an atmosphere of 90% relative humidity at 25 C.

Weeks in storage:	Aflatoxins (ppb)							
	0	1	2	3	4	5	6	7
Sound pods	0	0	<3	0	70	<3	1192	42
Damaged pods	0	0	20	5	7295	8143	11572	7714

Table 6. Aflatoxins detected in peanuts inoculated with a white-spored mutant strain of Aspergillus flavus (AF-2 white) after storage in an atmosphere of 90% relative humidity at 25 C.

Weeks in storage:	<u>Aflatoxins (ppb)</u>							
	0	1	2	3	4	5	6	7
Sound pods	0	0	21	30	42	20	70	86
Damaged pods	0	4	<3	30	<3	86	70	18

Table 7. Frequency of recovery of Aspergillus flavus similar to strain applied as inoculum to peanuts with sound pods after storage in an atmosphere of 90% relative humidity and 25 C.

Time in storage	<u>Inoculated with P-70-511</u>		<u>Inoculated with AF-2 white</u>	
	Cultures tested	Cultures like inoculated strain	Cultures tested	Cultures like inoculated strain
weeks	no.	%	no.	%
1	5	100	1	100
2	10	100	6	100
3	9	100	5	100
4	10	90	6	67
5	10	100	10	100
6	6	100	3	100
7	3	100	2	100

Table 8. Frequency of recovery of Aspergillus flavus similar to strain applied as inoculum to peanuts with damaged pods after storage in an atmosphere of 90% relative humidity and 25 C.

Time in storage	<u>Inoculated with P-70-511</u>		<u>Inoculated with AF-2 white</u>	
	Cultures tested	Cultures like inoculated strain	Cultures tested	Cultures like inoculated strain
weeks	no.	%	no.	%
1	10	100	10	100
2	10	90	10	100
3	10	100	10	100
4	10	100	10	100
5	10	100	9	100
6	10	90	10	100
7	10	70	10	100

SOME METHODS OF DETERMINING MILLING QUALITY OF FARMERS' STOCK PEANUTS

by

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INTRODUCTION

When farmers' stock peanuts are sold at buying points, the milling quality of the peanuts is estimated by the split kernel outturn from the official grade sheller. The payment to the farmer is discounted for split kernels in excess of 4 percent of net farmers' stock weight. The official grade sheller developed by Dickens and Mason 1) has as its performance requirements:

"(a) The amount of kernel damage should be as small as possible since measurement of size distribution is dependent upon intact kernels, (b) the shelling time for 1,000 grams of peanuts should be less than 5 minutes, (c) the amount of unshelled peanuts passing through the machine should be small, and (d) the machine should be easy to clean between samples."

Kernel damage was considered to be the most important performance criteria for evaluating the sheller. Thus, the official grade sheller was developed to provide a low split kernel outturn that does not necessarily agree or correlate with the split kernel outturn of commercial shellers.

The objectives of this paper are to compare the split kernel outturns from the official grade sheller with the actual outturns from a pilot shelling plant, and to report work on development of two laboratory-scale shelling apparatuses - one for shelling samples larger than 20 pounds and one for shelling samples smaller than 20 pounds.

A comparison of split outturn data from the official grade with pilot plant shellers was needed to see if a correlation existed between the two split kernel outturns. If a correlation existed, then the outturn from the official grade sheller could be used to predict accurately the split kernel outturn from shelling plants.

Development of laboratory-scale shelling apparatuses was needed by researchers and industry to determine what effect variables in peanuts and in techniques have on the milling quality of peanuts and to assist in setting up commercial shelling plants. Many more samples can be economically and practically evaluated by using laboratory shellers instead of shelling the samples with plant-size equipment.

1) Dickens, J. W. and Mason, D. D. A Peanut Sheller for Grading Samples: An Application of Statistics in Design. Transactions of the American Society of Agricultural Engineers, Volume 2, No. 11, pp. 42-45, 1962.

PROCEDURES

As the lots of peanuts (750 to 1,000 pounds each) were brought into the USDA pilot shelling plant for tests, a spout-type sampler collected representative samples (3 to 7 pounds) of each lot for official grade evaluation. Data from the evaluation, collected for Spanish-, Runner-, and Virginia-type peanuts for crop years 1965 through 1970, were averaged and analyzed to determine the relationship between split kernel outturns from the official grade sheller and the pilot shelling plant.

A 50-pound representative sample also was collected from each lot. Each sample was shelled, using the laboratory shelling apparatus. Shelling outturn data were analyzed to determine the relationship between split kernel outturns from the laboratory and the pilot plant sheller.

The larger laboratory sheller is approximately one-fourth the size of a commercial first-stage sheller (fig. 1). It has three 4-inch wide cast-iron sheller bars and can be equipped with either cast-iron type or steel T-bar type sheller grates. The length of the sheller grates is approximately 11 inches. Although the rotational speed of the shelling cylinder can be varied, for these tests the cylinder speed was 205 revolutions per minute (r.p.m.). Capacity of the sheller is 500 to 1,000 pounds per hour. Equipment which complements the sheller is:

1. Distribution tray for the sheller discharge.
2. Hull pickup system and settling chamber.
3. Vibrating screen for separating large unshelled peanuts, SMK (sound mature kernels) and small unshelled, oil stock, and split kernels.
4. Bucket elevator to convey SMK and small unshelled peanuts to gravity table.
5. Gravity table for separating SMK and small unshelled peanuts.

The smaller laboratory sheller was originally designed by the manufacturer to shell a sample of peanuts for moisture determination. After modification of this sheller in our shop, preliminary tests were conducted to compare the split kernel outturn with the outturn from the pilot plant. Tests with the smaller sheller were conducted with 1970 crop year Spanish- and Runner- type peanuts.

RESULTS AND DISCUSSION

Official Grade Sheller

Split kernel outturn from peanuts shelled by the official grade sheller did not agree with the split kernel outturn from the pilot shelling plant, as shown in table 1 and figure 2. The line $y = x$ in figure 2 represents the necessary relationship (1:1) for exact agreement. Each data point in figure 2 represents peanuts of different milling quality and is the average of from 2 to 18 tests. The scatter of the average data is such that the split outturn from the plant cannot be accurately described by using split outturn results from the official grade sheller. The least squares equation (dashed line in figure 2) developed from the data is not a reliable estimate. Thus, it appears that the official grade sheller is fairly insensitive to changes in milling quality.

An attempt was made to obtain correlation by grouping the data according to type of peanuts and calculating the average ratio of pilot shelling plant splits to official grade splits for each lot of peanuts for all years (table 1). The range of ratios was so wide for each type of peanut that this too did not provide a reliable estimate.

The correlations obtained by calculating the least squares equations of the data for each type of peanut were not entirely reliable. However, these equations are a more realistic predictor of split kernel outturn than the equation $y = x$ where y = split kernel outturn from the pilot plant and x = split outturn from the official grade sheller. The least squares graph for Runner-type peanuts, which showed the highest correlation of the three types is shown in figure 3. The least squares equations for Spanish- and Virginia-type are as follows:

Spanish-type

$$y = 2.21 + 1.13 x$$

$$r = 0.73$$

Virginia-type

$$y = 2.13 + 3.00 x$$

$$r = 0.77$$

where

y = split outturn from pilot plant

x = split outturn from official grade sheller

r = correlation coefficient of the data to the equation.

These equations were developed from the data where the official grades were determined concurrent with or immediately after the pilot plant tests. Adjustments to the equations are necessary if loss of kernel moisture or other changes in milling quality occur between evaluations.

The main reason for inconsistent correlation between the split kernels from the official grade sheller and commercial-type shellers is the difference in shelling action. Shelling actions in the official grade sheller are produced by a reciprocating, rubber covered rod above a steel grate, while the shelling actions in the plant shellers are produced by a steel cylinder rotating inside steel grates.

USDA Laboratory Shelling Apparatus

Split kernel outturn from the laboratory shelling apparatus is approximately the same as the split kernel outturn from the pilot shelling plant (table 2). The data for Runner-type peanuts (total splits) are almost identical for the laboratory sheller and pilot shelling plant. Total splits from the pilot plant are slightly higher than total splits from the laboratory sheller for Spanish- and Virginia-type peanuts. This may be due to the fact that Spanish- and Virginia-type peanuts, especially Florigiant, are very sensitive to factors which cause skin slippage. When the skin is removed, the cotyledons separate easily when cycled through normal handling and grading operations in the shelling plant. To check out this possibility, the 1967 crop year Virginia-type peanuts (Florigiant) were cycled through the grading operation of the pilot plant. Consequently, 8.1 percent more kernels were split. Total splits after handling was very near the same for the laboratory sheller and pilot shelling plant (table 2). Split kernel outturn of the first stage sheller in the laboratory sheller and pilot shelling plant were also in agreement.

The laboratory sheller is sensitive to changes in milling quality. The effect of a milling quality variable such as kernel moisture on outturns can be determined (table 3). A detailed analysis can be made to determine the outturns, shelling efficiencies, and shelling rates of peanuts from each stage of shelling.

The laboratory shelling apparatus has been successfully used by National Peanut Research Laboratory personnel in numerous studies to determine the effects of different variables on milling quality of peanuts and to set up

equipment in the pilot shelling plant. Some of these studies are:

1. Effect of Temperature on Shelling Runner- and Spanish-type Peanuts. ARS 52-65 by McIntosh and Davidson.
2. Selected Physical and Shelling Properties of Florunner Peanuts. ARS 52-68 by McIntosh and Davidson.
3. Shelling and Storage of Partially Dried (Cured) Peanuts. 1970 Journal of APREA, Vol. 2, No. 1 pp 57-64, by Davidson, Blankenship, and Hutchison.
4. Drying Farmers' Stock Peanuts at 40° and 60° F. Transactions of the ASAE, Vol. 13, No. 4, pp 444, 445, 446, and 447, 1970, by Woodward, Hutchison, and Davidson.

Although the laboratory sheller is sensitive to changes in milling quality and its outturns correlate with the pilot shelling plant, it is not a replacement for the official grade sheller because of the sample size needed (20 pounds or more). Also the laboratory sheller is not easy to clean after running a test. Since two or three stages of shelling are needed per sample for adequate correlation of results, the time required would eliminate it for many tests.

Experimental Sheller

The first 1,000-gram samples shelled using the experimental sheller resulted in split kernel outturns three to four times greater than the pilot shelling plant. The cylinder speed of the experimental sheller then was reduced from about 375 r.p.m. to 250 r.p.m., the round sheller bars replaced by ¼-inch-square bars and the bar spacing made adjustable. Tests showed the best bar spacing for Spanish- and Runner-type peanuts to be 1 inch and 1-¼ inches, respectively, table 4. Other samples shelled at these optimum settings resulted in split kernel outturns that were more consistent, table 5.

Since these were preliminary tests to investigate the feasibility of the experimental sheller, no definite conclusions can be drawn. However, this sheller appears to have the potential for shelling 1 to 20 pound peanut samples.

CONCLUSIONS

The split kernel outturn from samples shelled with the official grade sheller does not correlate well with the outturn from a commercial-type sheller. The official grade sheller is fairly insensitive to changes in milling quality of peanuts. The shelling action of the sample sheller is much more gentle than the shelling action of a commercial sheller.

The laboratory sheller is a useful and practical tool that can be used by research scientists and shelling plant operators to isolate and identify variables which affect peanut shelling. It can also be used to determine the milling quality of a particular lot of peanuts and in selecting the combination of grate sizes for shelling lots of peanuts.

The experimental sheller has the potential of being developed into a sheller that can provide an accurate method to determine the milling quality of small samples of peanuts.

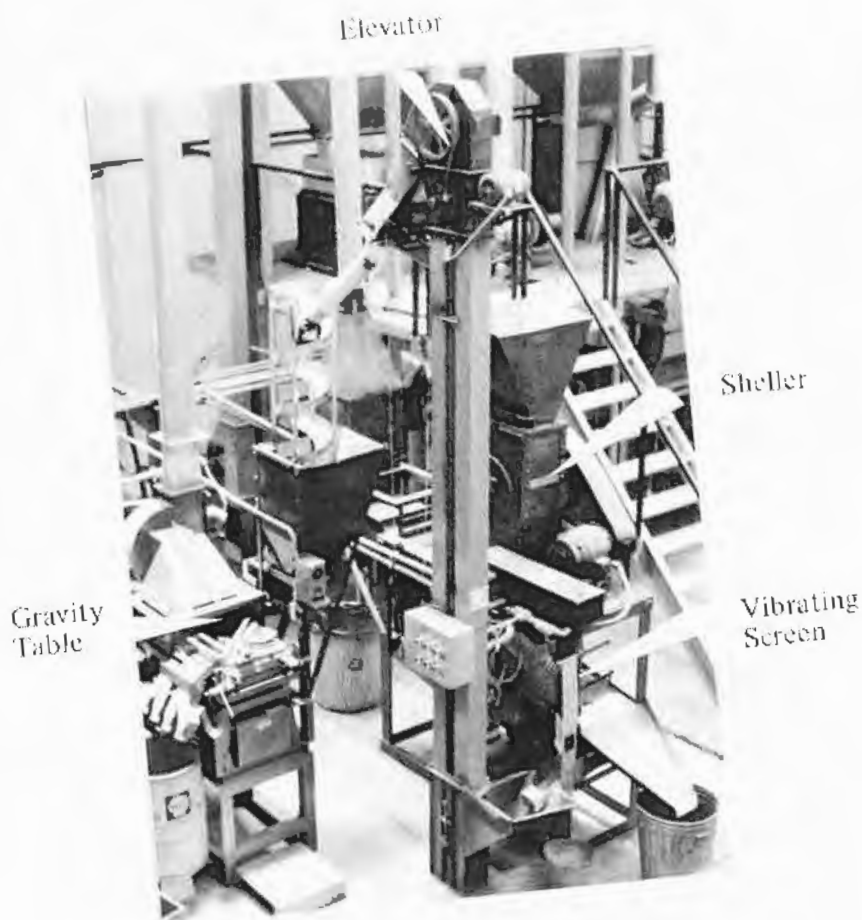


Figure 1. - USDA Laboratory Shelling Apparatus

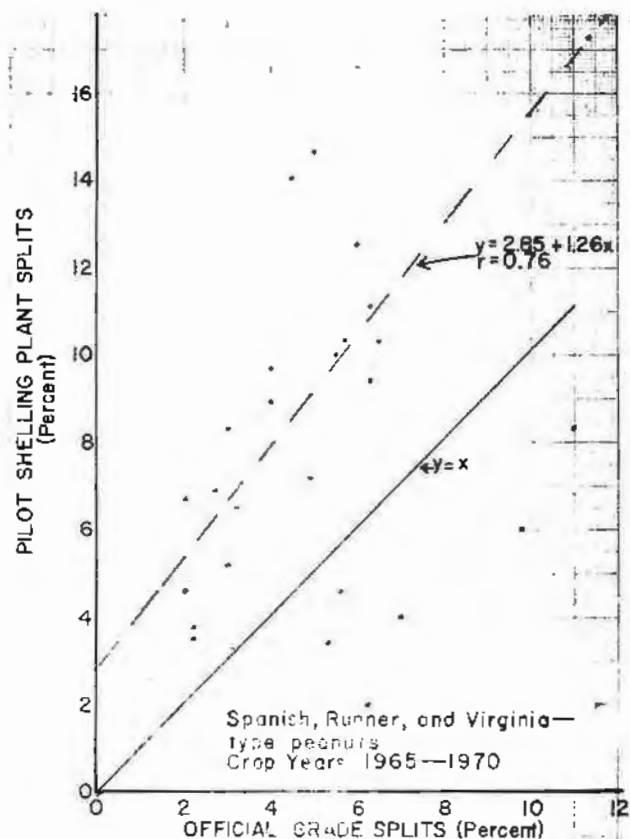


Figure 2.—Correlation of official grade sheller and pilot plant split kernel outturns.

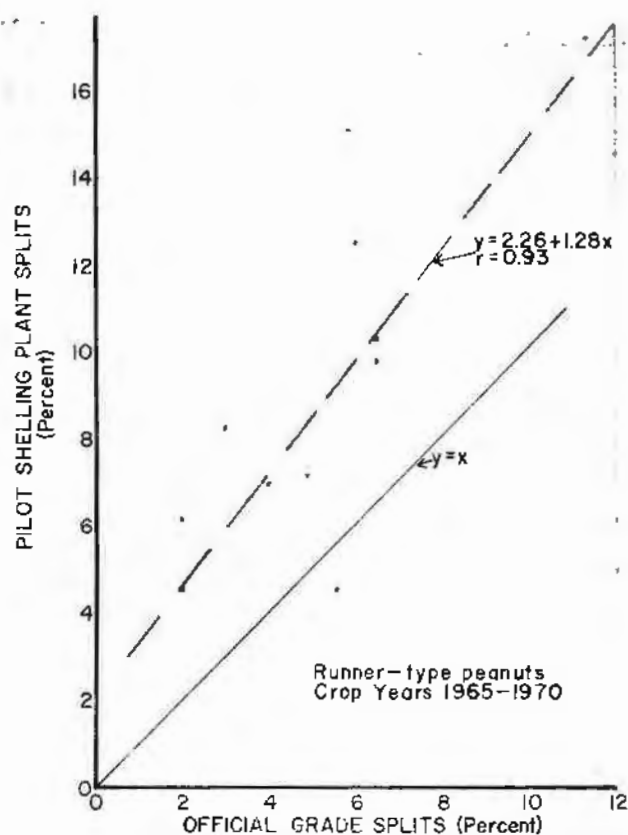


Figure 3.—Correlation of official grade sheller and pilot plant split kernel outturns.

TABLE 1.--Comparison of split kernel outturn obtained by shelling peanuts from the same lot in the official grade sheller and in the pilot shelling plant.

Crop year	Split kernel outturn		Ratio 1/
	Official grade	Pilot shelling plant	
	Percent	Percent	
Spanish-Type			
1965	5.3	3.4	0.60
1966	5.7	10.3	1.8
1966	2.2	3.8	1.7
1967	4.0	9.7	2.4
1968	2.7	6.9	2.6
1969	3.0	5.2	1.7
1969	6.3	9.4	1.5
1969	6.3	11.1	1.8
1970	8.3	11.0	1.3
1970	2.2	3.5	1.6
			Avg. 1.6
			Range 0.6-2.6
Runner-Type			
1965	3.0	8.3	2.8
1966	5.0	---	---
1967	6.0	12.5	2.1
1968	11.4	17.2	1.5
1968	5.5	10.3	1.6
1968	6.0	9.8	.8
1968	2.0	6.2	3.1
1969	4.0	7.0	1.8
1969	2.0	4.6	2.3
1970	5.6	4.6	.8
1970	14.3	21.2	1.5
1970	4.9	7.2	1.5
			Avg. 1.8
			Range 0.8 to 3.1
Virginia-Type			
1965	3.1	3.3	1.1
1966	5.3	10.0	1.8
1967	5.4	17.8	3.3
1968	2.0	6.7	3.4
1968	4.0	8.9	2.2
1969	5.0	14.6	2.9
1969	4.3	14.0	3.1
1970	3.2	6.5	2.0
			Avg. 2.5
			Range 1.1 to 3.4

1/ Plant splits + official grade splits.

TABLE 2.--Comparison of split kernel outturns obtained by shelling peanuts from the same lot in the official grade sheller, laboratory sheller, and pilot shelling plant

Crop year	Split kernel outturn				
	Official grade	Laboratory sheller	Pilot plant		
		First stage	Total	First stage	Total
	Percent	Percent	Percent	Percent	Percent
Spanish-type					
1967	4.0	7.6	7.3	7.6	9.7
1968	---	---	2.3	---	3.8
1970	---	10.3	---	12.9	12.3
Runner-type					
1967	6.0	13.1	12.5	12.4	13.3
1968	6.5	10.6	10.4	---	10.3
1968	6.0	9.8	9.5	7.7	9.8
1969	2.0	3.2	4.7	3.0	4.6
Virginia-type					
1967	6.0	10.6	1/10.0	10.8	18.7
1970	9.0	12.5	---	17.3	19.3

1/ Shelled peanuts from laboratory sheller were cycled through normal handling and grading process in pilot plant. This handling process caused an additional 8.1 percent split kernels.

TABLE 3.--Results of shelling Florigiant peanuts at two moisture contents with the laboratory sheller.

Stage of shelling	Size of openings in sheller grate	F.S. weight shelled	Hulls	Sheller efficiency	Sound mature kernels			Splits
					ELK	Medium	No. 1	
	Inches	Pounds	Percent	Percent	Percent	Percent	Percent	Percent
Moisture content 10 percent								
First	36/64	58.0	24.2	70.8	52.3	14.2	4.3	2.7
Second	30/64	12.0	25.0	85.8	49.0	15.2	3.7	1.6
Third	26/64	10.5	28.6	87.1	25.4	25.1	9.6	1.2
Total		80.5	24.4	100.0	47.6	15.4	4.8	2.3
Moisture content 7 percent								
First	36/64	54.5	25.7	81.4	41.1	12.0	4.8	10.8
Second	30/64	8.6	23.8	82.0	46.2	19.0	6.2	6.5
Third	26/64	3.5	21.2	80.5	25.4	21.8	10.2	4.9
Total		66.6	25.4	100.0	40.6	13.3	5.2	9.9

TABLE 4 - Bar spacing tests on experimental sheller, Crop Year 1970 peanuts

Type of peanut	Bar spacing	Split kernel outturn	Shelling efficiency
	<u>Inches</u>	<u>Percent</u>	<u>Percent</u>
Spanish ^{1/}	3/4	19.4	93
	1	16.3	86
	1-1/4	17.6	81
Runner ^{2/}	1	17.0	69
	1-1/4	12.6	58

^{1/} Shelled using 22/64 perforated metal grates.^{2/} Shelled using 24/64 perforated metal grates.

TABLE 5.--Correlation of experimental sheller and pilot shelling
plant split kernel outturns (crop year 1970 peanuts)

Type of peanut and test number	Split kernel outturn	
	experimental sheller	pilot plant
	<u>Percent</u>	<u>Percent</u>
	Spanish <u>1/</u>	
1 ^{2/}	10.0	7.4
2	10.5	7.3
3	11.9	6.8
4	10.0	6.6
5	8.6	7.3
6	8.1	7.3
7	9.6	7.6
8	10.7	7.3
9	10.9	7.7
10	9.1	7.8
11	9.8	7.1
12	11.7	6.1
13	11.9	5.8
14	7.9	8.3
	Runner <u>3/</u>	
15 ^{4/}	15.0	9.8
16	13.2	9.7
17 ^{5/}	13.3	9.9
18 ^{5/}	12.9	12.6
19	12.3	11.8
20	18.2	11.1
21	8.0	10.8

1/ 22/64 inch perforated metal grates used in experimental sheller for Spanish-type peanuts.

2/ 22/64 inch steel T-bar grates used in pilot plant for tests 1-14.

3/ 24/64 inch perforated metal grates used in experimental sheller for Spanish-type peanuts.

4/ 24/64 inch cast iron-type grates used in pilot plant for tests 15,16, and 17.

5/ 24/64 inch perforated metal grates used in pilot plant for tests 18-21.

METHIONINE CONTENT OF 25 PEANUT SELECTIONS, AND EFFECT OF MOLYBDENUM ON METHIONINE AND NITROGEN IN PEANUT PLANTS

by

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INTRODUCTION

Of all the amino acids present in peanuts (*Arachis hypogaea*), methionine has been consistently found to be in short supply.

Rosen (7) listed a methionine deficit for peanut protein of -77% as compared to whole egg. The major peanut proteins arachin and conarachin, according to Block and Bolling (4), contain respectively 0.6 and 1.9 g methionine per 16 g nitrogen. Altschul (1) reported a methionine content of 1.1 g per 100 g protein in alpha-conarachin. In each case, these values were very low when compared with other amino acids.

Scientists in India (5) have found a small but significant difference in amino acid concentration in different varieties.

The present report deals with the analyses of 25 experimental lines (or selections) of peanuts kindly provided by Dr. A. J. Norden, Peanut Breeder, University of Florida. Chemical assays were made with seeds harvested in 1969, and to check for reproducibility the same procedures were used with seeds from the 1970 crop.

Experiments were also performed to study the effect of molybdenum-fertilization on peanut plants.

METHODS

All peanuts used in the experiment were peeled of the testa and ground with mortar and pestle. The meal of 10 seeds was defatted with 20 ml of petroleum ether. After drying overnight at room temperature, 1 g of each sample was hydrolyzed in 4 ml of 6 N HCl for 24 hours at 110° C. Duplicates were used, and the experiment was repeated to prove reproducibility.

Methionine determination was done colorimetrically based on adaption of Bollings modification of the Sullivan-McCarthy method (4). The hydrolyzate was poured into a funnel with Whatman No. 50 filter paper, and each tube was rinsed twice with 0.5 ml ethanol. The filtrate, which was nearly black, was brought to pH 4 with ca. 2.5 ml of 5 N NaOH, and ca. 0.5 g of activated charcoal was added to each tube for decolorization. After adding 1 ml of phosphotungstic acid (20% in 0.1N HCl), the suspension was filtered into a graduated test tube. Each tube was then brought to a volume of 7.5 ml with 0.1 N HCl. In sequence were added: 1.5 ml of 5 N NaOH, 1.5 ml of glycine, and 0.3 ml of 10% fresh sodium nitroprusside. The tubes were mixed, using a Vortex mixer, and then put into a 37° waterbath for 15 minutes, which was followed by 10 minutes in an ice water bath. After cooling, 3 ml of 6 N HCl were added. By refiltering the liquid, a green precipitate was removed. This filtrate was immediately read in a B & L colorimeter set at 520 mμ.

A standard curve was made, ranging from 0 to 2 mg methionine. It is commonly known that a significant amount of methionine is changed during

*Contribution No. 4.

hydrolysis if special precautions are not taken. In order to obtain a correction factor, 10 mg L-methionine (from Sigma Co.) were weighed into a screw cap tube. This was hydrolyzed and analyzed exactly like the peanut samples. The correction factor obtained in 4 replicates amounted to 5.30, since only 18.7% of methionine was recovered by the technique used.

Nitrogen determination was accomplished by the micro-Kjeldahl method (2,6), using 20 mg samples of defatted peanut meal. Each flask received $\frac{1}{4}$ of a Kjeldahl tablet (Sargent Co.) and 3 ml H_2SO_4 conc.. The samples were then digested for ca. 1 hour. After partial cooling, 20 ml H_2O were added per flask. Before distillation, 10 ml of 40% NaOH with 5% sodium thiosulfate were added. The evolved NH_3 was trapped in 5 ml boric acid with bromocresol green-methyl red indicator. Titration was done with 0.01 N H_2SO_4 .

As a check of our methods we also analyzed duplicates of 20 mg NH_4Cl . This yielded a correction factor for all N-values of 1.05.

In calculating proteins, the values for percent nitrogen should be multiplied by 6.25, or 5.46 in peanuts. Results in the literature are often given as g/16 g nitrogen (which is the same as 100 g protein). We found it desirable to make our calculation comparable.

To determine the value of molybdenum addition to nutrient solutions on the methionine content, a series of plants was grown in vermiculite pots in the greenhouse. Every other day, the plants were given 200 ml of a solution containing nutrients in which the molybdenum concentration varied from 0 to 2 ppm.

When the plants were 4-6 weeks old, they were harvested. The leaves and stems were dried in an oven at 65°C overnight and then pulverized. This material was analysed for methionine and nitrogen, similar to the techniques used for seeds.

Statistical analyses were made in accordance with Sokal and Rohlf's text on biometrics (8).

RESULTS

The results of our analyses were recorded in Table 1. There were significant differences between the 25 peanut selections. The leading selection, Jenkins Jumbo, had 8.70 mg methionine per g peanut. This was followed by UF 69,415, Early Runner, and UF 69,204. Starr Spanish ranked 12th., while other named varieties, such as Florunner, Dixie Runner, Florispan, and Florigiant, had even less methionine than the forementioned ones.

Nitrogen percentages did not follow methionine contents proportionally as might have been expected. When methionine contents were expressed in g per 16 g nitrogen, the values were found to range from a high of 2.2 for Jenkins Jumbo to a low of 1.0 for Florigiant. Generally these figures fall within those previously reported by others (1,4).

In Table 2, methionine contents were recorded for peanuts grown in 1969 and 1970. The selections were ranked for methionine for both years. Generally ranks in both years were closely alike, but with a few exceptions. Methionine contents for 1970, however, were considerably lower in our analyses. No seeds from 1970 were available for either Jenkins Jumbo, the highest ranking selection, nor UF 69,114 which ranked lowest in 1969.

Table 3 illustrates the increases in both methionine and nitrogen contents in the leaves of peanuts due to variation in molybdenum-fertilization. Statistical analysis showed them to be significant.

DISCUSSION AND CONCLUSIONS

It can be noted from Table 1 that the first 4 entries contained about twice as much methionine as the lowest ranking selection. Peanut breeders, therefore, may like to include Jenkins Jumbo, UF 69,415, Early Runner, or UF 69,204 in their breeding program. Jenkins Jumbo, as the name indicates, is a very large peanut. The seeds measure up to $2\frac{1}{2} \times 1$ cm, which is considerably larger than the dimensions of standard varieties. Other large selections were not as rich in methionine. Since UF 69,415 had high methionine as well as high protein values, it too would appear very desirable.

Our assays showed that highest methionine content does not mean highest nitrogen, too; in other words, the ratio is not a constant. Statistical evaluation revealed no such correlation (Table 1). No effort was made to determine why. Most likely this indicates variability among the different proteins and other N-containing constituents.

The values for methionine per 16 g N should be high, preferably 2.0 (for milk this is 4.0), but since this is only a relative amount, the total value for mg methionine per g peanut seems to be more useful for the plant breeder.

By comparing the figures obtained for methionine with those reported by Rosen (7), we calculated that Jenkins Jumbo was only 45% deficient in methionine relative to whole egg. This is considerably better than the 77% deficiency reported for peanut in general.

Since the figures for g methionine per 16 g N (or 100 g protein) vary, we may conclude that the protein composition is different in the various selections.

In the analytical procedure used, much methionine was lost during hydrolysis. The method of Bidmead and Ley (3), where samples are first treated with performic acid and hydrolyzed in evacuated tubes, may be preferable if the equipment is available. Different figures may be obtained with this method, but the ranking for methionine will likely be the same as determined in this study.

When the effect of molybdenum on methionine and nitrogen was studied, a significant increase was found in both cases. The results reported above were obtained with peanut leaves, not with seeds; it can only be speculated that molybdenum also increases methionine and nitrogen content in seeds, even if only slightly.

ACKNOWLEDGEMENT

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Table 1. Methionine and nitrogen analyses of 25 selections of defatted peanuts

Lot No.	Selection	Methionine mg/g peanut *	Rank	Nitrogen %	Methionine g/16 g N **	Rank
6	Jenkins Jumbo	8.70	1	6.44	2.2	1
10	UF 69,415	8.16	2	7.34	1.8	4
1	Early Runner	7.90	3	7.36	1.7	7
9	UF 69,204	7.07	4	6.35	1.8	4
20	UF 69,103	6.96	5	6.36	1.8	4
25	UF 69,403	6.65	6	6.42	1.7	7
18	UF 69,318	6.52	7	6.39	1.6	10
14	UF 69,512	6.51	8	5.02	2.1	2
15	UF 69,608	6.34	9	6.46	1.6	10
17	UF 69,117	6.19	10	4.72	2.1	2
24	UF 69,709	6.12	11	6.71	1.5	15
8	Starr Spanish	6.01	12	7.19	1.3	16
3	Florunner	5.92	13	7.53	1.3	16
19	UF 69,112	5.84	14	5.91	1.6	10
21	UF 69,616	5.62	15	5.34	1.7	7
16	UF 69,317	5.54	16	5.49	1.6	10
13	UF 69,304	5.53	17	5.58	1.6	10
7	UF 69,714	5.49	18	7.28	1.2	20
4	Dixie Runner	5.16	19	6.46	1.3	16
11	UF 69,310	4.70	20	7.11	1.1	21
12	UF 69,208	4.59	21	6.71	1.1	21
22	UF 69,104	4.51	22	5.37	1.3	16
5	Florissant	4.49	23	6.37	1.1	21
2	Florissant	4.12	24	6.59	1.0	25
23	UF 69,114	3.74	25	5.51	1.1	21

* mean values not joined by the same line are significantly different at the .01 level as determined by a studentized multiple range test.

** $\frac{16(\text{Methionine})}{10(\text{Nitrogen})}$

Table 2. Comparison of methionine in peanuts harvested in 1969 and 1970

Lot No.	Selection	Methionine		Rank	Average
		mg/g peanut			
		1969	1970	1969	1970
6	Jenkins Jumbo	8.70	-	1	-
10	UF 69,415	8.16	6.25	2	<u>1</u>
1	Early Runner	7.90	5.32	3	<u>2</u>
9	UF 69,204	7.07	5.24	4	<u>3</u>
20	UF 69,103	6.96	4.14	5	<u>4</u>
25	UF 69,403	6.65	3.45	6	<u>7</u>
18	UF 69,318	6.52	3.31	7	<u>8</u>
14	UF 69,512	6.51	3.00	8	<u>10</u>
15	UF 69,608	6.34	3.82	9	6
17	UF 69,117	6.19	3.22	10	<u>9</u>
24	UF 69,709	6.12	3.00	11	<u>10</u>
8	Starr Spanish	6.01	4.10	12	5
3	Florunner	5.92	2.62	13	<u>13</u>
19	UF 69,112	5.84	2.55	14	<u>15</u>
21	UF 69,616	5.62	2.30	15	<u>16</u>
16	UF 69,317	5.54	2.02	16	<u>17</u>
13	UF 69,304	5.53	2.58	17	14
7	UF 69,714	5.49	1.95	18	<u>19</u>
4	Dixie Runner	5.16	1.73	19	<u>20</u>
11	UF 69,310	4.70	1.59	20	<u>21</u>
12	UF 69,208	4.59	1.98	21	18
22	UF 69,104	4.51	1.38	22	<u>22</u>
5	Florispam	4.49	2.88	23	12
2	Florigiant	4.12	1.23	24	<u>23</u>
23	UF 69,114	3.74	-	25	-

Table 3. Effect of molybdenum on methionine and nitrogen content of peanut leaves.

A. Methionine content (mg/100 g dry matter)						
Molybdenum	0 ppm	.5 ppm	1.0 ppm	2.0 ppm	n **	s **
Florunner R ₁	<u>.40</u> ^A	<u>.73</u>	<u>1.20</u>	<u>1.58</u>	3	.123
R ₂	<u>.29</u>	<u>.72</u>	<u>1.10</u>	<u>1.13</u>	3	.053
Florigiant R ₁	<u>.28</u>	<u>.29</u>	<u>.49</u>	<u>.71</u>	3	.073
R ₂	<u>.28</u>	<u>.62</u>	<u>.49</u>	<u>.62</u>	3	.077
Average	.30	.50	.82	1.03	-	.082

B. Nitrogen content (%)						
Molybdenum	0 ppm	.5 ppm	1.0 ppm	2.0 ppm	n	s
Florunner R ₁	<u>1.64</u>	<u>2.41</u>	<u>4.88</u>	<u>5.28</u>	4	.100
R ₂	<u>1.91</u>	<u>2.43</u>	<u>4.77</u>	<u>5.45</u>	3	.235
Florigiant R ₁	<u>1.00</u>	<u>1.68</u>	<u>3.18</u>	<u>3.69</u>	3	.315
R ₂	<u>1.01</u>	<u>1.88</u>	<u>2.92</u>	<u>3.11</u>	4	.234
Average	1.37	2.13	3.94	4.38	-	.194

* mean values not joined by the same line are significantly different at the .05 level as determined by a studentized multiple range test.

** n = number of observations per level.

s = square root of residual mean square in analysis of variance.

* Underscored values are similar to 1969 rank.

AN INDIRECT IMMUNOCHEMICAL ASSAY FOR TRYPSIN INHIBITOR ACTIVITY IN PEANUTS

by

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ABSTRACT & PAPER

Antiserum to the total proteins extracted from Virginia 56-R peanuts contains very few antibodies to the three reported trypsin inhibitors. Immuno-electrophoretic analysis of inhibitor fractions showed a faint precipitin arc only for the largest of these inhibitors (approx. 11,000 molecular weight). Based on an earlier immunochemical characterization of arachin in dormant and germinating peanuts, an indirect method for in vitro detection and estimation of trypsin inhibitor activity in peanuts was developed. The method consists of measurements of the electrophoretic migration of arachin untreated, treated with trypsin, and treated with trypsin which was first incubated with peanut extracts. Results obtained by comparing inhibitor activity in the peanut fractions to purified soybean trypsin inhibitor confirm the specificity and potential usefulness of this method for simultaneous analyses of several peanut fractions in vitro.

INTRODUCTION

Materials which inhibit enzymatic digestion of proteins are widely distributed in nature, especially in leguminous seeds. Of these, possibly the most widely studied are the trypsin inhibitors of soybeans. Kunitz (1) was the first to crystallize the soybean trypsin inhibitor (SBTI), which has since been separated into four active fractions (2). That these plant protease inhibitors are nutritionally significant is shown by the fact that the proteins of heated leguminous seeds have higher nutritional values than those of raw, unheated seeds (3-5, 7, 17). Trypsin inhibitors are suspected as the major factor affected by heat because of their ability to disrupt the normal digestive processes in the intestine.

Trypsin inhibitor activity has been reported in solvent-extracted raw peanut meals by several groups (6-8). The active material in the defatted meals could be solubilized by extraction with water or dilute HCl (5, 8). Trypsin inhibitor activity has also been reported in alcohol extracts of raw peanut skins (9, 10), but it seems doubtful that these alcohol-soluble factors are protein in nature. Woodham and Dawsou (7), examining the effects of heat on peanut proteins, found no trypsin inhibitor activity in peanut skins but did report that mild moist heat removed a growth-depressant factor completely. Recently two polyvalent trypsin inhibitors were extracted from raw peanuts with aqueous buffer, purified, and their amino acid sequences determined (11). This showed a molecular weight of 17,000 for the native inhibitor, which did not pass through a dialysis membrane and could be freeze dried.

In all of these reports, protease inhibition was assayed by measuring the hydrolysis of a protein (e.g., hemoglobin) or a synthetic substrate spectrophotometrically. In 1969, Catsimpoilas and Leuthner (12) reported a highly specific immunochemical method for detection and direct measurement of the SBTI. We attempted to measure directly, using immunochemical methods, three trypsin

inhibitor fractions isolated from raw peanuts by Stewart's procedure (13). However, the molecular weights of these peanut trypsin inhibitors are apparently smaller than the 17,000 reported by other workers (11). This report describes an indirect immunochemical method which was subsequently developed to detect trypsin inhibitor activity in microquantities of peanut meals or extracts. Instead of measuring the inhibitor directly, as done for the SBTI, the indirect method measures the effect of inhibitor fractions on tryptic hydrolysis of arachin, the major peanut protein.

MATERIALS AND METHODS

Peanuts, Virginia 56-R certified seed, were shelled and hand-selected for uniform size and quality by K. H. Garren and W. K. Bailey. The three trypsin inhibitor fractions were a gift from K. K. Stewart. These were prepared by aqueous extraction of whole raw peanuts, followed by combinations of fractional precipitation and DEAE-cellulose chromatography of the extract (13). Soybean trypsin inhibitor was a gift from J. J. Rackis. Pure arachin was prepared by cryoprecipitation (18). Antiserum to the total proteins of the peanut was prepared by Antibodies Inc., Davis, California.

Immunochemical Methods Employed

Immunoelectrophoretic analysis (IEA) was performed by the method of Grabar and Williams (14), with slight modifications. The gel was prepared from 1.5% ionagar (Oxoid Co.) in pH 8.2 Veronal buffer, 0.25 M. Electrophoresis was carried out for 2 hours at room temperature (24-25°C.) with a voltage gradient of 4 volts/cm. Immunodiffusion was performed on microscope slides according to Ouchterlony (15), using the same gel concentration and buffer conditions as for IEA. The slides were covered and diffusion allowed to take place for 24 hours at room temperature. All slides were dried in air while covered with filter paper, dyed with 1% Amido Black in 7% acetic acid, then destained with 7% acetic acid before viewing. The immunochemical characterization of arachin described by Daussant, et al, (16), was employed in the detection of trypsin inhibitor activity in peanut fractions.

RESULTS AND DISCUSSION

Current work in our laboratory on the effects of heat on peanut proteins showed an increase in the nutritional values of peanut meals heated at 110-120°C. for 1 hour (17). This increase in protein efficiency ratios of heated meals compared to that for unheated, raw peanut meals suggested the probable destruction of a trypsin inhibitor by the heat. Since these inhibitors are very minor components of seeds, the highly sensitive and specific immunochemical techniques seemed to offer the best means for the microdetection of trypsin inhibitor activity in peanuts. The immunochemical method described by Catsimpoolas and Leuthner (12) detects as little as 0.3 ug. of SBTI, using immune serum specific for the Kunitz SBTI (1).

Direct Immunochemical Assay

In order to determine if the antibodies of these three inhibitors were present in our antiserum, immunodiffusion patterns of the total peanut proteins and the

three fractions were compared. The results in Figure 1 show that antibodies to these inhibitors are essentially absent from this antiserum. Only Fraction A shows a very faint precipitin arc, indicating a low titer to this component. Also, the absence of a cross reaction between Fraction A and the total proteins (T), suggests that the titer for Fraction A is too low for detection in the total proteins extract employed here. According to Stewart (13), the molecular weight of these inhibitors ranged from 6,000 to 11,000, much smaller than the 16,000 to 23,000 for the SBTI (2). Since the total peanut proteins are extracted with phosphate buffer, the extracts must first be dialyzed against water to remove buffer salts before injecting into rabbits to induce the formation of antibodies in the serum. During this dialysis, the small molecular weight inhibitors were probably lost.

The absence of antibodies to these small molecular weight peanut trypsin inhibitors, therefore, precluded any attempt to measure their activity directly. However, Daussant et al. (16) noted a shift in electrophoretic mobility of arachin during germination of peanut seeds. They showed that this shift in mobility was due to proteolytic activity present in the germinating seeds by treating the dormant seed proteins with trypsin for one hour. The IEA patterns of trypsin-treated arachin and arachin of germinated seeds were identical.

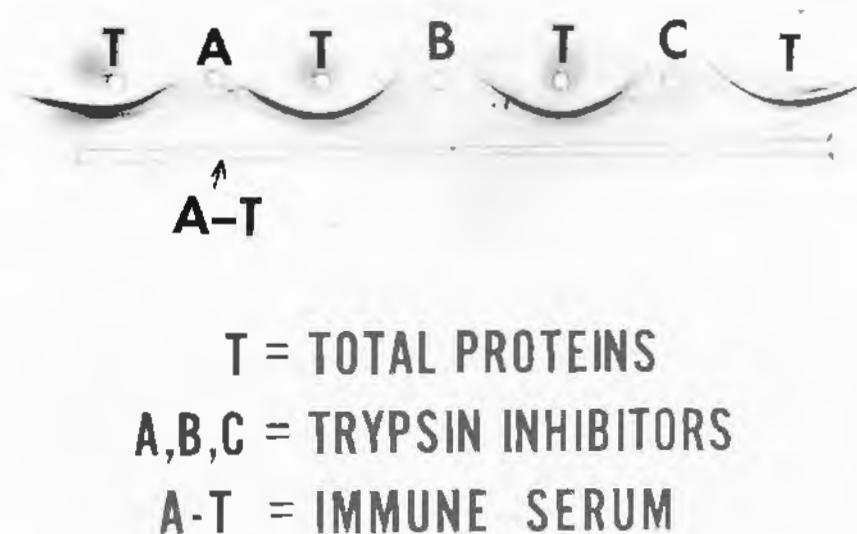


Figure 1. Ory and Neucere

Figure 1. Immunodiffusion of total peanut proteins and isolated peanut trypsin inhibitors. Conditions: gel and electrophoresis, described in text; T, total proteins of peanut extracted with phosphate buffer; A, B, and C, trypsin inhibitor fractions extracted with water from peanuts as described in text; A-T, antiserum in trough containing antibodies to total peanut proteins.

Indirect Immunochemical Assay

These facts were subsequently utilized in the development of the indirect assay method. The IEA patterns of pure arachin, of arachin treated with trypsin, and of arachin treated with trypsin which had been first reacted with SBTI, are

compared in Figure 2. The mobilities of arachin (well 1) and arachin treated with trypsin for 2 hours before electrophoresis (well 2) are notably different. If trypsin was first reacted with SBTI, then mixed with the arachin and incubated for 20 hours before electrophoresis (well 3), tryptic hydrolysis was completely blocked. The mobility of arachin treated with noninhibited trypsin for 20 hours before electrophoresis (well 4) is about the same as that in well 2; the only differences being a slightly smaller precipitin arc for arachin in slide 4 and the absence in 4 of the trace contaminant which is visible in 2 (arrow).

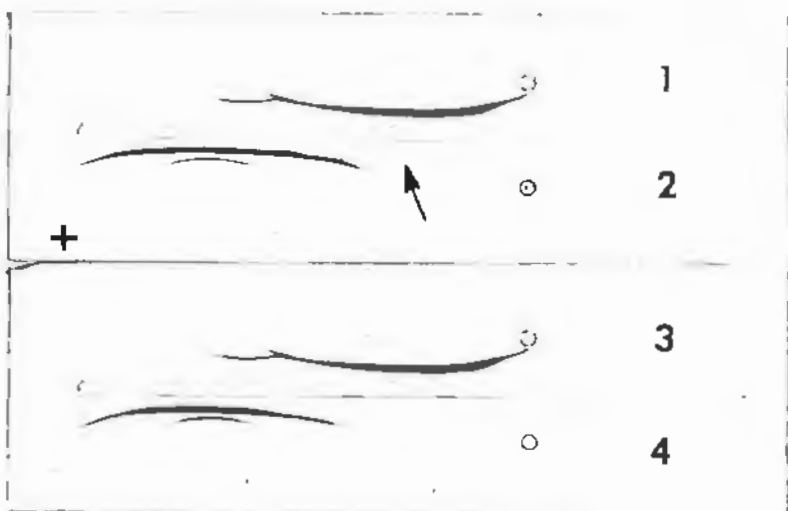


FIGURE 2. Ory and Neucere

Figure 2. Effects of trypsin and soybean trypsin inhibitor-blocked trypsin on immunoelectrophoretic analysis of arachin. Conditions: gel and electrophoresis, described in text. Proteins in wells I: 1, arachin; 2, arachin treated with 0.1% trypsin for 2 hr.; 3, arachin treated 20 hr. with 0.1% trypsin which was first reacted with soybean trypsin inhibitor; 4, arachin treated 20 hr. with 0.1% trypsin. Antiserum in trough contains antibodies to total peanut proteins.

These results, using SBTI-inhibited trypsin and purified arachin as the substrate, suggested the potential usefulness of the indirect approach to measure activity of small molecular weight trypsin inhibitors in peanuts. Figure 3 shows the results obtained by the Indirect immunochemical assay of trypsin inhibitor activity in the three Stewart Fractions. The IEA patterns of cryoprecipitated arachin (well 1) differs markedly from the broad arc of trypsin-treated arachin (well 2). In the other slides (3, 4, and 5), trypsin was first reacted with fractions A, B, and C of Figure 1, respectively, before incubating with arachin. IEA patterns of 3, 4, and 5 show conclusively that trypsin inhibitor activity is present in the three fractions and that tryptic hydrolysis of arachin was blocked. Although trypsin inhibitor activity is present in all three fractions, the inhibitors appear to be different molecules. According to Stewart (13), their molecular

weights estimated by gel filtration are 6,000, 9,000 and 11,000.

About 50 ug. of arachin was employed as substrate in these tests, to produce large, easily recognized precipitin arcs. The amounts used routinely, therefore, could be reduced. Since tryptic hydrolysis of arachin can be accomplished with much lower concentrations of enzyme compared to the substrate concentration, the amounts of trypsin inhibitor needed to block hydrolysis would also be smaller than those used in the present experiments. This means that the amounts of trypsin inhibitor detectable by this indirect assay method should be in the microgram range.

The small amounts of peanut trypsin inhibitor available so far have limited the expansion of this work; larger quantities are needed. However, future experiments are being designed to determine the minimum amounts of peanut trypsin inhibitor detectable by this indirect immunochemical assay, and the optimum conditions for obtaining best quantitative results.

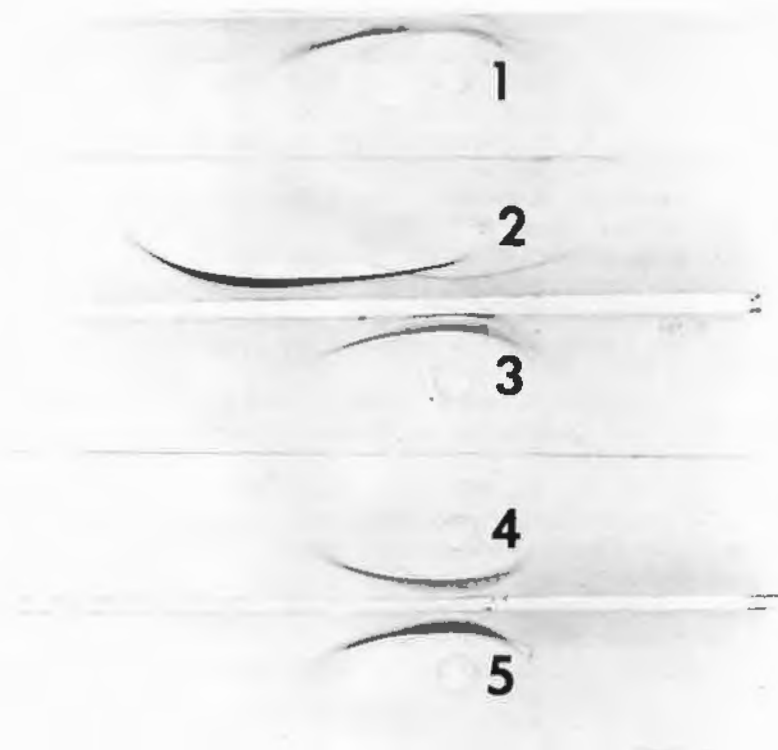


FIGURE 3. Ory and Neucere

Figure 3. Effects of trypsin and peanut trypsin inhibitor-blocked trypsin on immunoelectrophoretic analysis of arachin. Conditions: gel, electrophoresis, and proteins in wells, described in test; trypsin treatments for 3 hr. at room temperature; trypsin concentration and antiserum, same as in Figure 2.

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COMPARISON OF PROTEINS OF PEANUTS GROWN IN DIFFERENT AREAS

I. DISC ELECTROPHORETIC ANALYSIS OF QUALITATIVE AND QUANTITATIVE VARIATIONS

by

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ABSTRACT and PAPER

Proteins from crude extracts (i.e., pH 7.9 phosphate buffer, $I = 0.01$, soluble fractions from acetone powders of single peanuts) were separated by electrophoresis into distinct bands in a matrix system of polyacrylamide gel. Using polyacrylamide gel electrophoresis to characterize the protein makeup of peanut seeds, a number of cultivars from the different types, *Arachis hypogaea* L. subsp. *fastigiata* var. *vulgaris* (Spanish botanical type) and *A. hypogaea* L. subsp. *hypogaea* var. *hypogaea* (Virginia botanical and market types) grown in five regions (Virginia, Georgia, Louisiana, Texas, and Oklahoma) of the United States were analyzed. Examination of a large number of Virginia 56R seeds grown in Louisiana showed much intravarietal qualitative and quantitative protein electrophoretic variation. Similarly, some of these variations occurred within all the cultivars examined within and between the geographical locations. This consistency of the protein variation within and between the different cultivars made it difficult to clearly distinguish them electrophoretically. Some minor qualitative and quantitative variations in protein banding patterns partially distinguished a few of the different cultivars within and between peanut types grown in the different regions, but these variations were not consistent between the geographical locations. Major qualitative and quantitative protein banding differences distinguished some of the peanut types grown in different geographical locations. For example, the Virginia, Georgia, Louisiana, and Texas groups contain more of the large molecular weight storage globulins (i. c. arachin and conarachin) and albumins than do the cultivars of the Oklahoma group. The Oklahoma-grown cultivars contain more of the low molecular weight proteins than do the former groups. Possible explanations of this protein polymorphism within and between cultivar types and geographical locations are discussed.

INTRODUCTION

Gel electrophoresis of seed proteins has added much supplementary data to the classical genetic analyses (cytological and hybridization techniques) generally used to develop and relate cultivars of plant species. The genetic relatedness of cultivars can be determined by electrophoretically separating the seed proteins into thin bands and comparing their migrational patterns through a matrix system of agar, starch or polyacrylamide. This separation of proteins is based upon their ionic charge, molecular weight and conformation. Such electrophoretic comparisons of seed proteins have been accomplished for a large number of cultivars within a number of genera (1, 2, 6, 7, 8, 11, 13, 14, 15, 16, 23, 25). In general, these comparisons showed that little protein variation existed between seeds within a particular cultivar. This lack of variation (qualita-

tive and/or quantitative) was evident whether the cultivar was grown in environmentally similar or diverse geographical locations. Qualitative and/or quantitative differences within protein banding patterns were more prevalent between distant rather than closely related cultivars, supporting the data derived by the classical genetic techniques. However, groupings into distantly and closely related cultivars were not as clearly shown for certain species and these electrophoretic comparisons contributed little useful information to the classification of the cultivars.

Preliminary electrophoretic investigations of storage proteins from *Arachis hypogaea* indicated that representatives from the genetically different cultivar types (Virginia, Valencia, and Spanish) of this species showed some distinct differences in their banding patterns (12). In addition, the arachin fraction from individual seeds could be separated into two bands of slightly different mobilities (20, 21). The individual seeds of peanuts from the different cultivar types could be separated into one of three electrophoretic patterns with regard to the arachin fraction (banding patterns containing proteins A, B, or AB). It was concluded that this banding variation of the arachin fraction could be used to study genetic polymorphism within peanuts.

In the present investigation, proteins from crude peanut extracts (i. e., pH 7.9 phosphate buffer, $I = 0.01$, soluble fractions from acetone powders of single peanuts) were separated by electrophoresis into distinct bands in a matrix system of polyacrylamide gel and the protein patterns examined. A number of cultivars from the major peanut types of *A. hypogaea* L. subsp. *fastigiata* var. *vulgaris* (Spanish botanical type) and *A. hypogaea* L. subsp. *hypogaea* var. *hypogaea* (Virginia botanical and market types) were compared with one another. This collection of cultivars is a representation of most of the commercial acreage in the United States and includes the following five regions: Virginia, Georgia, Louisiana, Texas, and Oklahoma.

MATERIALS AND METHODS

Seeds from different cultivars of peanuts grown in five geographical locations of the United States for use in this investigation were generously supplied by Mr. W. K. Bailey, Beltsville, Maryland; Mr. J. I. Davidson, Dawson, Georgia; Dr. R. O. Hammons, Tifton, Georgia; Mr. J. A. Harris, Slidell, Louisiana; Dr. A. L. Harrison, Yoakum, Texas; and Dr. J. S. Kirby, Stillwater, Oklahoma. The Virginia 56R seeds grown in Slidell, Louisiana, were collected separately from 21 plants so that a study of intravarietal protein variation could be properly evaluated. The cultivars and the geographical locations where they were grown are shown in Table I.

TABLE I. Cultivars of the different types of *Arachis hypogaea* grown in different geographical regions for analysis of intra- and interspecific variation in protein electrophoretic patterns.

Spanish Botanical Type				Virginia Botanical Type		Virginia Market Type		
Virginia	Georgia	Texas	Oklahoma	Virginia	Georgia	Virginia	Georgia	Louisiana
Spanish Starr	Tifspen Starr	Coast Starr	Coast Starr	Early Runner Florunner	Early Runner Florunner	Virginia 56R	Florigiant	Virginia 56R
	Argentine	Argentine	Argentine	Virginia Bunch 67		Virginia 61H		
	Synarcosa		Spanhosa			Florigiant		
						NC17		
						NC 5		
						NC 2		

Twelve seeds of each cultivar were analyzed individually for protein content. In addition, 84 seeds (four seeds from each of 21 plants) of Virginia 56R grown in Louisiana were similarly examined. The skins of each dehulled seed were removed and the seed ground twice with a mortar and pestle in 10 ml of cold acetone. After each acetone washing, the samples were centrifuged at 39,000 g. The acetone powders were dried and the proteins extracted in 1.4 - 2.8 ml of pH 7.9 phosphate buffer, $I = 0.01$, followed by centrifugation at 39,000 g. The amount of buffer used to extract the protein depended upon the average size of the seeds from each cultivar (1.4 - 2.8 ml per seed). Within each cultivar, the acetone powders were ground with the same amount of buffer, disregarding variation in seed size. A sample of each supernatant was diluted to a protein content of each cultivar and qualitatively examined by polyacrylamide gel electrophoresis. The technique of polyacrylamide gel electrophoresis used was a combined method of Steward et al., (18) and Cherry et al., (1).

The authors acknowledge Mr. J. J. Bergquist for his skillful preparation of the photographs. The gels were photographed against a diffuse light background, printed at a size of 7 cm and mounted for the comparisons presented in this paper.

RESULTS AND DISCUSSION

Standardization of the techniques (protein extraction and polyacrylamide gel electrophoresis) used to examine the proteins from individual peanut seeds provided repeatable qualitative data for comparative purposes (Figure 1-87). The general (i.e., the polyacrylamide gels containing protein patterns occurring in highest frequency) intensity of staining, and spatial arrangement of the protein bands were consistent within and between all cultivars examined (Figures 1-5). Thus, variations from this general protein makeup of individual seeds examined for intra- and interspecific comparisons were easily detected. The samples of seeds from the different cultivars included in this study were small and may not be representative of the large field populations. However, it was assumed that selection for or against the proteins under study was not conducted in the field populations of the peanuts. Shaw (17) has presented information indicating that small samples such as those used in these experiments can still add much to the general picture of the variability of electrophoretic mutants. On the other hand, a specific protein banding pattern may predominate within a cultivar if the genes for these molecules are genetically linked to selected agronomic traits. The following discussion includes a comparison of the data from studies of peanut cultivars by classical genetic analyses to that derived from the biochemical examination of proteins from individual seeds.

INTRAVARIETAL VARIATION OF VIRGINIA 56R

Examination of 84 seeds from Virginia 56R grown in Louisiana showed much variation in the protein banding patterns (Figures 1-12). Seeds from 21 plants were examined. Protein variation occurred throughout these plants and can be distinguished into six groups as follows: Group I (Figures 1-5): 65 of the 84 gels examined contain two major (dark staining) protein bands in region 0.5-2 cm. These protein bands were quantitatively similar. Group II (Figures 6-7): in region 0.5-2 cm, the major band with a greater mobility has approximately double the staining capacity of the slower migrating band. Five gels were included in this group. Group III (Figures 8-9): in region 0.5-2 cm, the faster moving band

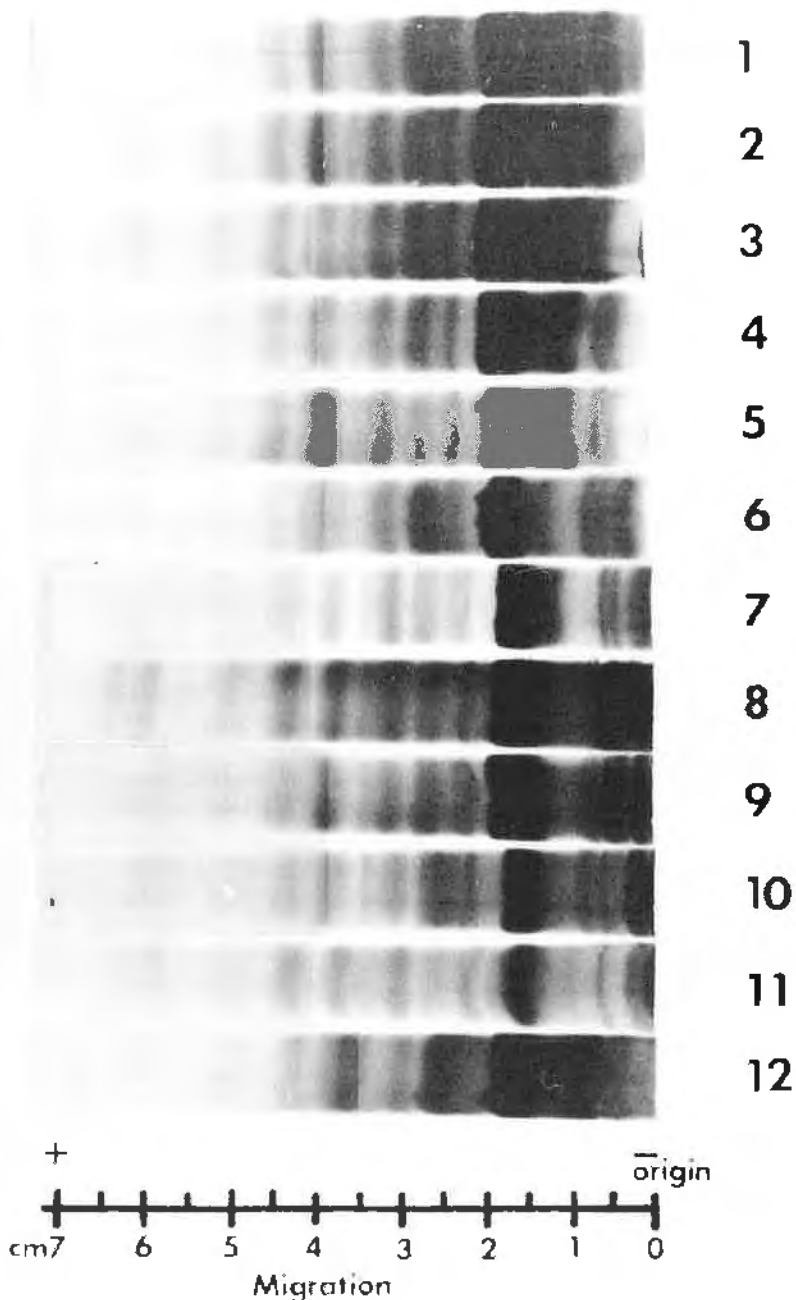


Figure 1-12. Protein electrophoretic patterns showing the range of intraspecific variability observed in Virginia 56R grown in Louisiana. Fig. 1-5, Group I. Fig. 6-7, Group II. - Fig. 8-9, Group III. - Fig. 10-11, Group IV. - Fig. 12, Group V. - Fig. 1-12, Group VI.

within seven gels contained much more protein than the slower band. In addition, the slower moving band has increased in mobility to a position similar to that of the faster band. Group IV (Figures 10-11): in seven gels, the slow moving major band of region 0.5-2 cm is absent. Group V (Figure 12): four gels of Group I do not appear to have the band in region 2.5 cm. Group VI (Figures 1-12): occurring throughout the five groups, region 5.5-6 cm contains either two, one or no bands.

In Groups III and IV, where the slower moving major band of region 0.5-2 cm is either in low concentration or absent, minor protein components (light staining) are present. These minor bands may be other proteins (albumins and globulins) or enzymes with similar mobilities as the major band (4). Tombs (20, 21) indicated that variability in the upper half of the gel patterns may be due to protein polymorphism in the arachin fraction. His two major protein bands were labeled as arachin A (highest mobility) and B (slowest mobility). Thus, Groups I, II, III, and IV may contain arachin A and B. However, quantitative and qualitative variations are apparent in these fractions.

The data from Groups I-VI indicate that within a cultivar much genetic polymorphism of specific genes or control mechanisms or both, that regulate the expression of these structural genes responsible for protein formation may be present. In addition, Cherry and Katterman (3) have indicated that such protein variations may be partially due to one or more of the following: (a) differential genetic expression of the alleles in the organism during maturation; (b) the premature collection of seed at different stages of maturation and thus the seeds are not ontogenetically equivalent; and (c) the ease of extraction of the different proteins from the individual seeds.

To reduce the possibility of examining physiologically immature seeds, medium to large size peanuts with unwrinkled seed coats from the samples of each cultivar were used in these experiments (5, 24). Using these samples, the following observations indicated that peanut immaturity did not play an important role in the protein electrophoretic variations observed between seeds: (a) The protein electrophoretic variations were present in both the medium and large seeds. (b) The zymograms of a number of enzymes showed no variations when (a) was used as a criterion for physiological maturity at the molecular level (to be published at a later date). (c) Immunoelectrophoresis of proteins from seeds of different sizes with antisera developed from known mature seeds showed no qualitative variations. Physiologically immature seeds show much variation in their immunoelectrophoretic patterns; this variation is especially noted during the early stages of development (N. J. Neucere and L. Y. Yatsu; ARS, USDA; personal communication, 1971).

COMPARISON OF THE CULTIVARS WITHIN AND BETWEEN PEANUT TYPES AND GEOGRAPHICAL LOCATIONS

The different cultivars examined from each peanut type and geographical location are shown in Table I. Cultivars representing the peanut types (Spanish botanical, and Virginia botanical and market types) grown in Georgia and Virginia were examined. Representatives of only the Spanish type grown in Texas and Oklahoma were studied. The protein variations observed in the Virginia 56R seeds grown in Louisiana also occurred within the other cultivars (Figures 13-64). This consistency of the protein variation within and between

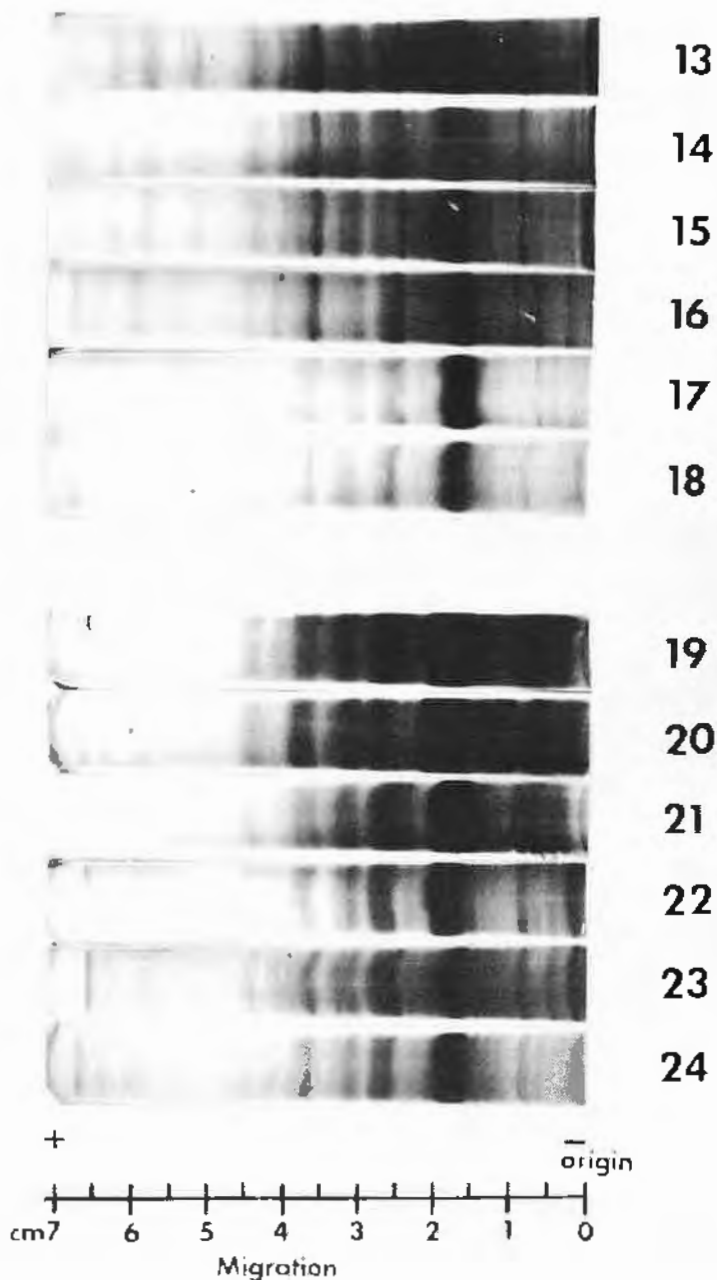


Figure 13-24. Protein electrophoretic patterns showing a representation of the cultivars of one type grown in Oklahoma and Texas. Fig. 13-18, Spanish botanical type (cultivars: Comet, Starr, Argentine and Spanhoma) from Oklahoma. - Fig. 19-24, Spanish botanical type (Cultivars: Comet, Starr and Argentine) from Texas.

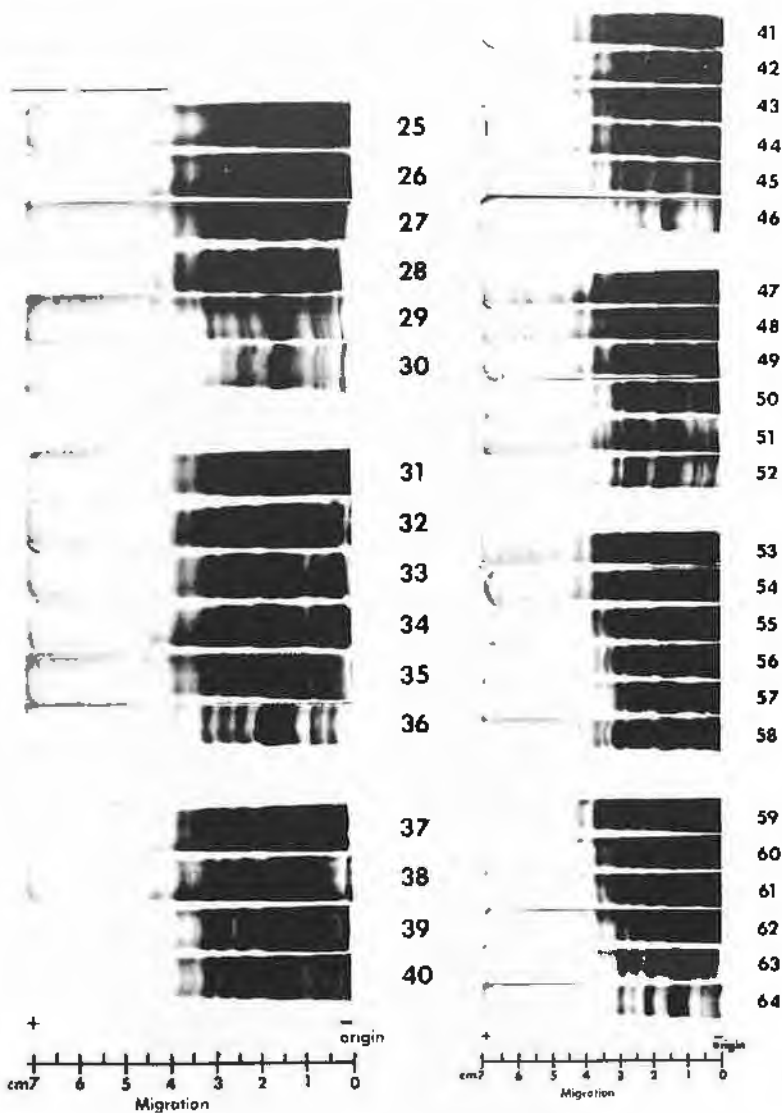


Figure 25-40. Protein electrophoretic patterns showing a representation of the cultivars of the different types grown in Georgia. Fig. 25-30, Spanish botanical type (cultivars: Tifspan, Starr, Argentine and Spancross). - Fig. 31-36, Virginia botanical type (cultivars: Early Runner and Florunner). - 37-40, Virginia market type (cultivar: Florigiant).

Figure 41-64. Protein electrophoretic patterns showing a representation of the cultivars of the different types grown in Virginia. Fig. 41-46, Spanish botanical type (cultivars: Tifspan and Starr). - Fig. 47-52, Virginia botanical type (cultivars: Early Runner, Florunner and Virginia Bunch 67). - Fig. 53-58, Virginia market type (cultivars: Virginia 61R, Florigiant, NC 17 and NC 5). - Fig. 59-64, Virginia market type (cultivars: Virginia 56R and NC 2).

the different cultivars made it difficult to clearly distinguish them electrophoretically. However, minor qualitative and quantitative variations in protein banding patterns partially distinguished some of the different cultivars within peanut types grown in one geographical location and between the peanuts grown in the different areas (summarized in Figures 65-87). Of most importance, major

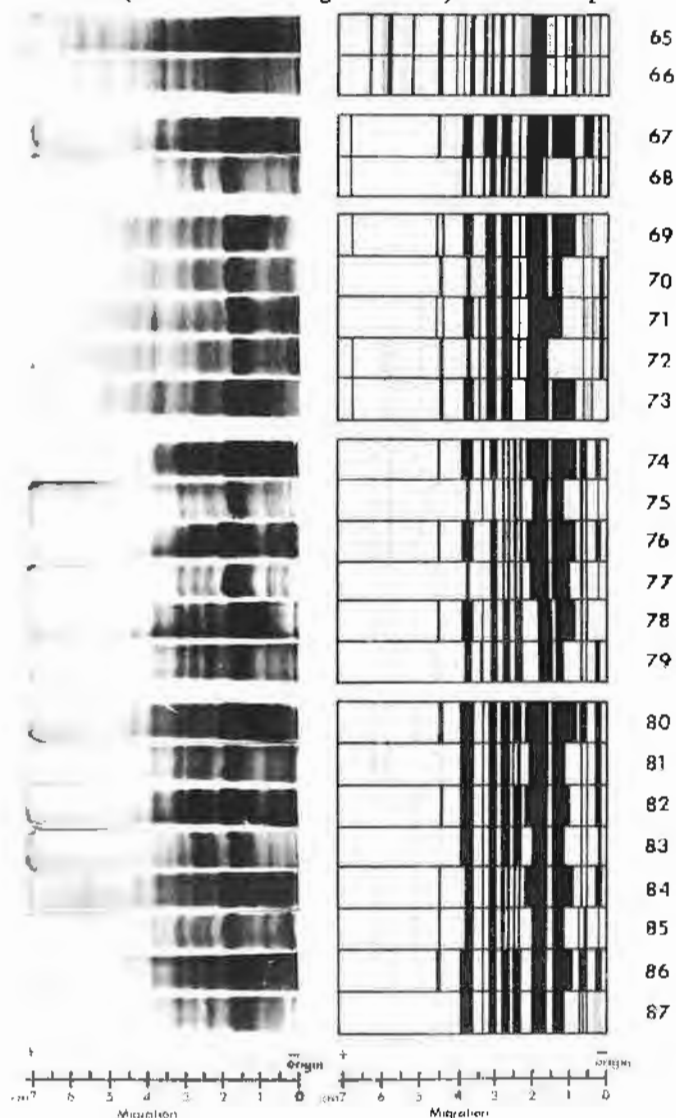


Figure 65-87. Protein electrophoretic and diagrammatic patterns showing a representation of the cultivars of the different types grown in the different geographical locations. Fig. 65-66, Oklahoma Spanish botanical type. - Fig. 67-68, Texas Spanish botanical type. - Fig. 69-73, Louisiana Virginia market type. - Fig. 74-75, 76-77, 78-79, Georgia Spanish botanical, Virginia botanical and Virginia market types, respectively. - Fig. 80-81, 82-83, 84-85, 86-87, Virginia Spanish botanical, Virginia botanical and Virginia market types, respectively and Virginia 56R and NC 2.

qualitative and quantitative protein banding differences between cultivars of the same peanut types grown in different geographical locations were noted. The following is a discussion of these data.

The protein content in the upper half of the polyacrylamide gels (region 0-4 cm) from individual seeds of the Oklahoma-grown cultivars (Figures 13-18; and 65-66) was quantitatively lower than that of peanuts grown in the other locations (Figures 19-64; and 67-87). The seeds from the Oklahoma-grown cultivars produced protein banding patterns similar to the Group IV gels of Virginia 56R grown in Louisiana (Figures 10-11), i.e., the slower moving arachin band in region 0.5-2 cm was quantitatively low or absent. This region (0-4 cm) in the gels of the Oklahoma peanuts contained a number of minor bands not clearly shown in most of the banding patterns of the other cultivars.

In contrast to this low protein concentration observed in region 0-4 cm for the Oklahoma cultivars, most of the peanuts from the other areas contained more protein in this region of the gel. The banding patterns of these latter cultivars were similar to Groups I, II, and III (Figures 19-64; 67-87; and 1-9). However, a few seeds of cultivars from the Spanish botanical type grown in Texas, Georgia, and Virginia, and the Virginia botanical type grown in Virginia produced protein patterns in region 0-4 cm similar to the Oklahoma peanuts (Figures 22-24; 29-30; 45-46; and 58).

The Oklahoma cultivars contained a greater amount and number of proteins in the lower half (4-7 cm) of the gel than peanuts grown in other regions (Figures 13-18; and 19-64). The protein patterns in the lower half of the gels of the latter cultivars were either unclear or similar to gels described in Group VI for the Louisiana-grown peanuts (Figures 19-64; and 1-12). In most cases, these electrophoretic patterns of Group VI were present mainly in the gels containing higher concentrations of proteins.

DEAE-cellulose fractionation and polyacrylamide gel electrophoretic examination of peanut proteins indicate that the molecules separated in the upper half of the gels are high molecular weight storage globulins (e.g., arachin and conarachin) and albumins (4). In addition, catalase and peroxidase activities are located in this region. These enzymes may account for some of the bands observed here. The proteins in the lower half of the gels are mostly enzymes (e.g., esterase and peroxidases) and low molecular weight proteins.

These electrophoretic studies indicate that peanuts from the Oklahoma region do not contain as much large molecular weight storage proteins as do the cultivars from Texas, Louisiana, Georgia, and Virginia. However, the former group seems to contain more low molecular weight proteins and/or enzymes.

Oklahoma peanuts are grown in an environment characterized by declining temperatures during the latter part of the growing season (W. K. Bailey, personal communication). This type of environmental change was also noted in Virginia; especially during the last six weeks of the growing season. This drop in temperature may possibly reduce metabolic activity of the peanuts during maturation. The protein electrophoretic patterns suggest that the effects of declining temperatures on protein metabolic systems in maturing peanuts are more pronounced in the Oklahoma group. The declining temperatures could affect specific control mechanisms that regulate the expression of structural genes involved in the synthesis of large molecular weight storage proteins. An alternate explanation is that the Oklahoma peanuts may have a greater need for specific functional proteins than for storage molecules during germination.

Thomason (19) found that barley germinated at different temperatures contained basic proteins (histones) which differed when separated in polyacrylamide

gels. It was suggested that the electrophoretic variations observed for the histones might be an indication of specific basic protein changes necessary to control (genetic regulatory mechanisms) physiological processes unique at different temperatures. Substrate nutrient levels (e.g., P, Cu, Fe, N, and Mn) in the soil were shown to influence protein and enzyme banding patterns both qualitatively and quantitatively (22). These alterations were especially true for metal-containing enzymes (e.g., peroxidases and catalases).

Thus, in contrast to other seed studies (2, 7, 8, 13, 15, 25) in which only quantitative differences in total protein concentration (but not in electrophoretic patterns) were observed between plants grown in different geographical locations, these studies on peanuts show a number of distinct qualitative and quantitative variations in banding patterns. The environmentally induced electrophoretic changes in protein banding patterns observed by Thomason (19) and Van Lear and Smith (22) may play similar roles in the alterations observed with peanuts grown in different locations.

Recently, Cobb and Swaisgood (5) presented data showing that the amino acid and sugar compositions and the roasted flavor quality of peanuts are influenced by the growth environment (weather, soil types). Their conclusion was that high quality peanut cultivars developed under optimal experimental conditions by chemists and plant breeders may not grow and reproduce as well under the different environmental conditions at the various planting sites. Thus the environment, rather than genetics, may be the primary determinant of quality. Studies concerning polyacrylamide gel electrophoresis of peanut proteins also indicate the importance of the environment on the protein composition of the different cultivars. Perhaps the amounts and types of peanut proteins can be manipulated in certain cultivars by altering their environment (i.e., irrigation, soil types and the amount and kinds of nutrients). Biochemical studies are needed to understand the relationships of the environment to the genetics, physiology and molecular composition of the peanut.

Seeds of cultivars from the three peanut types grown in Georgia and Virginia were compared. In all of these cultivars examined, qualitative and quantitative banding variations were observed which were similar to those present in region 0.5-2 cm of the Virginia 56R peanuts grown in Louisiana (Figures 69-87; and 1-12). However, minor quantitative and qualitative variations in region 2-3 cm suggested some differences between the cultivars of the different peanut types. Three distinct major bands were consistently present in this region for the Virginia market cultivars grown in Georgia (Figures 78-79). The gels of peanuts from the other two types (Spanish and Virginia botanical) of this latter area showed five distinct bands in region 2-3 cm (Figures 74-77). Within the Virginia-grown group, the Spanish and Virginia botanical type peanuts showed three distinct bands in region 2-3 cm, while the cultivars of the Virginia market type had five bands (Figures 80-85). However, two cultivars of the Virginia market type grown in Virginia (NC2 and Virginia 56R) had three distinct bands in this region (Figures 86-87). Comparison of Virginia 56R from Virginia to that grown in Louisiana showed distinct differences in region 2-3 cm (Figures 69-73; and 86-87). The slowest moving protein band of this region in the latter cultivar was quantitatively lower than that of the former seeds. These data indicate that some electrophoretic distinctions can be made between cultivars from different peanut types grown in a particular geographical location. However, these distinctions are not consistent between geographical locations and therefore interpretations of chemotaxonomic data by polyacrylamide gel electrophoresis of peanut proteins are difficult and uncertain. In addition, the presence of the different gel patterns

observed for Virginia 56R grown in Louisiana (Figures 1-12) within all of the cultivars by this biochemical technique.

The physiological importance of proteins and enzymes and their relationship to the molecular variation or stability within and between species of plants has been discussed by Gillespie and Kojima (9). They compared the degree of genetic variability in broad substrate-specific enzymes (e.g., esterases, alcohol dehydrogenase and acid phosphatase) to those with a limited substrate specificity (e.g., enzymes involved in energy metabolism). It was apparent in this study that enzymes of the former group exhibited much more variation than did the latter. Thus, the physiological importance of an enzyme, or of proteins in general, and the effects of the external and internal environment on these molecules can evidently play a role in determining the degree of variation present within a plant. Similar conclusions are indicated from the present studies on peanut proteins and from preliminary investigations of selected enzymes from the different cultivars (to be published at a later date).

Earlier genetic investigations (10) indicated that cultivated peanuts of *A. hypogaea* contain little variability and, for all practical purposes, were considered to be 100 percent inbred. Other studies revealed that these cultivated varieties are tetraploids ($4n=40$). In an electrophoretic comparison of seed proteins from recently synthesized and natural allopolyploids to synthetic mixtures of their possible parents, Cherry et al. (1, 2) indicated that evolutionary changes (e.g., gene mutation, diploidization and/or species-specific regulatory control mechanisms) in the genetic makeup for seed development may have occurred in these species of the genus *Gossypium*. It was suggested that the extent of the genetic changes within these allopolyploids depended upon the length of time that they have existed and the selective pressures to which they have been exposed. Changes such as these can continue to occur within the allopolyploids because the duplicated segments from the other genome can continue to produce materials for survival. Thus, new and improved genetic types can arise within the population and be selected. Since the peanut cultivars have been suggested to be tetraploids, similar evolutionary processes could explain some of the protein variations observed here.

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EFFECT OF GROWTH REGULATORS ON VEGETATIVE AND REPRODUCTIVE CHARACTERISTICS OF SIX PEANUT GENOTYPES 1

by

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ABSTRACT and PAPER

Excessive vine growth makes disease control and harvesting of peanuts (*Arachis hypogaea* L.) more difficult and possibly reduces yield due to channeling of energy into vegetative rather than reproductive growth. The crop is also subject to harvesting losses resulting from a breakage or disintegration of the peg (gynophore) that attaches the fruit to the plant.

In this study three peanut varieties and three experimental lines were treated with the growth regulators Kylar (succinic acid 2,2 dimethylhydrazide) and TIBA (2,3,5-triiodobenzoic acid) at two rates in greenhouse and field trials conducted at Gainesville, Florida in 1970. Effects were measured on cotyledonary lateral branch length, main stem height, internode length, peg strength, seed quality, and yield.

Cotyledonary lateral branch length, main stem height, and internode length were reduced by the use of Kylar and to a lesser extent by TIBA. However, the reduced vegetative growth was more pronounced in certain genotypes than in others. Both Kylar and TIBA were effective in producing darker green foliage but neither chemical had a significant effect on peg strength or yield. Effects on seed quality and seed vigor were inconsistent.

INTRODUCTION

Problems associated with peanut production have resulted in interest in the growth regulators, Kylar (succinic acid 2,2-dimethylhydrazide) and TIBA (2,3,5-triiodobenzoic acid). Both of these substances act as antiauxins (1,3,7), thereby giving several reported effects on peanut development. Kylar and TIBA have been reported to increase the strength of peg (gynophore) attachment (8), decrease vine growth (3,4,11) and increase yield (3,5,8,11). However, Cox(5) also reported no significant differences in yield in other tests. Brittain (3) found that Kylar treated plants, in addition to having shorter stems, had shorter and larger diameter internodes, greener leaves, and higher chlorophyll concentrations than control plants.

It has been observed for some time that one of the factors responsible for reduced peanut yields, especially with the large podded Virginia-type varieties, is the loss of pods during harvesting. Whitney and Porterfield (13) reported an 8.1% yield loss during peanut harvesting. Beasley (2) found total harvesting losses ranging from 5% to 35% and the below ground loss accounted for 56% of the loss. Large vines often hinder harvesting, as well as possibly reducing yields

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due to high energy utilization which is channeled into vegetative rather than reproductive growth. Hodges and Perry (8) reported that Florigiant peanuts treated with Kylar had lower pod losses and less defoliation before harvest. They stated that Kylar may result in better pod retention and higher yields for varieties having poor pod retention characteristics.

If Kylar and TIBA could help to correct the above unfavorable aspects of peanut production, higher net yields could result. The objectives of this study were to determine the effects of the growth regulators, Kylar and TIBA on plant height, cotyledonary lateral branch length, strength of peg attachment, and on the yield and quality of six different peanut genotypes.

MATERIALS AND METHODS

Greenhouse and field experiments were conducted at Gainesville, Florida, during 1970. The six varieties and experimental lines used in the experiments were chosen because of their variation in plant, pod, and peg characteristics as follows: Florigiant with a runner growth habit, has deep pegging, medium weak pegs, and large pods; Early Runner and Florunner have runner plant growth habit with moderately strong pegs and small pods; UF 69304 has spreading bunch growth habit with intermediate size pods and strong pegs; UF 69313 has small bunch plants with weak pegs and very large pod size; and UF 69115 has spreading bunch growth, large pods and weak pegs. The peg strength classifications above are based on several years of visual observations concerning the relative numbers of pods that separated from the plant and remained in the field at harvest time.

The growth regulators Kylar and TIBA were applied on the greenhouse experiment and field plots at the specified dates and rates as follows:

Kylar: Rate 1: 1122 gm/ha applied at 60 days after planting or at full bloom

Rate 2: same as rate 1 plus 561 gm/ha applied 30 days after the 1122 gm application

TIBA: Rate 1: 74 gm/ha applied 30 days after planting or at approximately 10% bloom

Rate 2: 74 gm/ha applied in three 25 gm applications 30, 40, and 50 days after planting or with the first application being applied at 10% bloom with the last two applications following the first at 10 day intervals

At harvest the length of the cotyledonary lateral branches and the main stems were measured in centimeters. Internode length was computed for the top (apical) 20 centimeters of branches and main stems, since the growth in this area would be most affected by chemical treatments. In both experiments peg strength was recorded in grams with the use of a "Hunter" mechanical force gauge, model L-5000, with a capacity of five kilograms. The gauge was mounted on a lever device designed and constructed to eliminate variation from one measurement to the next.

Analyses of variance were conducted on all data. Dunnett's Multiple Range test (6) was used to determine significant differences of treatments from controls. This procedure was used in preference to other standard tests, since these experiments were designed to compare the effect of chemical treatments with controls and not with other treatments.

Greenhouse Experiment

On March 24, 1970, UF 69304, UF 69313, and UF 69115 peanut lines were planted in pots on benches in a greenhouse at the University of Florida, Gainesville. Four seeds were planted in each four gallon pot and later thinned to two plants per pot. There were six replications each consisting of 15 randomized treatments (pots).

Kylar and TIBA were sprayed on the plants at the specified rates. Due to delayed plant development, the greenhouse applications were delayed until 15 days after the normal field application dates. However, the treatment application dates in the greenhouse adhered to the stage of flowering alternatives given above. Rate 1 of TIBA was applied on May 8, 1970, while rate 2 was applied on May 8, 18, and 28, 1970. The plants were sprayed with Kylar, rate 1 on May 28, 1970; rate 2 was applied on May 28 and June 27, 1970.

When the plants were small, Kylar and TIBA were applied with a DeVilbiss atomizer. As plant size increased a back-pack sprayer was used to make the applications. The greenhouse study was harvested during the period July 20 to 23. The length of cotyledonary lateral branches and main stem heights were taken and the breaking strength of 10 mature pegs from each plant was recorded. These pods and any mature pods remaining on the plant were removed and air dried. The dried peanuts were then shelled, and the seed counted and weighed. Germination percentage of the seed was determined during the period September 11 to 18, 1970.

Field Experiment

A field experiment comprised of two tests (A and B) was planted May 6, 1970, on the Agronomy Farm at Gainesville, Florida. In test A the varieties Florunner, Early Runner, and Florigiant were planted. Six replications of the 18 treatments were arranged in a randomized block design. The plots contained two rows 91.5 cm apart and 6.6. meters long. Test B contained the same experimental lines as were used in the greenhouse experiment, UF 69304, UF 69313, and UF 69115. This test was planted in randomized block with five replications. The field experiments were grown to maturity using recommended cultural practices.

In the field experiments, the Kylar and TIBA treatments were applied with a back-pack compression sprayer equipped with a boom with four nozzles which covered two rows at one time. Rate 1 and the first application of Rate 2 of TIBA were applied on June 10, 1970. The second and third applications of Rate 2, TIBA were applied on June 20, and 30, 1970. Rate 1 and the first application of Rate 2, Kylar, were applied on July 5, 1970, while the second application of Rate 2 was applied on August 4, 1970.

Measurements were taken during the week of September 14-18, 1970. Four plants were measured from each plot with five pegs being tested for strength on each plant. The balance of the plants in each plot were then harvested. The peanuts were cured in windrows, machine picked, and the pods dried in a forced air drier prior to being weighed for yield. Two 200 gram sub-samples were taken from the bulk yield of each plot and graded. Duplicate germination tests were conducted on both field tests, February 8 and 18, 1971, respectively. In addition to numbers of viable seed, the numbers of seed with emerged radicle lengths of at least 25 mm were recorded. A viable seed is defined as having an emerged radicle length of six mm or more. Seed with radicles less than 25 mm long were considered to have low vigor.

RESULTS AND DISCUSSION

Peg Strength

Peg strength differences in the field trials were not significantly changed with the use of Kylar or TIBA at the rates used and no trends were observed (Table 1). Significant differences in peg strength were found among the genotypes. Florunner and Early Runner are known to have relatively low pod losses in the field. The relatively high peg strength values obtained for the Florunner control (1,000 gm) is likely a factor in causing low field losses. Although Early Runner had a relatively low peg strength of 750 gm for the control its smaller pod size, which offers less resistance as it is pulled from the soil, probably compensates for its low peg strength.

According to the control, Florigiant has strong pegs with 1,080 gm strength. However, in the field, it has generally been considered to be weak pegged in that large pod losses often occur during harvesting. These losses may be due to its deep pegging zone and large pods.

Although the differences were not statistically significant, the peg strength of line UF 69304 in the greenhouse was most responsive to all rates of growth regulator treatments and particularly rate 2 of TIBA (Table 1). Past observations showed that UF 69304 has had low pod loss in the field and as a result had been considered a line with strong pegs. However, in this experiment peg strength was found to be lower for the control of UF 69304 than for the other lines. Possible reasons for this may be that the intermediate pod size of this line offers less resistance as it is pulled from the soil, it has an inherently tough peg, and the different environmental conditions in the greenhouse as compared to the field. When a variety has good peg strength, it may be reasonable not to expect much increase in peg strength from the use of growth regulators.

Line UF 69115 has at times had considerable loss of pods in the field which was attributed to its weak pegs. Results in the greenhouse indicated that the control plants of this line, however, had the highest peg strength of the three lines. It may be possible that the field losses were due mainly to the increased surface area of its large pods rather than to weak pegs. If this were the case considerable field losses could occur in spite of strong pegs. It should be noted that the second rate of TIBA gave the highest peg strength of UF 69115. Rates 1 and 2 of Kylar and rate 1 of TIBA may have been detrimental to the physiological processes affecting peg strength of UF 69115.

Branch Lengths, Main Stem Heights, and Internode Lengths

In field trials, Kylar significantly shortened the cotyledonary lateral branches for all genotypes and caused a shorter mean internode length for two of the experimental lines (Table 2). TIBA, at rate 2, significantly shortened the branches of Florunner and UF 69115 but not the other varieties. It should be noted that the branch internodes of lines UF 69304 and UF 69313 at rate 2 of TIBA were significantly shortened without a significant reduction in branch length. No explanation is at hand, but TIBA may have a tendency to increase the number of nodes. At rate 1 the effects of TIBA were not significant. In no case did TIBA show a significant effect on internode lengths of the lateral branches in the field trials. Significant differences in mean branch lengths were found among genotypes. Florigiant had the longest branches and UF 69313 had the shortest.

Some significant reductions in the branch and internode length of the

cotyledonary laterals were found in the greenhouse study (Table 2). The internode length of line UF 69304 was highly significantly (.01) reduced when the highest rate of TIBA was applied. Significant reductions in the mean branch length of experimental line UF 69313 occurred for three of the chemical treatments. Kylar at rate 1 produced the shortest branches with a length of 28.7cm as against the control length of 38.4 cm. Both rates of Kylar and TIBA produced highly significantly shorter internodes than the control which was 2.78 cm in length. Significant (.05) shortening of branches for line UF 69115 occurred for rates 1 and 2 of Kylar. TIBA had very little effect on the branch length of this line and neither chemical had a significant effect on the internode length.

In the field trials Kylar and TIBA caused significant reductions in the main stem height of Florunner, Florigiant, and UF 69115 but not of the other genotypes (Table 3). Kylar at rate 2 reduced internode length in the same genotypes while TIBA at rate 2 affected only Florigiant.

In the greenhouse, significant differences were recorded for main stem height and internode length of UF 69313 (Table 3)). Experimental line UF 69304 showed no significant difference in main stem height but rates 1 and 2 of TIBA gave significant reductions in mean internode length to 1.48 cm and 1.51 cm, respectively, while the control obtained 1.90 cm in internode length. Experimental line UF 69115 showed no significant differences in main stem height or internode length for any of the chemical treatments. The vegetative growth of line UF 69313 gave a greater response to Kylar and TIBA than either of the other two lines.

Reductions in vegetative growth of the peanuts in these trials caused by Kylar and TIBA were similar to those reported by Brittain (3), and McGill (11). This effect may be due to increased calcium concentrations in the stems. Other workers reported that stem and cell elongation is reduced as Kylar (3,8) or TIBA (9) induced calcium increases. The reductions in growth caused by TIBA may also result from its antiauxin effect in which the activity of growth promoting auxins is lowered (7) or may be caused by an inhibition of auxin transport (10). Reductions in main stem height occurred but were somewhat inconsistent. The results sometimes showed no correlation between decreases in branch and stem lengths with internode lengths.

The darker green color observed in the treated plants in all the tests may be due to increased chlorophyll concentrations caused by a higher rate of carbon dioxide assimilation and greater photosynthetic efficiency as proposed by Brittain (3) or to an increased concentration of nitrogen in the smaller plants. It was observed that TIBA caused curling and the development of a few small, dark brown to black spots on the leaves within a week after application but these abnormalities disappeared later.

Seed Quality

Rate 1, Kylar, significantly increased the percentage of shriveled seed of Early Runner and UF 69115 while rate 1 of TIBA gave a decrease for UF 69304 (Table 4). No effects were observed on the other genotypes. The growth regulators had no significant effect on the percentage of damaged seed or on the percent of extra large kernels for any of the genotypes and thus these data are not presented.

Kylar at rate 1 significantly reduced the sound mature kernels (SMK) of

Florunner while TIBA at rate 1 significantly increased the SMK of UF 69304 (Table 4).

Kylar at rate 2 caused significant reductions in the 100-seed weight of Florunner and Florigiant (Table 4). No effects were noted from the other treatments nor were the four remaining genotypes influenced by the chemicals. It is not known why occasional differences were observed in seed quality characteristics for these varieties and lines. However, residues of TIBA have been found to accumulate in soybean seed (12) and a similar accumulation may result under certain conditions with peanuts.

Germination of the greenhouse seed was reduced 17% by rate 2, Kylar, in line UF 69304 and 15% in line UF 69115 (Table 5). This reduction is not easily explained; however, Kylar, at the increased rate of application may have some detrimental chemical or physiological effect on the germination processes which may be related to residuals of the chemicals in the seed.

In the field trials, TIBA at rate 2 gave a significant increase in the percentage of viable seed of Florunner but none of the treatments affected the viability of the seed of the other genotypes. Kylar significantly reduced the seed vigor of the three named varieties while TIBA reduced only Early Runner (Table 5). It is not known why an insignificant trend toward increased vigor was observed for the experimental lines. Inherent genetic differences in the response of these lines to the chemicals may account for the upward trend in vigor.

The observations of growth regulator effects on seed quality in this study bear out McGill's (11) concern for the effect of Kylar on seed peanuts and emphasizes the need for more research in this regard.

Yield

Peanut yields in the greenhouse and field trials were not significantly affected nor were there any consistent trends following the use of Kylar and TIBA. The mean yield for the six genotypes in the field trial was 3638 kg/ha of unshelled pods. The Kylar treated peanuts averaged 1.8% more yield than the controls while the TIBA treated peanuts averaged 3.5% less yield than the controls. Wide responses to growth regulators have been reported by other researchers. Most of the failures to increase yield by the use of Kylar in these experiments agree with Brittain's (3) results. The yield results obtained from TIBA in these trials agreed with Cox (5), when he reported no significant increase in yields.

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TABLE 1. EFFECT OF GROWTH REGULATORS ON PEG STRENGTH OF PEANUTS IN FIELD AND GREENHOUSE TRIALS, 1970.

Variety or Experimental Line	Treatment Chemical Rate ^a		Mean strength per peg (gm) ^b	
			Field	Greenhouse
Florunner	Kylar	1	950	
		2	1110	
	TIBA	1	1030	
		2	1040	
	Control	0	1000	
Early Runner	Kylar	1	780	
		2	820	
	TIBA	1	690	
		2	780	
	Control	0	750	
Florigiant	Kylar	1	1070	
		2	1040	
	TIBA	1	1060	
		2	1060	
	Control	0	1080	
UF 69304	Kylar	1	970	853
		2	980	814
	TIBA	1	960	823
		2	870	891
	Control	0	970	769
UF 69313	Kylar	1	1030	759
		2	1000	837
	TIBA	1	950	744
		2	1020	905
	Control	0	1050	804
UF 69115	Kylar	1	1230	878
		2	1220	849
	TIBA	1	1160	854
		2	1040	954
	Control	0	1100	909

^a Kylar 1 = 1122 gm/ha; 2 = 1683 gm/ha in split applications.
TIBA 1 = 74 gm/ha; 2 = 74 gm/ha in split applications.

^b Force required to detach pods from plant - differences were not significant at .05 level when compared with control.

TABLE 2. EFFECT OF GROWTH REGULATORS ON COTYLEDONARY LATERAL BRANCHES OF PEANUTS IN FIELD AND GREENHOUSE TRIALS, 1970.

Variety or Experimental Line	Treatment Chemical	Rate ^a	Mean branch length (cm)		Mean internode length (cm) ^b	
			Field	Greenhouse	Field	Greenhouse
Florunner	Kylar	1	75.6**		3.74	
		2	71.9**		3.61	
	TIBA	1	81.3	4.04		
	Control	0	76.4**		3.88	
Early Runner	Kylar	1	78.5**		3.37	
		2	78.4**		2.83	
	TIBA	1	83.6	3.26		
	Control	0	84.2	3.49		
Florigiant	Kylar	1	91.3	4.31		
		2	83.9**	3.77		
	TIBA	1	101.0	4.21		
	Control	0	94.0	4.71		
UF 69304	Kylar	1	54.1	29.6	2.42*	2.34
		2	48.6**	30.0	2.30**	2.24
	TIBA	1	54.0	31.5	2.93	2.00
	Control	0	52.4	30.3	2.88	1.88**
UF 69313	Kylar	1	54.0	28.7**	3.48	2.17**
		2	47.2*	30.8**	2.45**	2.07**
	TIBA	1	57.8	32.2**	3.46	2.01**
	Control	0	56.5	33.8	3.58	2.03**
UF 69115	Kylar	1	64.4**	26.9*	2.98	1.83
		2	60.7**	26.7*	2.87	1.82
	TIBA	1	68.7	31.7	3.13	1.86
	Control	0	66.9*	31.5	3.29	1.53

^a Kylar 1 = 1122 gm/ha; 2 = 1683 gm/ha in split applications, TIBA 1 = 74 gm/ha; 2 = 74 gm/ha in split applications.

^b Measured in a 20 cm section of apical end of branch.

* Significant at .05 level from control.
** Significant at .01 level from control.

TABLE 3. EFFECT OF GROWTH REGULATORS ON MAIN STEM HEIGHT AND MAIN STEM INTERNODE LENGTH OF PEANUTS IN FIELD AND GREENHOUSE TRIALS, 1970

Variety or Experimental Line	Treatment Chemical	Rate ^a	Mean main stem height (cm)		Internode length (cm) ^b	
			Field	Greenhouse	Field	Greenhouse
Florunner	Kylar	1	44.3		1.56	
		2	38.4**		1.25*	
	TIBA	1	45.7		1.57	
	Control	0	40.1*		1.73	
Early Runner	Kylar	1	44.5		1.70	
		2	41.4		1.35	
	TIBA	1	51.2		1.70	
	Control	0	47.7		1.59	
Florigiant	Kylar	1	49.7**		2.12	
		2	49.1**		1.77**	
	TIBA	1	59.0		2.25	
	Control	0	52.7*		2.02**	
UF 69304	Kylar	1	41.8	28.8	1.82	1.82
		2	35.3	29.8	1.56	1.80
	TIBA	1	39.1	29.4	2.00	1.48*
	Control	0	36.0	29.5	2.15	1.51*
UF 69313	Kylar	1	45.5	30.2**	2.85	1.79**
		2	39.2	30.8**	1.99	1.71**
	TIBA	1	51.7	30.7**	2.98	1.76**
	Control	0	47.6	31.8**	2.66	1.75**
UF 69115	Kylar	1	45.1*	24.7	1.69	1.36
		2	43.3**	25.3	1.64*	1.43
	TIBA	1	45.9*	27.7	1.93	1.43
	Control	0	45.8*	27.1	1.85	1.20

^a Kylar 1 = 1122 gm/ha; 2 = 1683 gm/ha in split applications, TIBA 1 = 74 gm/ha; 2 = 74 gm/ha in split applications.

^b Measured in a 20 cm section of apical end of branch.

* Significant at .05 level from control.
** Significant at .01 level from control.

TABLE 4. EFFECT OF GROWTH REGULATORS ON SHRIVELED SEED SOUND MATURE KERNELS, AND SEED WEIGHT OF PEANUTS IN FIELD TRIALS, 1970.

Variety or Experimental Line	Treatment		Shriveled Seed %	Sound mature kernels %	Weight per 100 seed (gm)
	Chemical	Rate ^a			
Florunner	Kylar	1	7.7	67.7*	59.1
		2	8.3	69.6	58.4
	TIBA	1	6.2	71.6	63.1
		2	7.0	71.8	62.7
	Control	0	7.3	71.1	63.0
Early Runner	Kylar	1	9.9*	66.3	48.5
		2	9.4	65.7	48.2
	TIBA	1	7.0	69.3	49.0
		2	8.0	68.4	51.1
	Control	0	8.0	67.2	50.8
Florigiant	Kylar	1	2.6	70.8	94.1
		2	2.8	72.0	87.9**
	TIBA	1	2.2	72.4	94.6
		2	2.9	71.0	91.0
	Control	0	2.6	71.7	96.3
UF 69304	Kylar	1	5.4	61.5	76.7
		2	3.8	62.2	73.8
	TIBA	1	2.7*	67.9**	81.8
		2	4.5	64.9	79.1
	Control	0	4.4	60.9	79.8
UF 69313	Kylar	1	2.6	60.9	98.4
		2	2.0	60.5	100.4
	TIBA	1	2.3	63.4	103.8
		2	1.8	64.2	100.6
	Control	0	2.1	62.0	98.2
UF 69115	Kylar	1	4.9*	66.1	90.1
		2	3.8	69.0	88.7
	TIBA	1	4.8	69.0	92.1
		2	3.2	65.8	94.0
	Control	0	3.2	71.5	93.5

^a Kylar 1 = 1122 gm/ha; 2 = 1683 gm/ha in split applications.
TIBA 1 = 74 gm/ha; 2 = 74 gm/ha in split applications.

* Significant at .05 level from control.

** Significant at .01 level from control.

TABLE 5. EFFECTS OF GROWTH REGULATORS ON THE VIABILITY AND VIGOR OF GERMINATING PEANUT SEED IN FIELD AND GREENHOUSE TRIALS, 1970

Variety or Experimental Line	Treatment		Greenhouse		Field	
	Chemical	Rate ^a	% viable seed		% viable seed	% seed with strong vigor ^b
Florunner	Kylar	1			95.8	30.0
		2			97.0	22.0*
	TIBA	1			96.3	17.0**
		2			92.3*	27.0
	Control	0			95.8	34.5
Early Runner	Kylar	1			98.0	16.0**
		2			96.8	18.0**
	TIBA	1			98.3	25.5*
		2			100.0	25.5*
	Control	0			99.3	30.3
Florigiant	Kylar	1			98.8	34.3**
		2			99.5	33.0**
	TIBA	1			99.5	61.3
		2			92.5	52.5
	Control	0			99.5	55.0
UF 69304	Kylar	1	91.5		94.5	17.5
		2	81.6**		84.5	19.5
	TIBA	1	98.2		89.5	39.5
		2	92.8		87.0	21.5
	Control	0	98.2		86.5	19.5
UF 69313	Kylar	1	87.0		90.0	45.5
		2	85.1		88.5	33.5
	TIBA	1	98.6		88.5	38.5
		2	94.0		90.0	36.0
	Control	0	94.4		90.5	31.5
UF 69115	Kylar	1	95.5		94.0	41.5
		2	83.5*		94.5	44.0
	TIBA	1	100.0		95.5	48.5
		2	97.9		94.5	43.5
	Control	0	97.8		96.0	35.0

^a Kylar 1 = 1122 gm/ha; 2 = 1683 gm/ha in split applications.
TIBA 1 = 74 gm/ha; 2 = 74 gm/ha in split applications.

^b Strong vigor are seeds with radicle length of at least 25 mm.

* Significant at .05 level from control.

** Significant at .01 level from control.

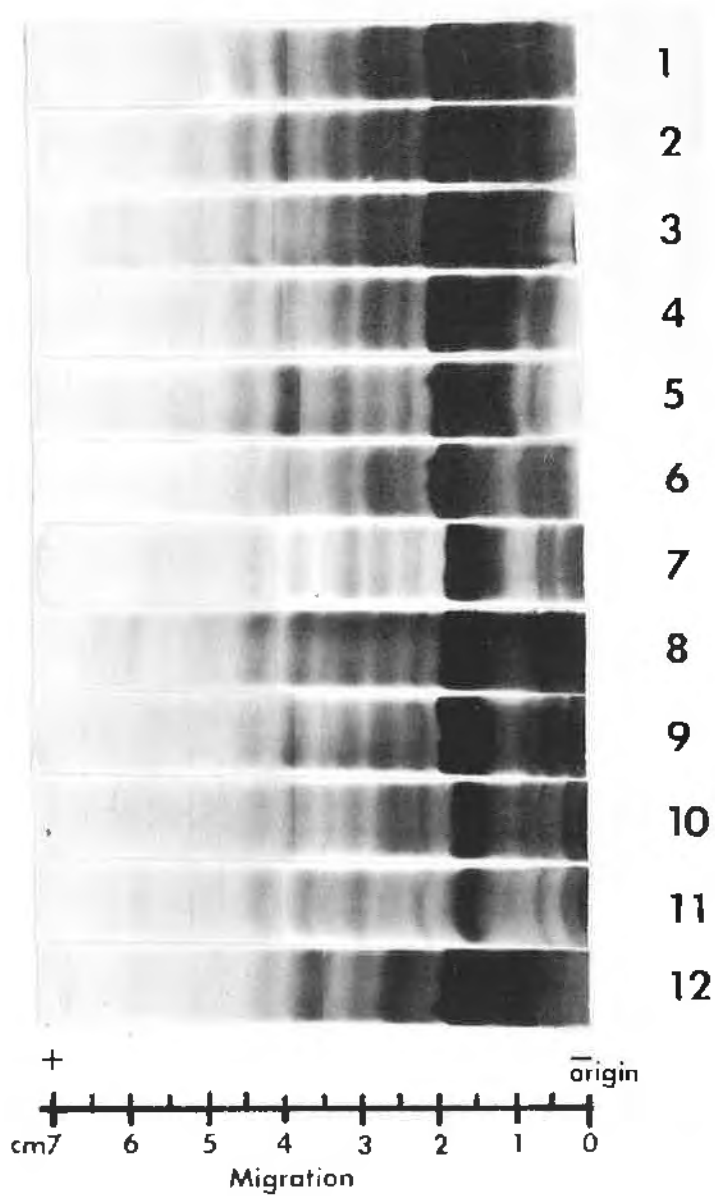


Figure 1

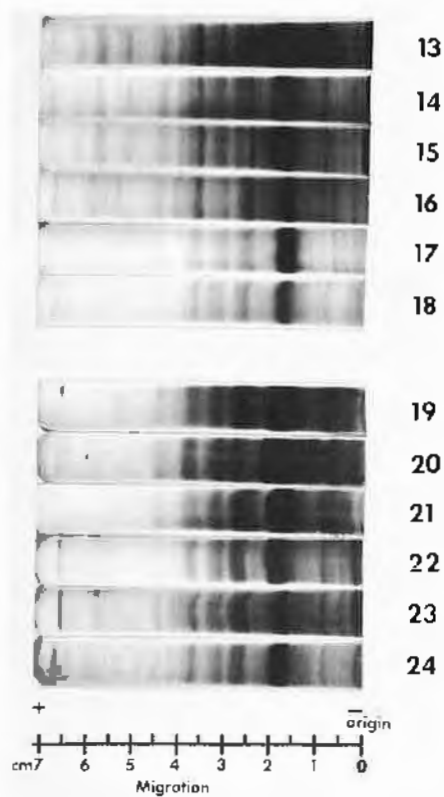


Figure 2

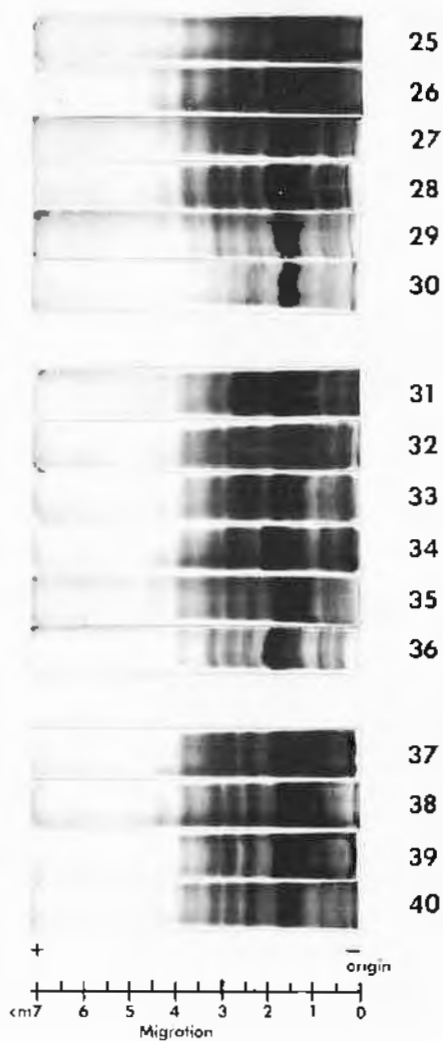


Figure 3

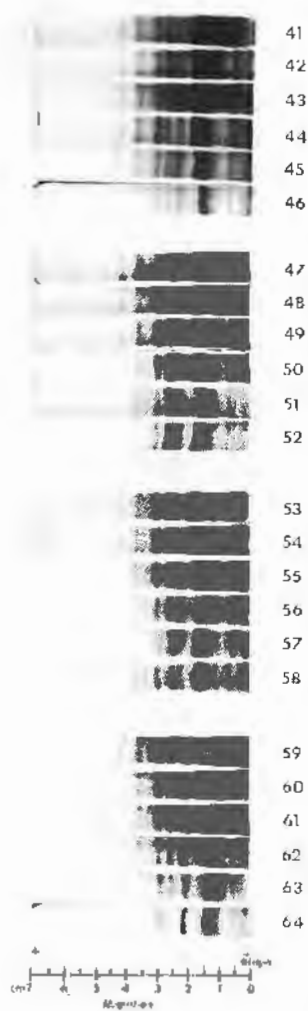


Figure 4

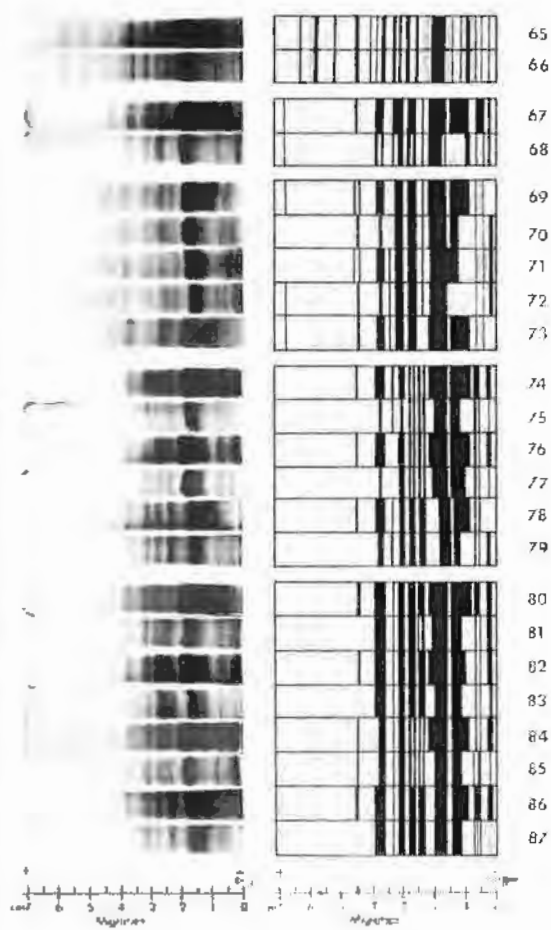


Figure 5

EFFECT OF SOIL pH AND CALCIUM SOURCES ON YIELD, GRADE AND MINERAL COMPOSITION OF VIRGINIA BOTANICAL TYPE PEANUTS 1

by

Euro A. Bracho, E. B. Whitty, W. G. Blue and A. J. Norden 2

ABSTRACT and PAPER

Field and greenhouse experiments were conducted to determine the response of peanut varieties to sources of Ca. Florunner and Florigiant varieties were grown in the field study and Florigiant and NC-17 in the greenhouse study. Calcium sources were gypsum, Magi-cal spray and Magi-cal dust in the field experiment and gypsum, Magi-cal spray and Claw-El Calcium, a chelated Ca compound, in the greenhouse. Three soil pH values were established for the greenhouse study.

Yield, grade and mineral composition of various plant parts were measured. No significant differences among Ca sources were found in yield and grade of peanuts; but gypsum increased Ca and Mg, and decreased P and K contents of various plant parts. Significantly lower levels of Mg and greater levels of Ca were found in post-harvest soil samples following gypsum application. Soil pH levels significantly affected the yield of kernels and vines and the mineral composition of the plants. A positive linear correlation between yield of vines and kernels was found. There were significant differences among varieties in yield, grade and mineral composition.

INTRODUCTION

Calcium has a marked effect on peanut yield and quality. Gypsum (29% Ca) has been the primary source of Ca for emerged peanuts. Other products have recently become available for supplying Ca to the peanut plant. Magi-cal and Claw-El Calcium are trade names of two new products. In general, the manufacturers' recommended rates of the new materials supply much less Ca than the normally used rates of gypsum.

Colwell and Brady (2) found that gypsum at 448 kg/ha exerted a marked beneficial effect on yield and grade of large-seeded peanuts, especially on soils with low Ca levels. Gypsum did not increase either yields or percent of filled pods on soils containing 280 ppm as much as it did on soils with lower Ca values. Middleton et al. (10) found that yield and kernel development of a Virginia bunch variety were significantly increased when gypsum was applied. The largest increase in yield was obtained when the soil level of Ca was 42 ppm and was least marked when the content was 230 ppm.

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"Hollow heart" and "black heart" are forms of concealed damage in peanut kernels. Applications of Ca from gypsum or hydrated lime decreased black heart considerably and hollow heart moderately (3, 13). Calcium applications have been reported to increase the Ca content of roots and tops (12), shells (9) and kernels (6).

The objective of this study was to determine the effect of gypsum, Magi-cal and Claw-El Calcium on different varieties of peanuts grown at different soil pH levels.

METHODS AND MATERIALS

Field Experiment

This experiment was carried out on the Agronomy Farm at the University of Florida during the 1970 season. The soil was Arredondo fine sand with chemical characteristics as shown in Table 1. The design was a split plot with eight treatments and four replications. The varieties Florunner and Florigiant were the main plots and four Ca sources (gypsum, Magi-cal dust, Magi-cal spray and control), the sub-plots. Plots consisted of two rows spaced 91.5 cm apart and were 6 m long. Gypsum was applied by hand over the row in a band 40.6 cm wide on June 19 at 896 kg/ha. Magi-cal dust was mixed with dry sand and applied by hand over the pegging zone on June 19 and 26, July 3, 10, 17, 24 and 31, and on August 7 at the rate of 8.4 kg/ha per application. Magi-cal spray was applied by a knap-sack sprayer on the same dates as Magi-cal dust at the rate of 4.65 l/ha per application. Total Ca applied was 260, 20 and 32 kg/ha for gypsum, Magi-cal dust and Magi-cal spray, respectively.

The peanuts were planted on May 6, 1970 and spaced 7.6 cm apart in the row. Rainfall was evenly distributed during the peanut growing season. Fertilization consisted of 11.2 kg/ha of N; 9.8 of P, 37.2 of K, and 22.4 of FTE 503 broadcast and disced in on April 20, 1970. Normal weed, insect and disease control measures were followed.

The peanuts were dug mechanically on September 9, 1970, sun-cured and picked on September 14 and 15, 1970. The unshelled fruit were dried and weighed.

TABLE 1

Chemical characteristics
of experimental soils

	Field experiment (Arredondo fine sand)	Greenhouse experiment (Lakeland fine sand)
Available phosphorus (ppm)	13.00	7.00
Cation exchange capacity (meq/100g)	2.01	1.45
Exchangeable cations (ppm)		
Calcium	296.00	250.00
Magnesium	42.00	20.00
Potassium	72.00	12.00
Soil reaction (pH)	6.8	5.6
Organic matter (%)	-	1.21

One week before harvesting, six plants per plot were selected at random and separated into roots, foliage, hulls and seed for mineral Analysis. Nitrogen was determined by the micro-Kjedahl method, P by the molybdenum blue method, K by flame photometry, and Ca and Mg by atomic absorption.

Shelling percentage and percentages of sound mature kernels, extra large kernels, shrivels and damaged seed were determined.

One week after harvest, soil samples were taken from the 0-15 cm depth in the pegging zone for chemical analyses.

Greenhouse Experiment

Florigiant and NC-17 varieties were used. Chemical characteristics of the soil, Lakeland fine sand, are shown in Table 1. The surface 15 cm of soil from a field area was screened and air-dried. Hydrated lime was added at the rate of 1.46 tons/ha to soil with an initial pH of 5.6. This resulted in a pH of 8.1. The limed and unlimed soils were then mixed and pH of 6.8 resulted. Thus, soils with pH values of 5.6, 6.8 and 8.1 were used.

Glazed clay pots were placed on greenhouse benches in a randomized complete block design with four replications. Four Ca treatments (gypsum, Magi-cal, Claw-El Calcium and the control) were used to each of the three soil pH levels and with each of the two varieties.

Five days before planting, 56 kg/ha of N, 24.4 of P, 69.7 of K and 33.6 of FTE 503 were mixed with the upper 7.6 cm of soil in each pot. Reagent grade chemicals were used.

On October 19 and 20, 1970, four seeds were planted in each pot and thinned to two uniform plants per pot on November 6, 1970. The plants were watered as needed with tap water. On December 6 and 7, 1970, Mg (50 ppm) in the form of reagent grade $MgSO_4$ was added when Mg deficiency symptoms were observed.

Gypsum was applied December 1, 1970 at 896 kg/ha. Claw-El Calcium was applied December 1, 1970 at 9.35 l/ha. Magi-cal spray was applied by a Devilbiss atomizer at 9.35 l/ha per application on December 1, 12 and 23, 1970 and January 3, 14 and 25, 1971. Total Ca applied was 260, 48 and 1.8 kg/ha for gypsum, Magi-cal and Claw-El Calcium, respectively.

Just prior to harvest on March 2-3, soil samples were taken to a 7.6 cm depth in each pot. Each plant was separated into foliage, roots and pods and oven-dried at 70 C. Dried pods were shelled by hand and weighed. Roots, foliage, hulls and seed were analyzed for P, K, Ca and Mg by the methods used for the field experiment.

Three post-harvest soil samples from the check treatment were analyzed for total nutrients. A 1 N NH_4OAc (pH 4.8) solution (7) and perchloric acid digestion were used for determining extractable cations and total nutrients (8).

RESULTS AND DISCUSSIONS

Field Experiment

There were no significant differences among treatments on the yield and quality of the two varieties. Gypsum and Magi-cal dust gave the highest and

lowest unshelled and sound mature kernel yields, respectively, for both varieties. Magi-cal dust gave the lowest percentage of extra large kernels.

Florunner produced a higher yield of unshelled kernels than Florigiant, 3690 and 3100 kg/ha, respectively. Florunner was superior in shelling percent, 77 versus 71. Florigiant had a lower percent of shrivels, 3.8 compared with 6.0 for Florunner.

Some significant differences were recorded between varieties in N and P content. Florigiant had more N (1.52%) and P (0.17%) in the roots than Florunner which had 1.31% N and 0.14% p.

There were significant differences among Ca treatments in the Ca content of the plants. Gypsum resulted in a higher Ca content of foliage and hulls (Table 2). This was probably due to the higher Ca rate applied. Florigiant had a higher Ca content in the roots (0.83%), while Florunner had more Ca in the seed (0.06%). The possible reason may be as reported by Hallock et al. (4) that genotypic differences in nutrient contents of plant parts occur. Also, there may have been a slight translocation of Ca from the roots into the pods (1, 11). There were no significant interactions between varieties and Ca sources.

Extractable Ca and Mg remaining in the soil after harvest are shown in Table 3. Calcium levels in control plots were higher than the 280 ppm value stated by Colwell and Brady (2) as critical for obtaining response in yield and quality to Ca applications. Soil Mg levels were lowest in plots that had received gypsum. This may have been due to displacement of much of the exchangeable Mg by mass action of the relatively large amount of Ca from the gypsum treatment which permitted leaching of Mg below the 15 cm sampling depth.

Greenhouse Experiment

No significant differences among Ca sources were found for root, top (stem and leaves) or kernel yields (Table 4). There was a highly significant positive correlation ($r = 0.65$) between yields of tops and kernels.

Highly significant differences were found in kernel yield as a result of the soil lime amendments (Table 4). A pH of 6.8 was superior to pH 8.1 and 5.6. However, pH 8.1 was superior to pH 5.6. There were significant differences among soil pH levels in yields of tops, with pH 6.8 producing a higher yield than pH 8.1 and 5.6. Although the effect of soil pH on root weights was not significantly the same order of magnitude was maintained for kernels as for tops.

Florigiant produced a significantly higher kernel yield than NC-17. There were no significant differences between varieties in yield of tops and roots (Table 4).

There were significant differences in the Ca content in the different plant parts of both varieties as influenced by Ca sources. Gypsum augmented the Ca content in the hulls and seed when compared with other treatments (Table 5). Since more Ca was applied in the gypsum, a higher Ca level was in contact with the pods during their formation, which should increase Ca assimilation (5, 11).

Magi-cal spray increased the Ca content of stem and leaf tissues when compared with Claw-El Calcium and the control (Table 5). Despite an attempt to remove all residues, some Magi-cal material may have remained on leaf

T A B L E 2

Mean calcium content (%) in stems and leaves and hulls of peanut as influenced by calcium sources. Field experiment. *

Calcium Source	Stem and Leaves	Hulls
Magi-cal dust	1.19 b	0.14 b
Magi-cal spray	1.15 b	0.14 b
Gypsum	1.25 a	0.17 a
Control	1.15 b	0.14 b

* Means within a column followed by different letters are significantly different from each other at the 0.01 probability level.

T A B L E 3

1N NH_4OAc (pH 4.8) extractable Ca and Mg (ppm) in post harvest soil samples as influenced by calcium sources. Field experiment. *

Calcium Source	Calcium	Magnesium
Magi-cal dust	315 a	31 b
Magi-cal spray	321 a	34 a
Gypsum	363 a	27 bc
Control	333 a	35 a

* Means within a column followed by different letters are significantly different at the 0.01 probability level.

TABLE 4

Mean yield (g/pot) of roots, tops and kernels as affected by calcium sources, soil pH, and variety. Greenhouse experiment. *

Calcium sources	Roots	Tops	Kernels
Control	6.1 a	15.8 a	13.9 a
Gypsum	6.0 a	16.2 a	14.9 a
Magi-cal spray	6.1 a	16.9 a	14.9 a
Claw-El Calcium	6.1 a	17.1 a	13.7 a
Soil pH			
5.6	5.5 a	15.0 b	11.6 c
6.8	6.5 a	18.3 a	16.8 a
8.1	6.2 a	16.3 b	14.7 b
Variety			
Florigiant	6.0 a	16.3 a	14.8 a
NC-17	6.2 a	16.7 a	13.9 b

* Means within a column for calcium sources, soil pH and variety followed by different letters are significantly different at the 0.05 probability level.

TABLE 5

Mean effect of calcium sources on calcium content (%) in different plant parts. Greenhouse experiment. *

Calcium sources	Roots	Stems and Leaves	Hulls	Seed
Control	1.09 a	1.96 c	0.18 b	0.08 b
Gypsum	1.10 a	2.05 bc	0.26 a	0.10 a
Magi-cal spray	1.02 a	2.11 ab	0.19 b	0.08 b
Claw-El Calcium	1.08 a	1.94 c	0.18 b	0.08 b

* Means within a column followed by different letters are significantly different at the 0.05 probability level.

surfaces. There was no evidence of greater translocation of Ca to the hulls and seed from the Magi-cal treatment.

Significant differences among soil pH levels were recorded for K content of foliage, hulls and seed and for P content of hulls and seed (Table 6). There were highly significant differences in Mg content of the different plant parts also occurred as a result of variable soil pH. Magnesium concentration was significantly higher in the roots and tops at pH 5.6 than at the other values. However, the reverse occurred for hulls and seed where the highest Mg content occurred at pH 8.1.

NC-17 had a higher P concentration in the hulls than Florigiant (Table 7). There were significant differences between varieties in the K content in different plant parts. NC-17 contained significantly more K in the roots, tops and hulls. The K content in seed was significantly higher for Florigiant. The NC-17 variety had a significantly higher content of Ca in the roots than Florigiant. However, Florigiant contained a significantly higher Ca content in the hulls and seed. A similar situation occurred in the field experiment. This seems to be additional evidence that there is negligible translocation of Ca from the roots to the pod (4, 5, 11). NC-17 contained significantly more Mg in stem-leaf tissues.

There were changes in soil pH values of the control plots during the experiment, with the soil at pH 5.6 and 6.8 increasing to 6.5 and 7.1 respectively. The original soil contained 625 ppm total Ca and the interval of 5 months between the first and last sampling suggested an increase in exchangeable Ca which would justify the post-harvest pH of 6.5. Also the tap water used for irrigation contained Ca and Mg. Thus the lack of differences between Ca sources in kernel yields may have been due to near adequacy of Ca in the native soil.

There were highly significant differences in extractable Ca as influenced by the source of Ca applied (Table 8) because of differences in the Ca content of the various sources.

Less extractable Mg (Table 8) was found in the plots where gypsum was applied. A similar pattern was found in the field experiment.

There were highly significant differences in extractable nutrients due to soil pH (Table 8). The P, Mg and Ca levels varied proportionally to soil pH, all being significantly higher at pH 8.1. More extractable Mg was present in the post-harvest samples than was present initially plus the quantity added as $MgSO_4$. The total Mg level after harvest (225 ppm) was much higher than the extractable Mg. It is possible that insoluble Mg may have been converted to a soluble form during the experiment.

Significant differences were found in P and Mg content of the hulls and the K content of the seed as a result of the different Ca sources. Gypsum significantly decreased P content in the hulls to the lowest level (0.06%). This indicated the possibility of reduced P solubility and absorption where Ca levels were high. Seed of plants treated with gypsum had significantly lower K content (0.60%) than all other treatments. The gypsum treatment gave the highest Mg content (0.19%).

TABLE 6

Mean effect of soil pH on phosphorus, potassium, calcium and magnesium content (%) in the roots, tops, hulls and seed of two peanut varieties. Greenhouse experiment. *

Soil pH	Roots				Stem and leaves				Hulls				Seed			
	P	K	Ca	Mg	P	K	Ca	Mg	P	K	Ca	Mg	P	K	Ca	Mg
5.6	0.13a	1.50a	0.75c	0.52a	0.13a	1.85b	1.82c	0.96a	0.08a	1.27a	0.16c	0.16b	0.38b	0.64a	0.08c	0.21b
6.8	0.14a	1.46a	1.03b	0.47b	0.13a	1.98a	1.96b	0.80b	0.06b	1.12b	0.20b	0.16b	0.35c	0.61b	0.09b	0.21b
8.1	0.14a	1.48a	1.43a	0.48b	0.14a	2.00a	2.27a	0.83b	0.06b	1.08b	0.24a	0.18a	0.40a	0.62b	0.10a	0.23a

* Means within a column followed by different letters are significantly different at the 0.05 probability level.

TABLE 7

Mean phosphorus, potassium, calcium and magnesium content (%) in the roots, tops, hulls and seed of two peanut varieties. Greenhouse experiment. *

Varieties	Roots				Stem and leaves				Hulls				Seed			
	P	K	Ca	Mg	P	K	Ca	Mg	P	K	Ca	Mg	P	K	Ca	Mg
Florigiant	0.13a	1.35a	1.03b	0.47b	0.14a	1.89b	2.00a	0.96a	0.06b	1.02b	0.21a	0.16b	0.38a	0.66a	0.09a	0.22a
NC - 17	0.13a	1.62a	1.12a	0.51a	0.13a	2.08a	2.03a	0.76b	0.08a	1.29a	0.19b	0.18a	0.37a	0.58b	0.08b	0.23a

* Means within a column followed by different letters are significantly different at the 0.05 probability level.

TABLE 8

Mean effect of calcium sources and soil pH on 1N HCl 0.4c (pH 4.8) extractable phosphorus, calcium and magnesium (ppm) in post-harvest soil samples. Greenhouse experiment. *

Calcium sources	Ca	Mg
Control	367 b	128 a
Gypsum	493 a	106 b
Hagl-cal spray	380 b	131 b
Claw-El Calcium	359 b	125 b

Soil pH	P	Ca	Mg
5.6	17 c	231 c	99 c
6.8	23 b	403 b	125 b
8.1	34 a	565 a	145 a

* Means within a column for calcium sources and soil pH followed by different letters are significantly different at the 0.01 probability level.

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PEANUT LEAF SPOT AND RUST CONTROL ON PEANUTS

by

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Peanut leaf rust (*Puccinia arachidis*) has become of increasing concern to the producers of fall peanuts in South Texas for the past several years. It was first reported in South Texas in 1941 by Ken Knight (4). A report on the rapid development of peanut leaf rust in Texas was presented by Harrison (2) in 1967 stating that peanut rust had caused economic losses in 1965 and 1966 on the fall crop of peanuts in South Texas and indicated that certain fungicides might reduce the incidence of the disease. Since this report, rust has repeatedly caused serious losses in South Texas each fall. Frequent applications of the fungicides in use for *Cercospora* leaf spot control in the South Texas area apparently have reduced rust losses but no fungicide program has been completely satisfactory. Arneson in 1970 (1) reported that combinations of Dithane M45 plus nickelous sulfate and Benlate plus Plantvax appear promising for the control of leaf spots and rust in Honduras and Nicaragua.

Rust and the *Cercospora* leaf spots are frequently associated together on the fall crop of peanuts in South Texas. Either disease can cause serious losses but the two in combination have at times been disastrous.

Excellent control of the *Cercospora* leaf spots can be obtained by a number of fungicides, if properly applied. The data, however, on chemical control of rust is very meager. This is due primarily to the infrequent appearance of rust in the spray plots at the Texas A & M University Plant Disease Research Station at Yoakum, and its irregular appearance in years prior to 1965.

EXPERIMENTAL PROCEDURES

Tests were conducted in 1970 in order to try to find a satisfactory fungicide program for the control of the combination of rust and *Cercospora* leaf spots and to learn something on the nature of the losses caused by rust. There were two general types of tests. In one series, *Cercospora* leaf spots were controlled by spraying the area with Benlate. (Benlate can give almost perfect control of *Cercospora* leaf spots but has little or no beneficial fungicidal effect on peanut rust). This permits rust to be the predominate leaf disease, if conditions are favorable for rust development. Other chemicals were superimposed on the Benlate treated areas to study their effect on rust. These studies are designated as the rust control tests.

In the second series of tests no special attempt was made to eliminate either rust or the *Cercospora* leaf spots from the plots. The chemicals were applied on a pre-determined schedule (weather permitting), and then evaluated for their effectiveness in controlling foliage disease complexes.

Two locations for these studies were used. One location near Pearsall in Frio County on the George A. Toalson and Sons' farm and the other location was at the Texas A & M University Plant Disease Research Station at Yoakum¹.

¹The test on the George A. Toalson and Sons' farm in Frio County was partially supported by a grant-in-aid from the Texas Peanut Producers Board. This same grant-in-aid helped to conduct in part the tests at the Texas A & M University Plant Disease Research Station at Yoakum along with grants-in-aid from several of the companies supplying the chemicals listed in the tables.

All chemicals in the tests were applied at approximately 50-gallons per acre. In the Toalson tests a special tractor mounted 2-row sprayer was used. The sprayer was powered with an 11 gpm PTO Warner 10F 4-piston pump. The sprays were applied at approximately 200 psi pump pressure. Part of the Toalson test area was used to study the effect of some fungicides on the control of peanut rust. This area was sprayed four times with Benlate at 0.5-lb formulation per acre per application to control *Cercospora* leaf spots. The rest of the Toalson test area was used to study the effectiveness of various fungicides for the control of a combination of rust and leaf spots. Each test plot in both areas consisted of two rows 49-feet long with two buffer rows between the plots. There were five replications in each Toalson test.

A second rust control test was conducted at the Texas A & M University Plant Disease Research Station at Yoakum. *Cercospora* leaf spots were controlled with Benlate as in the Toalson rust control test. Additional sprays were superimposed on the Benlate treated area with a tractor mounted sprayer with three nozzles per row. The test plots for rust control were two rows 185-feet long with two buffer rows between each test plot. There were four replications of each treatment.

Other tests at the Texas A & M University Plant Disease Research Station at Yoakum were used to study the effectiveness of various chemicals for the control of all foliage diseases that should occur.

The *Cercospora* leaf spots were the only major foliage diseases in one of the 1970 tests at Yoakum while rust contributed to the foliage disease complex in two of the tests.

Data from these studies were taken on the development of both peanut leaf rust and *Cercospora* leaf spots. Disease indices were taken by visually observing the severity of the foliage diseases in the field or, as in the case of rust, on leaves in the laboratory. Leaf samples were collected at random from each plot for the leaf rust ratings, taken to the laboratory, and rated visually using a modification of the Horsfall-Barratt disease rating system (3). An attempt was made to give each leaflet a rating based on the number of rust pustules per leaflet but this rating and the resulting calculations to get a reliable index was so time consuming that this system was abandoned in favor of the general visual rating system. Only the lower surface of the leaves were used for the rust ratings. In addition to the disease index ratings, data were also obtained on yields and grades from the various tests. They are presented in Tables 1 to 6.

RESULTS AND DISCUSSIONS

The data demonstrate that fungicides vary in their effectiveness for controlling leaf rust and *Cercospora* leaf spots. Bravo, Dithane M45, Fungi Sperse and Plantvax reduced the severity of leaf rust and increased the yield of nuts in the absence of *Cercospora* leaf spots (Tables 1 and 2). Du-Ter, in the Pearsall test, also showed some value for reducing the incidence of leaf rust. These data demonstrate that peanut leaf rust alone can cause economic losses to the peanut producer. Yields were reduced by approximately 600-pounds of clean nuts per acre in both the Pearsall and Yoakum tests when rust was not controlled.

In tests where both leaf rust and the *Cercospora* leaf spots were general, Bravo, Dithane M45, Fungi Sperse and KX3 reduced the severity of both types of foliage diseases and increased yields of nuts (Tables 3, 4 & 5). R & H 176 also gave promising results for controlling both leaf rust and *Cercospora* leaf spots (Table 4).

The data in Table 3 and 4 demonstrate that Benlate has little or no effect on the control of peanut leaf rust. Observations indicate that when Benlate is used for *Cercospora* leaf spot control, rust appears to be more severe than when Benlate has not been used. BAS 3021 F and Topsin M (Penwalt TD 1771) (Table

4) appear to have similar effects as Benlate on peanut leaf rust. All three materials, however, give excellent control of *Cercospora* leaf spots. The data in Table 6 demonstrate that Benlate is in the top group of fungicides for reducing *Cercospora* leaf spots and increasing peanut yields.

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Table 1: Fungicides for control of rust in near absence of *Cercospora* leaf spots^{1/}. Yoakum, Texas 1970

Treatment ^{2/}	Rate/Acre/ Application	Rust Index ^{3/} 10/19	Lbs Nuts ^{4/} Acre
Bravo	1.5 Lbs	7.6	2916
Dithane M45	1.5 Lbs	6.5	2903
Plantvax EC	0.5 Gal	6.1	2639
Fungi Sperser + Ca	1.0 Gal	5.4	2877
Check	0.0	1.4	2356

^{1/} Entire area treated four times with Benlate at 0.5 lb/A/application for leaf spot control.

^{2/} Six applications from July 28 to September 10

^{3/} Rust index. Approximately 20 leaves were picked at random and rated visually by examining the lower surface of the leaves as follows: 1 = rust generally severe on most leaflets (the number of pustules averaging approximately 75 to 100 or more per leaflet) and 9 = no rust pustules evident on any of the leaflets.

^{4/} Dug October 19

Table 2: Fungicides for control of rust in near absence of Cercospora leaf spots^{1/}. Pearsall, Texas, 1970.

Treatment ^{2/}	Rate/Acre/ Application	Rust Index 3/ 10/19	Lbs Nuts/ Acre ^{4/}
Bravo	1.5 Lbs	7.4	2861
Plantvax EC	0.5 Gal	6.6	2420
Du-Ter	0.4 lb	6.3	2610
Fungi Sporse SZ	1.0 Gal	6.2	2691
Dithane M45	1.5 Lbs	5.7	2737
Fungi Sporse + Ca	1.0 Gal	5.4	2642
Check	0.0	2.5	2223

^{1/} Entire area sprayed four times with Benlate at 0.5-lb/A/application for leaf spot control.

^{2/} Seven applications from July 22 to September 15

^{3/} See Table 1 Footnote 3

^{4/} Dug October 20

Table 3: Fungicides for the control of rust and Cercospora leaf spots. Pearsall, Texas, 1970

Treatment	Rate/Acre/ Application	Disease Index		Lbs Nuts/ Acre ^{4/}
		L.S. ^{2/} 9/28	Rust ^{1/} 10/19	
Bravo	1.5 Lbs	8.5	7.1	2609
Fungi Sporse SZ	1.0 Gal	8.0	6.0	2512
Fungi Sporse + Plantvax	1.0 + .25 Gal	8.0	5.7	2435
Du-Ter + Plantvax	0.4 lb + .25 Gal	8.0	6.3	2336
Fungi Sporse + Ca	1.0 Gal	7.8	4.6	2464
Du-Ter	0.4 lb	7.7	5.4	2284
Benlate + Plantvax ^{1/}	0.5 lb + .25 Gal	7.4	3.3	2243
Benlate + Oil 696 ^{1/}	0.5 lb + 1.0 Gal	7.0	2.9	2223
Benlate ^{1/}	0.5 lb	6.6	2.1	2060
Dithane M45	1.5 Lbs	6.4	4.0	2235
Dithane M45 + Plantvax	1.5 Lbs + .25 Gal	6.5	4.2	2219
Check	0.0	4.4	1.7	1997

^{1/} Applied July 22, July 31, August 19 & September 7. All other treatments received 7-applications from July 22 through September 15

^{2/} Leaf spot index based on a general visual rating as follows: 1 = complete defoliation; 9 = no defoliation and only occasional spots on a few leaves.

^{3/} See Table 1 Footnote 3

^{4/} Dug October 20

Table 4: Fungicides for the control of peanut rust and *Cercospora* leaf spots. Yoakum, Texas, 1970.

Treatment	Rate/Acre/ Application	Disease Index		Lbs Nuts/ Acre 2/
		L.S. 1/ 10/6	Rust 2/ 10/7	
Benlate 2/	0.50 lb	7.8	1.7	2704
Benlate S2/	0.50 lb	8.0	1.6	2743
Benlate N2/	0.50 lb	7.8	1.2	2635
Benlate + Oil 6961/ 2/	0.50 lb	8.7	1.6	2900
Benlate + Oil 7951/ 2/	0.50 lb	8.7	3.4	2933
Benlate	0.25 lb	7.5	1.7	2908
Benlate + Oil 6961/	0.25 lb	7.6	1.3	2726
Fungi Sporse SZ	0.50 gal	7.1	3.1	2850
Fungi Sporse SZ	1.00 gal	7.6	3.4	2722
Fungi Sporse + Ca	0.50 gal	6.4	2.2	2882
Fungi Sporse + Ca	1.00 gal	7.3	2.5	2926
Fungi Sporse 7870	0.50 gal	7.3	2.3	2872
Fungi Sporse 7870	1.00 gal	7.7	2.3	2802
Bravo	1.50 lbs	8.5	4.5	3202
Bravo + Oil 6961/	1.50 lbs	8.5	4.1	2969
Penncult TD 1771	0.50 lb	7.6	2.2	2781
SAS 3201-P	1.00 lb	8.0	1.8	2741
KK3	1.50 lbs	7.1	2.7	2824
NAM 176	1.00 lbs	7.2	6.2	3035
Vandice Maneb 80	1.50 lbs	6.5	2.3	2879
Amanin Maneb + 2N	1.50 lbs	7.3	3.0	2897
Dithane M45	1.50 lbs	7.2	3.6	3024
Dyrene	2.00 lbs	7.5	3.6	2650
Check	0.0	3.7	1.7	2309

1/ Enco Oil @ 1-gallon per acre per application

2/ Four applications from July 23 to September 15. All other treatments received seven applications

3/ See Table 1 Footnote 3

4/ See Table 3 Footnote 2

5/ Dug October 12

Table 5: Effect of Pinolene on fungicides for the control of *Cercospora* leaf spots and rust. Yoakum, Texas, 1970

Treatment 1/	Rate/Acre/ Application	Disease Index		Lbs Nuts/ Acre 2/
		L.S. 3/ 10/17	Rust 2/ 10/19	
Bravo +	1.5 lbs	8.5	6.9	3041
Bravo -	1.5 lbs	7.9	5.0	3136
Dithane M45 +	1.5 lbs	7.2	5.9	2679
Dithane M45 -	1.5 lbs	6.3	4.2	2685
Fungi Sporse + Ca +	1.0 gal	7.2	4.5	2877
Fungi Sporse + Ca -	1.0 gal	5.7	3.2	2472
KK3 +	1.5 lbs	6.9	4.4	2659
KK3 -	1.5 lbs	6.6	3.1	2969
Fungi Sporse 7870 -	1.0 gal	6.7	3.9	2847
Check	0.0	1.6	1.2	1407

1/ Seven applications from July 22 to September 14
+ = Pinolene @ 1 pt/acre/application
- = Without Pinolene

2/ See Table 3 Footnote 2

3/ See Table 1 Footnote 3

4/ Dug October 19

Table 6: Interaction of fungicides and date of harvest on peanut production. Yoakum, Texas, 1970

Treatment	Rate/Acre/ Application	Lbs Nuts/Acre			Leaf Spot Index On		
		Days From Planting			2/		
		101	112	126	9/28	10/5	10/17
Bravo	1.5 Lbs	2464	2856	3494	8.9	9.0	8.0
Benlate	0.5 Lb	2545	2816	3336	9.0	8.9	7.2
Fungi Sperse + Ca	1.0 Gal	2436	2903	3171	8.7	8.0	5.6
KX3	1.5 Lbs	2464	2707	3113	8.4	7.9	4.9
Dithane M45	1.5 Lbs	2334	2779	2789	8.3	7.4	6.3
Check	0.0	2352	2380	1898	5.6	3.1	1.3

^{1/} Seven applications from July 21 to September 14

^{2/} See Table 3 Footnote 2

^{3/} Dug September 24, October 5 and October 19, respectively

LATERAL FRUIT DISTRIBUTION OF A VIRGINIA-TYPE PEANUT

by

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INTRODUCTION

Physical characteristics of the peanut plant have been studied by many scientists. Studies have included descriptions of the peanut plant relative to its foliage, flower, fruit and root characteristics.

Little or no quantitative information is available on the fruit distribution of peanuts with lateral distance from the plant's tap root. General information and observations have indicated that most of the mature fruit is found on the lower branches near the tap root of the plant, whereas, most of the immature fruit is found farther away from the tap root.

Information on the fruit distribution may be used in the design of harvesting equipment and for determination of bandwidth in the application of agricultural chemicals. Consequently, this paper describes the procedure and results of a study on the lateral fruit distribution of Va. 61R peanuts during the harvesting period.

Methods and Procedures

A study to determine the lateral fruit distribution of Va. 61R (Virginia runner-type) peanuts was conducted over a 3-year period. Determinations of the peanut dry weight, moisture content, and meat content were made at weekly intervals throughout the harvesting period. This period began in late September and ended in early November.

To obtain peanuts for this study, a metal frame, 3 ft x 3 ft, was constructed (Figure 1). One dimension was divided into seven equal sections by removable sheet metal partitions. In the field the center section of the frame was positioned over the tap roots of the plants parallel with the row direction. A sheet metal scoop was used to remove the peanut vines, peanuts, and soil within each section to a depth of approximately 7 inches. The soil was screened through 1/4-inch hardware cloth and other extraneous material was removed by hand.

The peanuts were placed in quart cans, weighed in the laboratory and dried in an oven for 3 days at a temperature of 180°F. Upon removal, the peanut dry weight was recorded, the peanuts were hand shelled, and the meat content (dry weight) was recorded for each section.

In 1968, one observation per week was made, whereas in 1969 and 1970, duplicate observations were made for each week during the harvesting period. From each observation the percent of peanuts within each section (d. b.), the meat content of the peanuts within each section (d. b.), and the peanut moisture content within each section (w. b.) were determined. The total dry weight of the peanuts for the 3 ft x 3 ft area was the basis for the percent of peanuts calculations. The moisture content and meat content percentages were based on the peanuts in each individual section.

RESULTS

As indicated (Table 1) the percent of peanuts produced by the plants remained about the same in each section during the 5-week testing period (late September to early November). An average (Table 2) of 36.6 percent was produced in the center section, 20.1 and 22.1 percent were produced in the two

adjacent sections, and 8.4 and 9.7 percent were produced in the next two sections from the row center. Thus, 96.9 percent of the peanuts were produced within a lateral distance of +13 inches, or a bandwidth of 26 inches (Figure 2) centered over the plant row.

In contrast to the fruit distribution, the moisture content of the fruit varied across sections during the testing period and with lateral distance from the plant's tap root (Figure 3). The peanut fruit moisture content during the first week averaged about 8 percentage points higher than the peanut fruit moisture content during the fifth week. The average peanut moisture content increased from about 49 percent in the center section to about 67 percent in the outer sections.

The meat content relationship was inverse of that for the moisture content. The meat content of the peanuts during the first week averaged about 14 percentage points lower than the meat content during the fifth week (Figure 4). The average for all of the test weeks decreased from about 65 percent in the center section to about 53 percent in the outer sections.

These results illustrate quantitatively the maturity pattern for Va. 61R peanuts. That is, on a group basis parallel to the row the peanuts have a higher moisture content and less meat content with increase in distance perpendicular to the row center. Less than 4 percent of the total peanuts were produced outside a 26-inch bandwidth centered over the plant's tap root.

DISCUSSION

Because of the long vine growth of this peanut plant, the vines tend to wrap around the plow shank of most diggers during the digging operation. This wrap retards the flow of peanut plants through the digger and increases the possibility of peanuts being stripped off of the plant. Decreasing the bandwidth from 36 inches (row width) to 26 inches may decrease the overall losses by more than the amount being lost outside the 26-inch bandwidth.

A curve similar to Figure 2 which would indicate the net dollar value of the peanuts with lateral distance from the row center could be very useful to the peanut producer. Such a curve would be difficult to develop because it should account for the grade distribution, the harvesting and drying costs, and digging losses. However, if the curve could be developed, an optimum harvest width is expected to occur within the 26-inch bandwidth due to the maturity pattern of this variety.

In the band application of agricultural chemicals, granular insecticides and nematicides, these results may be used to select a bandwidth to cover an area in which a specified percentage of peanuts is produced. The results presented in this paper are for one variety; however, the same type of information has been obtained for a number of varieties in the Variety and Quality Evaluation Program¹.

SUMMARY

The lateral fruit distribution of Va. 61R peanuts was determined weekly throughout the harvesting period for 3 years. Peanut dry weight, peanut moisture content and meat content distributions were presented based on a 3 ft x 3 ft area partitioned into seven equal sections parallel with the row center.

An average of 96.9 percent of the peanuts was produced within a bandwidth of 26 inches centered over the plant's tap root. The peanut fruit moisture content within each section decreased with time during the harvesting period

¹ Monzingo, R. W., unpublished data, Tidewater Research Station, Holland, Virginia.

and increased with distance from the row center. The percent of meat content within each section increased with time during the harvesting period and decreased with distance from the row center. Practical uses for this type of information were discussed.

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Table 1. Lateral fruit distribution (% of total peanuts, d.b.) for the 5-week test period.

Test Time	Section						
	1	2	3	4 ^c	5	6	7
First week ^a	1.4	10.4	18.8	36.2	23.6	8.9	0.7
Second week ^a	2.7	9.7	19.4	34.7	23.4	8.6	1.5
Third week ^a	1.5	9.6	21.4	38.1	21.0	7.6	0.8
Fourth week ^a	2.2	10.3	22.2	33.3	21.7	8.9	1.4
Fifth week ^a	1.7	8.4	18.7	40.9	20.9	7.8	1.6
Average ^b	1.9	9.7	20.1	36.6	22.1	8.4	1.2

^a Average for week noted over 3 years

^b Average for all weeks over 3 years

^c Centered over tap root of plant

Table 2. Lateral fruit distribution, moisture content, and meat content for Va. 61R peanuts for 3 years.

Date	Dry Weight of Peanuts (gm)	Section						
		1	2	3	4 ^c	5	6	7
<u>Peanut Dry Weight (% of total, d.b.)</u>								
1968 ^a	486.9	0.9	7.8	22.2	40.1	20.3	7.9	0.8
1969 ^b	529.3	1.5	10.4	22.8	35.5	20.6	8.5	0.8
1970 ^b	477.0	3.3	10.8	15.2	34.3	25.5	8.8	2.0
Average	497.7	1.9	9.7	20.1	36.6	22.1	8.4	1.2
<u>Moisture Content (% w.b.)</u>								
1968 ^a		70.4	61.6	59.2	51.5	60.0	66.6	73.7
1969 ^b		64.7	59.5	54.5	50.0	55.2	59.5	66.2
1970 ^b		61.5	55.9	51.2	45.7	49.8	56.3	65.5
Average		65.5	59.0	55.0	49.1	55.0	60.8	68.5
<u>Meat Content (% d.b.)</u>								
1969 ^b		60.0	61.6	64.0	65.9	64.0	60.2	57.5
1970 ^b		49.1	54.6	59.1	63.2	59.3	53.6	46.9
Average		54.6	58.1	61.6	64.6	61.6	56.9	52.2

^a Average for 5-week period, one observation per week

^b Average for 5-week period, duplicate observations per week

^c Centered over tap root of plant

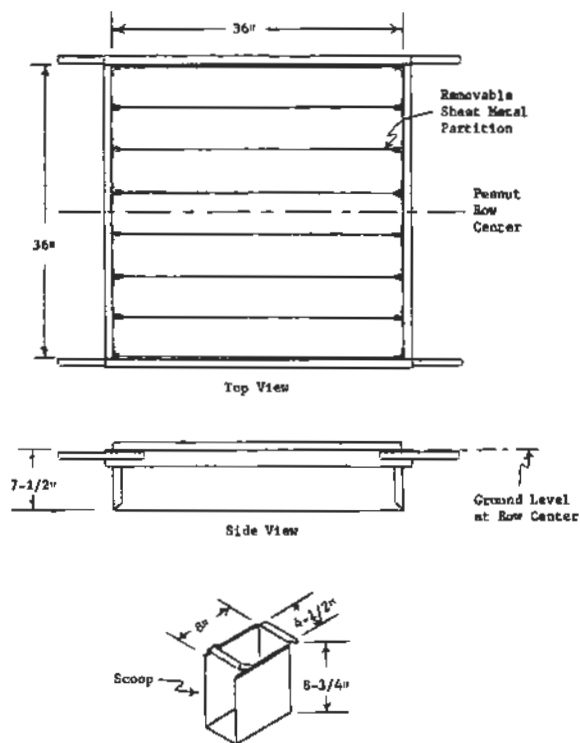


Figure 1. Line drawing of framework and scoop used in the fruit distribution study.

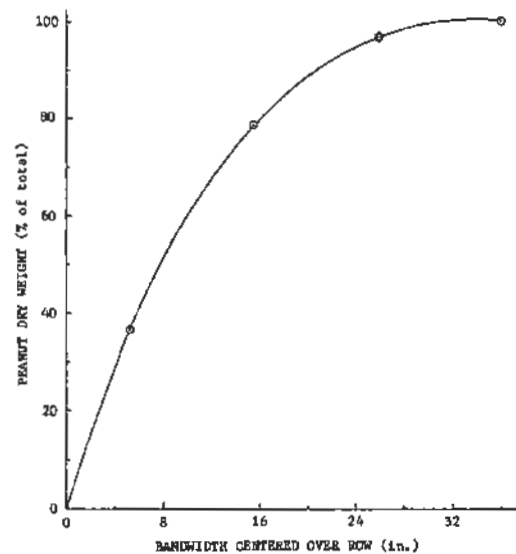


Figure 2. Peanut fruit distribution with bandwidth centered over the row for Va, 61R.

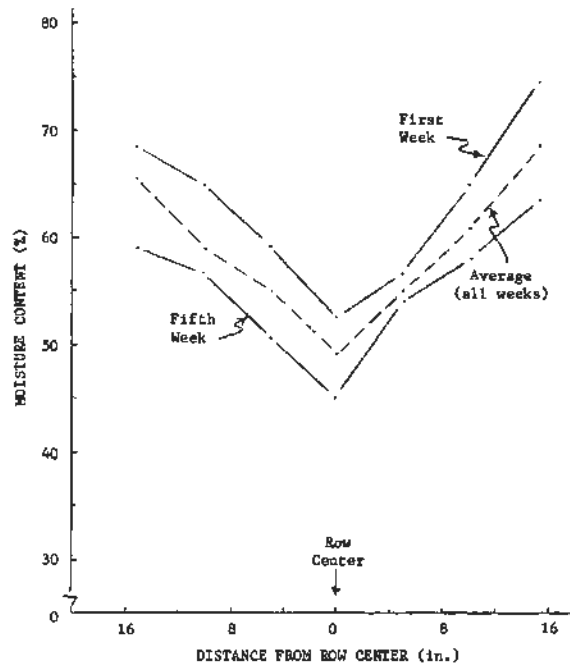


Figure 3. Moisture content distribution with distance from the row center for Va. 61R peanuts.

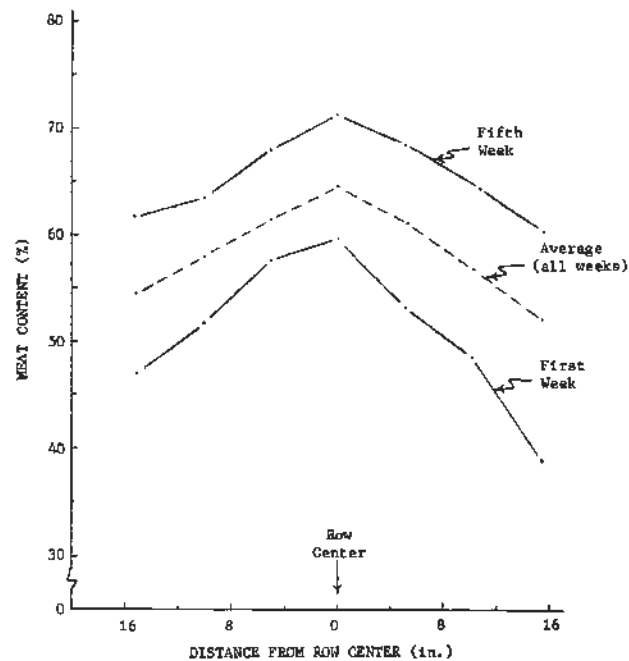


Figure 4. Meat content distribution with distance from the row center for Va. 61R peanuts.

EFFECT OF COMBINE PROCEDURES ON FRUIT CARRYOVER BETWEEN PEANUT PLOTS

by

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INTRODUCTION

Traditionally, peanuts from yield trials at the Virginia Experiment Station have been harvested by digging, stacking on poles, allowing to dry naturally and picking with a stationary peanut picker (1). Most producers now harvest their peanuts by digging, windrowing, allowing to dry for five to seven days, combining and drying artificially. This combine method was shown by Duke (2) to give an approximately 3 percent increase in pounds harvested per acre over the stack-pole method. Duke (3) also showed that the stack-pole method, from digging through picking, required 38 man hours per acre compared to 4.5 hours for the combine method. However, additional labor associated with artificially drying and curing the crop must be added to the combine method.

With a shortage of labor and more emphasis on using procedures comparable to those used by growers, many research workers have begun to harvest their peanut yield trials with commercial combines. The commercial combines because of their complex picking cylinders, augers and screens are more difficult to clean out than the stationary type picker. Consequently, when using a combine a certain amount of fruit carryover between plots must be assumed. Therefore, in 1970 an experiment was designed to determine the percentage of fruit carryover between plots when using certain combine procedures.

PROCEDURES

A randomized complete block design with four replications was used. Plot size included two 36-inch rows 50 feet long. Two commercial combines, A and B, with bagging attachments were used. The lower cleaning units of the two combines differed in that combine A used air to move the peanuts and combine B used an auger system. Three combine cleaning procedures were used:

- (1) No cleaning with combine A and combine B (stopping at the end of each plot and letting the combine self-clean until peanuts stopped flowing in the bag).
- (2) Vine cleaning with combine A and combine B (rerunning the vines from the plot back through the machine in an effort to "sweep" the combine clean).
- (3) Hand cleaning with combine A (by using a homemade hoe and collection pan the peanuts were taken from the front sand screen and dumped into the cleaning unit).

The principle source of carryover with combine A was the fruit which accumulated on the sand screen in the front of the machine whereas with combine B the principle source was the fruit which accumulated on the sand screen and also under the auger. By rearranging the spring teeth on the first cylinder the sand screen could be hand cleaned in combine A, however, with combine B hand cleaning was not practical due to the design of the machine. Likewise, with combine B there was no practical way to clean under the auger.

The varieties Florigiant and NC 17 were used in separate experiments for each of the three procedures. NC 17 is a large-seeded Virginia bunch type peanut which has less vigorous vine growth and is smaller in plant size than the variety Florigiant which is a large-seeded Virginia runner type.

After digging and inverting the plants, peanut pods were sprayed with a different color paint for four consecutive plots. The harvested pods were sepa-

rated by color into the plot being combined, the first preceding plot, the second preceding plot and third preceding plot. Each color group was weighed and the percentage of fruit carryover determined.

The data were subjected to an analysis of variance. Duncan's New Multiple Range Test was used to determine differences significant at the 5 percent level.

RESULTS AND DISCUSSION

Most of the total fruit carryover came from the plot immediately preceding the plot being combined. A review of all procedures showed that approximately ninety-six percent of the total carryover with Florigiant and approximately ninety-three percent with NC 17 came from the first preceding plot. However, this discussion will be limited mainly to the total fruit carryover which includes the carryover from the first, second and third preceding plots.

For the Florigiant variety the highest total percentages (Table 1) of fruit carryover were obtained with the no cleaning procedure for combine B and no cleaning of combine A. There was no statistical difference between the two combines using this procedure. Cleaning combine B with vines gave the next highest percentage which was not significantly different from no cleaning with combine A. The lowest total percentages were obtained by vine cleaning with combine A and hand cleaning with combine A. There was no statistical difference between these two procedures.

Statistical differences were significant in each case for the carryover from the first plot preceding the plot being combined. These differences were the same as with the percentage of total carryover described above. For the second and third preceding plots there was no significant difference between any of the treatments.

For the NC 17 variety the highest total percentage (Table 2) of fruit carryover was obtained with no cleaning of combine A. Using combine B with the no cleaning procedure gave a significantly lower percentage than with combine A but no difference statistically from the percentage for vine cleaning with combine A. The smallest total percentage of carryover was obtained from hand cleaning with combine A. This treatment was statistically different from any other treatment.

As with the Florigiant variety, NC 17 showed the same statistical pattern for the first plot preceding the plot being combined as for the total fruit carryover. There was statistical difference between plots for the second preceding plot, however, these were rather erratic with no clear pattern. No significant differences were obtained for the third preceding plot.

The average data for both varieties (Table 3) shows the percentage of total fruit carryover with the no cleaning procedure was not statistically significant between combine A and combine B. Also with combine B there was no statistical difference observed between the percentage of carryover for the no cleaning and vine cleaning procedures. Percentage of total fruit carryover from vine cleaning with combine A was significantly lower than with combine B. The treatment with the smallest carryover percentage was hand cleaning with combine A. This treatment was also statistically different from all other treatments.

The same statistical pattern was observed for the first plot preceding the plot being combined as for the total fruit carryover. Statistical differences were recorded for the second preceding plot and no differences were observed for the third preceding plot.

The time required to combine a plot (Table 4) was inversely related to the effectiveness of the procedure used. This was true when combining either the Florigiant or NC 17 variety. Significant differences in combining time were obtained with each procedure with each combine. Average time per plot for Florigiant and NC 17 was the longest for hand cleaning with combine A. The

shortest time required per plot was for no cleaning with combine B. Combine A required more time per plot than combine B when compared within the same procedure. Every treatment combination was statistically different from any other combination.

SUMMARY

Three combine cleaning procedures in combination with two commercial combines and two varieties of large-seeded Virginia type peanuts were used to determine the percentage of fruit carryover between peanut plots when combined with commercial machines. The results were:

1. Most of the total fruit carryover between plots came from the first plot preceding the plot being combined -- approximately 96 percent with Florigiant and 93 percent with NC 17.

2. Percentage of total fruit carryover with the various combine procedures ranged from 1.56 to 4.62 percent with Florigiant and .54 to 5.84 percent with NC 17 when using a plot size of two rows 50 feet long.

3. Combining time per plot for a plot size of two rows 50 feet long ranged from 57 seconds for no cleaning with combine B to 196 seconds for hand cleaning with combine A.

4. Hand cleaning with combine A gave the smallest percentage of total fruit carryover between plots but required the longest combining time per plot.

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Table 1. Percentage of Fruit Carryover During Combine Harvest for the Variety Floriziant.

Treatment Procedure	Combine	First Preceding Plot	% Fruit Carryover		Total Carryover
			Second Preceding Plot	Third Preceding Plot	
No cleaning	A	4.24ab ^{1/}	.06	.05	4.35ab
	B	4.52a	.08	.02	4.62a
Vine cleaning	A	1.58 c	.08	.08	1.74 c
	B	3.30 b	.04	.04	3.38 b
Hand cleaning	A	1.44 b	.06	.06	1.56 c

^{1/} Means sharing the same subscript are not statistically different at the .05 level.

Table 2. Percentage of Fruit Carryover During Combine Harvest for the Variety NC 17.

Treatment Procedure	Combine	First Preceding Plot	% Fruit Carryover		Total Carryover
			Second Preceding Plot	Third Preceding Plot	
No cleaning	A	5.46a ^{1/}	.20a	.18	5.84a
	B	3.93 b	.07 bc	.18	4.18 b
Vine cleaning	A	2.54 b	.13ab	.16	2.83 b
Hand cleaning	A	.46 c	.04 c	.04	.54 c

^{1/} Means sharing the same subscript are not statistically different at the .05 level.

Table 3. Average Percentage of Fruit Carryover During Combine Harvest for the Varieties Floriziant and NC 17.

Treatment Procedure	Combine	% Fruit Carryover			Total Carryover
		First Preceding Plot	Second Preceding Plot	Third Preceding Plot	
No cleaning	A	4.85a ^{1/}	.13a	.11	5.09a
	B	4.23ab	.08 bc	.10	4.41ab
Vine cleaning	A	2.06 c	.11ab	.12	2.29 c
	B	3.37 b	.06 bc	.09	3.52 b
Hand cleaning	A	.95 d	.05 c	.05	1.05 d

^{1/} Means sharing the same subscript are not statistically different at the .05 level.

Table 4. Time Required (Sec./Plot) to Combine Harvest the Varieties Floriziant and NC 17.

Treatment Procedure	Combine	Time Required (Sec./Plot)		
		Floriziant	NC 17	Average
No cleaning	A	113 c ^{1/}	96 c	104 c
	B	55 e	58 d	57 e
Vine cleaning	A	132 b	132 b	132 b
	B	94 d	-	91 d
Hand cleaning	A	200a	192a	196a

^{1/} Means sharing the same subscript are not statistically different at the .05 level.

PEANUT RUST: A REVIEW OF LITERATURE

by

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ABSTRACT and PAPER

Puccinia arachidis Speg., the incitant of rust of the cultivated peanut, *Arachis hypogaea* L., is endemic to the Western Hemisphere. It is widespread in the Caribbean region and Central America and has been reported from several countries in South America and from the United States. Outside the Americas the rust reputedly has become established only on the island of Mauritius.

On plants subjected to early and intensive rust attack, leaves fail to attain normal size and fall prematurely, growth of the shoot is slowed, the life cycle of the plant may be shortened by more than 15 to 20 days, and the seeds produced are usually smaller and lower in oil content.

The fungus produces uredospores within uredial pustules found primarily on the leaves of the host. Uredospores readily become airborne and disseminate the fungus. Under appropriate conditions of temperature and moisture, uredospores germinate, penetrate, and infect the host within hours and a new crop of uredospores matures within 10 days. Teliospores have been reported from South America but not elsewhere. At present, nothing is known about the role of the teliospore, the occurrence of pycnia and aecia, the involvement of an alternate host in the life cycle, or the occurrence of physiologic races.

The peanut rust fungus has been reported to attack only species within the genus *Arachis*. Although some cultivars within the species *A. hypogaea* possess resistance, the majority are susceptible.

Various dusts and sprays have been used against peanut rust but specific recommendations for the employment of fungicides remain to be developed.

Additional information on the biology, life cycle, host range, distribution, pathogenicity, destructiveness, and epiphytotic behavior of *P. arachidis* is needed to evaluate properly the threat of rust to the world's peanut crops.

I. HISTORY AND GEOGRAPHIC DISTRIBUTION

Rust of the cultivated peanut, *Arachis hypogaea* L., is incited by the fungus *Puccinia arachidis* Speg. Little information concerning the biology of the pathogen or its epiphytotic potentialities and destructiveness has appeared in the scientific literature.

Spegazzini first described the pathogen in the early 1880's from rusted peanut plants collected in Paraguay. In early literature the names *Uredo arachidis* Lagerth., *Uromyces arachidis* P. Henn., and *Bullaria arachidis* (Speg.) Arthur & Mains were occasionally applied to the peanut rust organism. These names are now considered synonyms for *Puccinia arachidis* Speg.

Peanut rust is apparently endemic to the Western Hemisphere. It is widespread in Central and South America. It has been reported from Antigua, Barbados, Cuba, Dominican Republic, Grenada, Guadeloupe, Guatemala, Honduras, Jamaica, Montserrat, Nicaragua, Panama, Puerto Rico, and St. Vincent. In South America it has been found in Argentina, Brazil, British Guiana, Colombia, Paraguay, Peru, Surinam, Uruguay, and Venezuela. In North America it has been reported in Alabama, Florida, Georgia, Louisiana, North Carolina, Texas, and Virginia (6, 14).

Outside the Americas, *P. arachidis* has apparently become established only on the island of Mauritius (22, 25, 30).

A single report dated 1912 notes the occurrence of the pathogen in Asiatic Russia (12) and a single report dated 1937 concerns the appearance of the rust in Mainland China (26). There have been no subsequent reports of the rust in these areas. If, indeed, the reports were accurate, it is highly probable that the rust did not become established.

II. ECONOMIC IMPORTANCE

It is difficult to assess the economic importance of peanut rust from the sparse, scattered, and conflicting literature currently available. In the field, the almost universal occurrence of *Cercospora* leaf spots, caused by *C. personata* (Berk. & Curt.) Ell. & Ev. and *C. arachidicola* Hori, along with peanut rust also makes it difficult to determine the loss attributable to rust alone.

Some general information is available, however, from which extrapolation of the potential economic importance of the disease can be made (11).

An early account by Burger (4) records a 50% loss due to rust in a 15-acre field at Torrey Island, Florida, in 1920.

South (24) reports that peanuts may be seriously attacked by the peanut rust fungus in the Antilles and that infected plants die prematurely with resulting decrease in quantity and quality of the peanuts.

Nowell (21) reports that attacks of peanut rust in Barbados are sometimes severe enough to cause death of the host plants.

In the Dominican Republic in 1925 an epiphytotic of peanut rust practically destroyed the entire harvest (8). In 1958 and 1959 Castellani (6) observed serious damage to the peanut crops in various parts of the Dominican Republic.

In October of 1961 peanut rust was first reported in Virginia. Plants in small scattered areas of initial infection were killed and growers harvested their plants prematurely to avoid severe losses (23). At the same time, rust was first reported in North Carolina (28).

The first recorded occurrence of peanut rust in Texas was made by KenKnight in 1941 (13). In October of that year rust was found in seven fields of Spanish peanut in Frio County. One field of about 20 acres was appreciably damaged. The plants were uniformly and severely rusted and the leaves had a scorched appearance. The rust appeared to have spread from this field to the other six. From 1941 until 1965 the disease appeared sporadically at infrequent intervals in widely separated fields in south Texas and was, apparently, of no special concern to the growers. In 1965, however, the situation changed and peanut rust, along with *Cercospora* leaf spot, became epiphytotic in many fields. Together they caused severe losses. Peanuts in many fields were dug 2 to 4 weeks early because of defoliation. This resulted in lowered yields and grades. In 1966 peanut rust was again widespread in southern Texas and was found on dryland as well as irrigated peanuts. Again there were appreciable losses from the rust and leaf spot combination in fields harvested in late September, October, and November. Some crops were dug 2 to 4 weeks earlier than desirable to avoid further losses (10).

Muller (19), writing of plant disease problems in Central America, states that peanut crops often fail because of *P. arachidis*, especially during seasons that are unusually dry.

McLaughlin and Chester, after reviewing the peanut rust literature up to 1953, concluded, "Little is actually known of the epidemic potentialities of *P. arachidis* but the fungus is widespread in some peanut-growing areas and, with increased production of peanuts, might become a limiting factor in production" (17).

Although quantitative data on yield loss attributable to peanut rust are lacking in the literature, it is evident that the peanut rust fungus shares with other plant rusts the potential to become epiphytotic and inflict damage on plantings of its host.

III. HOST SUSCEPTIBILITY

Documented evidence on varietal reaction to peanut rust is scarce. In 1941, KenKnight (13) reported, "... as a result of artificial, as well as natural inoculation under field conditions, at least a few lesions of rust were found on plants of 50 varieties (all that were thoroughly inoculated) of peanuts. Runner varieties appeared most susceptible, perhaps because for the most part they were greener when inoculated." Rusted selections with varietal names were: Basse, Carolina Runner, Dixie Giant, Gudayitham, Japanese, Jumbo Runner, Macspan, Mauritius, Nagpur Groundnut No. 34, Pearl, Senegal, Small Spanish, Tennessee Red, Virginia Bunch (Florence Strain), and West African.

In 1959 and 1961, Mazzani and Hinojosa (16) in Venezuela observed 254 varieties for reaction to peanut rust. The test varieties were exposed to natural infection in the field. Only one variety, Tarapoto, which was introduced into Venezuela from Peru in 1955, was classified as resistant. Twelve other varieties were classified as having some resistance to peanut rust, but the nature of this resistance is not clear from the data presented. Interpretation of the data suggests that pustules of a susceptible type were present on these varieties but in distinctly lesser numbers than on the other 241 varieties. The 12 varieties classified as somewhat resistant and the country from which Venezuela obtained them are: a nameless variety, Jamaica; Spanish, Uruguay; Valencia, Australia; Tatu, Brazil; 15235, Cuba; Tipo 3, Argentina; Tingo Maria, Peru; Argentine, Improved Spanish, Tennessee Red, and PI 221063, United States; and a nameless variety, Venezuela.

In 1964 McVey (personal communication) observed approximately 1,500 peanut accessions that were exposed to natural rust infection in USDA field plots in Puerto Rico. Among the accessions of *A. hypogaea*, only Tarapoto was markedly resistant although some accessions were noticeably less rusted than others.

McVey (18) also induced rust on seven varieties grown in the greenhouse in Puerto Rico. He inoculated them with a water suspension of spores and incubated them in a saturated atmosphere for 16 or 24 hours. The varieties were Tennessee Red, Early Runner, Argentine, NC4X, PI 259746, PI 259747, and a Valencia type locally grown in Puerto Rico.

In 1970 Bromfield and Cevario (3) screened accessions of *A. hypogaea* for reaction to a culture of peanut rust from Puerto Rico and to a culture from Frio County, Texas. Accession PI 314817, a Valencia type collected originally in Peru, and accession PI 315608, a white-seeded Virginia type selected from Virginia Adom in Israel, were physiologically resistant to both cultures. One hundred seventy-one accessions tested to both cultures, 68 tested only to the culture from Puerto Rico, and 4 tested only to the culture from Texas were susceptible.

Recently Marion Cook in Jamaica screened peanut accessions for reaction to the Jamaican peanut rust population. Tarapoto, PI 314817, and PI 298115, an earlier accession of PI 315608, were observed to be resistant (personal communication).

Screening for reaction to rust was underway in Barbados and Ecuador in 1971 but results are not yet available (personal communications).

Arachis nambyquarae Hoehne, *A. prostrata* Benth., and a hybrid, *A. hypogaea* x *A. nambyquarae* have been reported by West (29) to be susceptible to peanut rust.

McVey (personal communication) observed that *A. glabrata* Benth. in a peanut nursery in Puerto Rico was immune to peanut rust.

Bromfield and Cevario (3) report that five accessions of *A. glabrata* tested to a culture of peanut rust from Puerto Rico were immune. Small, weakly sporulating pustules developed on the one accession of *A. monticola* Krapovickas &

Rigoni tested. No macroscopic evidence of rust developed on *Glycine max* (L.) Merr. (varieties Bansei, Clark, Hood, Watson), *Medicago sativa* L. (alfalfa), *Melilotus alba* Desr. (sweet clover), *Phaseolus vulgaris* L. (varieties Black Valentine, Penn Salt, Red Kidney, Tender Green), *Pisum sativum* L. (variety Alaska), or *Trifolium pratense* L. (red clover) under conditions favoring an abundance of pustules on companion plants of Starr or another Spanish type peanut variety.

Guarch (9) reports that *P. arachidis*, in the telial stage only, was collected on *A. marginata* Gardn. in Uruguay and that in 1936 W. A. Archer collected peanut rust on various wild species of *Arachis* in southern Brazil.

No reports of *P. arachidis* on species other than those in the genus *Arachis* were found in the literature.

IV. SYMPTOMS AND EFFECTS

Peanut rust is generally first noticed when its uredial pustules, typical of uredial pustules in general, rupture the epidermis of the leaves. The mature pustules are pulverulent in appearance, cinnamon brown in color, and about 0.5 to 1 mm in diameter. A narrow zone of chlorotic tissue frequently surrounds each pustule. Pustule size is modified to some extent by position and degree of crowding. If the number of pustules on a leaflet is small, the individual uredia may be as large as 2 mm in diameter. As the number of pustules per leaflet increases, the size of each individual uredium diminishes. Pustules on the upper (adaxial) surface of a leaflet tend to be smaller than those on the lower (abaxial) surface for a given pustule density.

Uredial pustules are more numerous on the lower surface of a leaflet than on the upper surface. Castellani (6) has counted 200 to 250 pustules/cm² of lower leaf surface and 70 to 100 pustules/cm² of upper leaf surface on plants subjected to severe rust attack.

According to McVey (18), whitish flecks on the lower leaf surface are the first macroscopic evidence of rust infection. Approximately 24 hours later, yellowish-green flecks become visible on the upper surface and pustules appear as minute orange spots within the whitish flecks on the lower surface. The immature pustules enlarge and within another 48 hours rupture the leaf surface and expose uredospores to the atmosphere.

Pustules have been reported on all aerial parts of the plant with the exception of the flower and the peg (gynophore, carpophore) (6).

The numerous pustules rupturing the epidermis enhance transpiration and impose water stress on the infected plants. One effect of water stress may be premature leaf fall.

On plants subjected to early and intensive rust attack, leaves fail to attain their normal size and fall to the ground prematurely. Growth of the shoot is slowed, the life cycle of the plant may be shortened by more than 15 to 20 days, and the seeds produced are usually smaller and lower in oil content.

Appreciable leaf fall may set the stage for secondary effects adverse to the peanut crop. The cast leaves, rich in organic food matter, serve as substrate for the rapid buildup of populations of facultative parasites like the ubiquitous *Sclerotium rolfsii* Sacc. Well-developed colonies of these fungi can then invade the weakened peanut plants and cause further damage (6).

Arthur (1), writing in 1929, stated, "When the rust appears toward the end of the season it does little damage, but with an early attack, especially on wet soil, considerable defoliation, premature ripening of the haulms, and a large proportion of shriveled kernels may result."

Martyin (15), discussing peanut rust in Texas in 1941, related that one field of about 20 acres of peanuts "... was rather uniformly and severely rusted so that the leaves had a scorched appearance." More recently, Harrison (10) reported that occasional peanut fields in Frio County, Texas, infected with peanut rust

and *Cercospora* leaf spot, had the appearance of having been seared with a blowtorch.

V. ETIOLOGY

A. Uredial Stage

The uredial stage of peanut rust is the commonly observed stage. The uredospores are produced in pustules on leaflets, petioles, stipules, and stems. Arthur (2) describes uredospores as ellipsoid or obovoid, 16 to 22 by 23 to 29 microns, with cinnamon brown wall, and possessing two, nearly equatorial, germ pores. Castellani's (6) description of the uredospores agrees well with that of Arthur. Castellani, in addition, reports slender, conical ornamentations about 1 micron high on the outer wall. These are visible in water mounts of the spores but not in mounts made with lactophenol, lactic acid, or glycerin. The uredospores at maturity detach easily from the mycelium on which they are formed and readily become airborne.

Castellani (6) obtained germination of uredospores in van Tiegham cells containing sterile 2% glucose water. Time and temperature factors were not reported. A small percentage of uredospores in a population held in the laboratory (conditions unspecified) retained germinability for 3 months.

Castellani (6) also made preliminary investigations of conditions under which uredospores germinate and infect. Water suspensions of fresh uredospores were applied with small cotton wads to plants. The inoculated plants were held for 4 days in a laboratory at 80 to 90% relative humidity and 28 to 32 C. During this time they were sprinkled lightly with water twice a day. They were then removed to the outside. Twelve to 14 days after inoculation, pustules were observed on the lower surfaces of inoculated leaves. Uninoculated check plants remained free of pustules.

McVey (18) successfully infected 30-day-old plants. Inoculated plants were kept visibly wet in a moist chamber for 16 to 24 hours following inoculation and then placed in a greenhouse at 22 to 25 C during the night and 30 to 43 C during the day. Under these conditions, uredial sporulation occurred at about 10 to 12 days.

Two methods of inoculation were utilized by McVey in these tests. In one, uredospores were suspended in water containing the surfactant B-1956 (Rohm and Haas) and applied to leaf surfaces with a camelhair brush. In the second, the uredospore suspension was sprayed onto the plants with an artist's air brush. Placement of inoculum on either the lower or the upper leaf surface by either method resulted in infection. However, the first macroscopic evidence of infection, and all subsequent phases of symptom development, occurred approximately 24 hours earlier on leaflets inoculated on the lower surface than on the upper surface.

McVey made cleared and stained whole mounts of peanut leaves and verified penetration of rust through both the upper and lower leaflet surfaces. He did not, however, describe details of the germination and infection processes, nor have they been reported by others.

Brounfield and Cevario (3) infected plants by dusting them with a mixture of 1 part uredospores and 5 parts talc at the rate of about 0.3 mg spores per plant and then incubating them in one of two ways. In some tests inoculated plants were transferred to dew chambers and held under dew for 16 - 20 hours at an ambient air temperature of 20-25 C. They were then removed from the chambers and returned to greenhouse benches. In other tests plants were inoculated in place on the greenhouse bench, covered with a tent of polyethylene sheeting, and misted overnight (16-18 hours). Both methods consistently permitted abundant infection. The minimum night temperature in the greenhouse was usually

near 20 to 25 C; the maximum day temperature was near 30 C during late fall, winter, and early spring, but 40 C or higher during summer.

Infection was also consistently obtained on detached leaflets that were dusted with uredospores, misted with a fine spray of water, placed on moistened filter paper enclosed in Petri dishes, held in darkness at 20-25 for 16-18 hours, and then placed on a laboratory bench at 25 C.

B. Telial Stage

Telia and teliospores have not been reported on *A. hypogaea* in the United States, the Caribbean area, or Central America. The only report of teliospores on *A. hypogaea* in South America is that contained in Spegazzini's original description of the fungus. Arthur (2), in his manual of plant rusts, describes the teliospores as oblong, often with three or four cells, 14 to 16 by 38 to 42 microns, germinating at maturity, the wall chestnut brown, smooth, and with colorless pedicel. Unfortunately, the source of the material on which Arthur based his description is not given.

Castellani (6) states that he never observed teliospores in the Dominican Republic although he observed "hundreds upon hundreds of plants." Other workers in the Antilles have also mentioned the absence of telia.

Guarch (9) has reported observing teliospores on *Arachis marginata* Gardn. in Uruguay. Archer and Gehrt deposited specimens, identified as *Arachis glabrata*, bearing uredia and telia of peanut rust in the National Fungus Herbarium, Plant Industry Station, Beltsville, Maryland. This material had been collected in Brazil.

Results of investigations of conditions inducing telial formation and teliospore germination for peanut rust are completely lacking in the literature. Currently the role of the teliospore in the life history of this rust is not known.

C. Pycnia and Aecia

It is not known whether the fungus produces pycnia and aecia nor whether an alternate host is involved in the life cycle of the rust.

D. Physiologic Specialization

To date, races of *P. arachidis* have not been demonstrated. Although Bromfield and Cevario (3) in making screening tests used rust isolates from two widely separated regions (Puerto Rico and Texas) they could not separate the cultures into two physiologic races on the basis of reaction types induced on 171 accessions of *A. hypogaea*, several accessions of other species of *Arachis*, or six non-peanut legume species. None of the accessions tested functioned as a differential.

VI. EPIPHYTOLOGY

The yearly appearance of rust in the peanut fields of southern Texas from 1965 onward has become a cause of increasing concern to peanut growers in the United States. Prior to 1965, rust had occurred only sporadically on widely separated fields and only late in the season. This pattern suggested repeated introductions of inoculum from distant sources and an inability of the fungus to overwinter between successive crops. In 1965 and succeeding years, however, rust appeared much earlier in the cropping season and attained epiphytotic proportions in many fields. The source of the inoculum remains unknown but the assumption that local sources now exist is reasonable.

The appearance of rust in the peanut fields of the southeastern United States has also been sporadic during the past several decades. Again the pattern of

scattered infection appearing late in the season suggests distant sources of initial inoculum. The islands of the Caribbean, particularly Hispaniola and Cuba, are the most likely source region for this inoculum (6, 7, 23, 28).

In the Caribbean area, the Dominican Republic, occupying much of the island of Hispaniola, is by far the largest grower of peanuts. Cropping is continuous and at any time of the year peanut tissue is available somewhere on the island for infection by peanut rust. In this uniformly favorable situation, the rust perpetuates itself continuously by means of successive uredial generations.

A similar situation to that existing in the Dominican Republic, but involving smaller acreages, also exists in Cuba, Puerto Rico, Jamaica and other islands in this region.

The peanut crops of Venezuela are frequently attacked by peanut rust late in the season (16). The source of inoculum for these outbreaks is not known. In fact, there is a general dearth of specific information on the source of inoculum and the epiphytotic development of the rust for all of South America.

The local and long-distance dissemination of peanut rust uredospores has not been specifically studied, but a knowledge of other rusts with similar uredospores suggests that airborne spores could be lofted from a source region, e. g. Dominican Republic, and initiate disease under appropriate conditions of host and environment in distant areas.

Although germination of uredospores has been observed after passage through the digestive tract of larval *Prodenia* species, voracious eaters of peanut leaves, it is highly unlikely that insects play a significant role in either the local or long-distance transport of inoculum (6).

On the basis of reports by farmers and his own observations made during 1958 and 1959, Castellani (6) concludes that peanut plants in the field in the Dominican Republic do not become rusted until they are about 40 days old. McVey's (18) observations in Puerto Rico also indicated that in the field rust is not present until the plants are about 6 weeks old. McVey states, "Plantings less than 6 weeks old were found that contained older volunteer rusted plants; but the young plants showed no evidence of infection. Plantings 6 weeks old or older had a light scattering of rust on the lower leaves." However, in the greenhouse, McVey was able to infect plants of any age, even those with only the first leaves expanded. This apparent discrepancy in behavior is only one of many aspects of peanut rust that needs investigation.

Conflicting statements concerning the effect of environment on peanut rust development and resulting damage also exist in the literature. Muller (19, 20) writes that *P. arachidis* often causes failure of peanut crops in Guatemala during seasons that are unusually dry. Martyn (15) writing about the peanut rust situation in Jamaica, states, on the other hand, that rust is usually worse in wet weather. Discrepancies of this sort, either real or apparent, require resolution.

VII. POTENTIAL CONTROL MEASURES

A. Control Through Disease Resistance

The use of disease-resistant varieties of crop plants is a practical, effective, and widely used method for controlling many plant diseases in cases where acceptable resistant lines have been developed. Disease-resistant lines are obtained by several procedures including: (i) selection of resistant individuals from populations subjected to intensive infection, (ii) crossing varieties carrying factors for resistance with varieties possessing other desirable characteristics but lacking resistance, and (iii) hybridizing resistant wild species with susceptible varieties of the cultivated species.

Within the species *Arachis hypogaea* three sources of physiologic resistance to peanut rust have been found: Tarapoto (PI 259747), PI 314817, and PI 315608.

Accession PI 314817 and Tarapoto (PI 259747) are Valencia type peanuts from Peru. They are in the *A. hypogaea* subspecies *fastigiata* var. *fastigiata*. Accession PI 315608 is a Virginia type peanut in the subspecies *hypogaea* var. *hypogaea*. Tarapoto has comparatively large sharply reticulated horny pods that frequently contain 3 or 4 dark purple seeds. Pods of PI 314817 are reticulated but smaller and more slender than those of Tarapoto and contain up to 3 or 4 pink or flesh colored seeds. PI 315608 is a typical Virginia type peanut with white seedcoats and an erect habit of growth.

None of these three peanuts in present form is considered acceptable in the United States for commercial purposes. However, their genes for rust resistance can undoubtedly be incorporated into desirable commercial varieties by breeding. Similarly, the possibility exists that genes for immunity, present in *A. glabrata*, can be incorporated into commercial varieties of *A. hypogaea* by appropriate interspecific hybridization procedures.

Assuming that genes for physiologic resistance or immunity to peanut rust can be incorporated into an acceptable commercial variety, the duration of this protection is unpredictable. To date, races of *P. arachidis* have not been demonstrated. However, in view of the occurrence of races in other rust fungi, it is highly probable that races also occur in the peanut rust organism. Thus a variety possessing resistance to a rust population in a given season or a given area may not be resistant to the rust population in another season or in a different area. Experiences of this sort are well documented for cereals and cereal rusts, bean and bean rust, and many other host-rust combinations. A similar situation would be expected with peanut and peanut rust.

Mazzani and Hinojosa (16), McVey (18), and Bromfield and Cevario (3) have reported that some accessions support fewer rust pustules than others when subjected to the same inoculum load and infection conditions. Thus it appears that some peanut lines possess generalized or field resistance that may be exploitable.

It has been generally observed that resistance to a specific disease usually occurs in plants obtained from areas where both host and pathogen are endemic. In areas where a specific host and pathogen have had very long association, resistant forms evolve as a result of natural selection. Thus, central South America would probably be an area likely to provide rust-resistant peanut stocks.

B. Control Through Use Of Chemicals

Control of a plant disease by use of chemicals is often feasible. The chemical control of peanut rust has been attempted from time to time, usually on a relatively small scale, with varying degrees of success. The majority of chemical control measures reported involved attempts to prevent fungus penetration and establishment.

The older literature makes references to applications of sulfur dust or Bordeaux mixture as being somewhat effective against peanut rust. In view of the lack of quantitation, i. e., amounts applied, frequency of application, percentage yield increase, etc., the effectiveness of the materials employed cannot be adequately assessed in retrospect.

Castellani (6) reports that peanut crops in the Dominican Republic are frequently dusted with the following formulation to combat fungus pathogens and insect pests: 50% copper oxychloride, 10 parts by weight; sulfur, 75 parts; DDT, 5 parts; and inert substances, 10 parts. According to Castellani, "The use of such a powder has yielded noteworthy results in combating the cercosporia (*Cercospora personata* and *C. arachidicola*) and some lepidopteran parasites, but very modest results against the rust."

Ter Horst (27), working in Srinagam, reported that Brestan (triphenyltin acetate) and Hoechst 2799, both of which contain tin, reduced *P. arachidis*

infection. The Brestan was applied at the rate of 18 to 20 gal/acre but the frequency of application was not given.

Harrison (10) has documented results obtained in south central Texas in 1965 and 1966 with several fungicides tested for effectiveness against both rust and leaf spots. He concluded that the following had some fungicidal value against both *Puccinia* leaf rust and *Cercospora* leaf spots when applied on a 7- to 14-day schedule:

Dithane M-45	(zinc + maneb)
Chlorothalonil	(tetrachloroisophthalonitrile)
Difolatan	(N-[(1, 1, 2, 2-tetrachloroethyl) sulfonyl]- cis-4-cyclohexene-1, 2-dicarboximide)
Sprelox S	(50% sulfur)
Polyram	(mixture of 5.2 parts by weight of amoniates of [ethylenebis (dithiocarbamate)] zinc with one part by weight ethylenebis [dithiocarbamic acid] bimolecular and trimolecular cyclic anhydrosulfides and disulfides)
Dusting sulfur	(325-mesh)

VIII. DISCUSSION AND CONCLUSIONS

The scientific literature on peanut rust and its casual agent, *P. arachidis*, is sparse, often conflicting, and frequently confusing. The lack of research information on the pathogen and the disease can be readily appreciated, however. First, it is apparent that the organism is most common and damaging in the Caribbean area. Here, although peanuts are widely grown, they do not constitute a major crop either in cash value or in acreages committed. The number of plant pathologists actively working in the area is relatively small and those that are, understandably, respond to the problems associated with the more lucrative crops. Second, the organism has not become established in India, China, Nigeria, or Senegal, major peanut-producing countries of the world. Therefore, plant pathologists in these countries have been under no stimulus to investigate peanut rust. Third, in temperate zone regions of the Western Hemisphere where peanuts are an important crop in a diversified agriculture, e. g., southern United States and Argentina, the rust appears only sporadically. Thus, again, the stimulus to mount a sustained study of the disease is minimal.

Both *A. hyopgaea* and *P. arachidis* are thought to have originated in South America. From the time of Columbus the peanut plant has been widely distributed from its ancestral home and now occupies vast acreages in Africa, India, and eastern Asia. To date the rust pathogen has not become established in the African and Asian peanut fields. There is, however, the constant danger that inoculum may eventually bridge existing barriers under conditions favoring rapid disease development and epiphytotic spread. There are many well-documented examples of rust fungi behaving in this manner. Tropical corn rust (*Puccinia polysora* Underw.) is an especially good example because of interesting parallels in the present peanut rust situation and the corn rust situation prior to 1949.

Corn is a crop of New World origin that has been successfully and widely introduced into agricultural areas throughout the world in the post-Columbian era. Tropical corn rust, one of three rusts attacking corn, is also of New World origin. Prior to 1949 it was found only in the Americas. In early 1949, *P. polysora* suddenly appeared in Sierra Leone in western Africa and rapidly spread eastward along the coast and across central Africa to Kenya, and southeast toward Rhodesia. By 1953 it had reached Southern Rhodesia and the islands of Madagascar, Mauritius, and Reunion off the east coast of Africa. During its

migration it reached epiphytotic proportions and caused great economic loss (5). Thus, once the rust fungus had breached the geographical barrier of the Atlantic Ocean, it spread rapidly and destructively throughout a vast territory. In so doing it behaved as have many other rusts including coffee rust, stripe rust of wheat, white pine blister rust, and antirrhinum rust.

In the southeastern United States, peanut rust has appeared only sporadically, arising presumably from airborne spores originating in the Caribbean area, and has not become epiphytotic. To date, inoculum has arrived only late in the season. There is general concern that appreciable inoculum will sometime arrive sufficiently early in the season to permit the development of several uredial cycles. If this were to occur, a widespread and devastating epiphytotic is a distinct possibility, particularly in view of the apparent lack of rust resistance in the peanut cultivars commercially grown in the Southeast.

In view of the potential of *P. arachidis* for damage, a broad research effort is needed to fill in the many gaps in our knowledge of its biology, life cycle, host range, distribution, pathogenicity, destructiveness, and epiphytotic behavior.

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EFFECT OF SEED TREATMENT AND GERMINATION ENVIRONMENT ON SEED DORMANCY OF PEANUT, ARACHIS HYPOGAEA

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ABSTRACT & PAPER

Both seed treatment with tetramethylthiuramdisulfide (thiram) and germination environment (germinator vs sandbed) had a substantial effect on dormancy of seed of 13 promptly-cured Spanish and Valencia peanut genotypes. Germination environment influenced dormancy of treated 1969 stack cured seed of 15 Virginia genotypes. When 1970 stack cured seed of 19 Virginia genotypes were planted without treatment in a sandbed, dormancy was strikingly different from comparable treated seed tested in the germinator. When 19 Virginia genotypes were cured promptly under controlled conditions, germination environment significantly influenced seed dormancy when tests were run 2 weeks after curing and after 178 days in cold storage. Seed treatment significantly influenced seed dormancy when tests with these same peanuts were made in a germinator 2 weeks after completion of curing, but after 178 days storage at 40 F and 65% relative humidity, seed treatment did not influence dormancy in either germination environment.

In all tests, seed dormancy was less when tests were run in the germinator than when run in the sandbed. Whenever seed treatment was effective, the treatment reduced dormancy when compared to untreated seed. All Spanish and Valencia genotypes responded in a similar manner to germination environments and seed treatments. Not all of the Virginia genotypes were affected to the same degree by the germination environments, but all responded in a similar manner to seed treatments.

INTRODUCTION

We undertook this research to determine whether the germination environment or the application of thiram as a seed protectant would affect dormancy of peanut seed. For several years we had conducted tests on dormancy of peanut seed in a seed germinator in our laboratory, and all seed had been treated with thiram. Toole (1) and coworkers reported that ethylene gas at a concentration of 100 ppm in air was effective in breaking dormancy of peanut seed. Recently Ketring and Morgan (2) reported that a peanut seed during germination gives off a burst of ethylene at about the time the radicle emerges from the seedcoat, and that as little as 3.5 ppm of exogenous ethylene could induce an otherwise dormant seed to germinate. We wondered if seed that germinated in our tests in the germinator might have given off enough ethylene to have induced dormant seed to germinate and to that extent might have given us erroneous information about the dormancy status of seed under investigation. In addition, during a discussion of results of research on seed dormancy at the APREA meeting in San Antonio, Texas in 1970, an unqualified statement was made that the seed protectant thiram was effective in breaking dormancy of peanut seed. Accordingly, we investigated the extent to which seed treatment and the

germination environment might influence the dormancy of seed of different genotypes of Spanish, Valencia, and Virginia type peanuts.

MATERIALS AND METHODS

Seed Sources

Seed used were from the 1969 and 1970 crops grown at the Tidewater Research Station, Holland, Virginia under cultural practices that are recommended for production of peanuts in Virginia. At maturity, plants were dug with a mechanical digger-shaker. For prompt curing, pods were hand-picked from a portion of the plants of each cultivar immediately following digging, and the remainder of the plants were placed on field stacks for curing. Hand-picked pods were transported to Beltsville, Maryland, and were cured in thin layers on the floor of an attic where air at a temperature of about 21 to 32 C was circulating vigorously. Occasionally the air temperature was as high as 35 C for a short period of time. Time from digging to completion of curing under these conditions in 1970 was 8 days for Spanish and 10 days for Virginias. Stack curing was for 6 weeks in 1969 and 7 weeks in 1970. Plants in stacks were picked with a stationary carding-type mechanical picker. All seed used in the study were carefully hand shelled and graded, and only sound mature seed were included in the tests.

Genotypes

Our tests included 12 Spanish, 1 Valencia, and 19 Virginia genotypes. The Spanish were Starr, Argentine, Comet, Spanhoma, Tifspan, Spancross, Improved Spanish, Georgia C32S-39 and PI's 248759, 268644, 268689, and 268771B. The Valencia was Tennessee Red. The Virginias were NC 4X, NC 5, NC 13, NC 17, Georgia 119-20, Virginia Bunch 67, Virginia Bunch 46-2, Virginia 56R, Virginia 61R, Holland Station Runner, Dixie Runner, Early Runner, Florunner, Southeastern Runner 56-15, Florigiant, Florida 439-16-6, and PI's 277188, 290650, and 319178S5.

Seed Treatments

Seed treatments involved were (1) no treatment and (2) the application of thiram as Arasan-75¹) at the rate of 6 ounces per 100 pounds of seed.

Germination Environments

Seeds were tested for dormancy in a commercial type germinator in the laboratory and in a sandbed in the greenhouse. In the germinator, where temperature averaged 26±1.5C, seed were placed between layers of wet germination paper on wire trays. Additional water was needed. Germination counts were recorded after 3 days. Any seed with a radicle that had pierced the seedcoat was considered to have germinated. In the greenhouse seed were spaced 1.4" apart and 1.0-1.25" deep in moist medium fine sand, with rows 3" apart. Air temperature in greenhouse was between 22 and 27C. Germination counts were made after 10 days.

Sampling

We used 4 samples of 25 seed each for each genotype-seed-treatment combination in each germination environment in 1970 tests with promptly cured Spanish, Valencia, and Virginia genotypes. We used 8 samples of 25 seed each in the test with 1970 stack-cured Virginias. For 1969 tests which included only treated seed, we used 4 samples of 50 seed each of each genotype in each germination environment.

RESULTS

Both germination environment and seed treatment had a striking influence on seed dormancy of 13 Spanish and Valencia genotypes (Table 1). When tested in a germinator, the dormancy of untreated seed averaged 61.5% higher than for treated seed. In the sandbed dormancy was 26.8% higher for untreated than for treated seed. Overall, dormancy was 57.3% higher in sandbed than in germinator, and 39.7% higher for untreated than for treated seed. All genotypes responded in a similar manner to the seed treatment and germination environment variables.

Results with 19 genotypes of promptly cured Virginia type peanuts were not as striking as those with the early-maturing Spanish and Valencia (Table 2). When seed of these promptly cured Virginia Genotypes were planted in sandbed, seed treatment had no effect on dormancy. When tested in the germinator, untreated seed showed 11.6% more dormancy than treated seed. Dormancy averaged 10% higher in the sandbed than in the germinator. Some genotypes responded more than others to the different germination environments.

Average dormancy level for seed of all but one of 17 of the Virginia genotypes decreased sharply after 178 days of storage at 4 C and 65% relative humidity, but the average relative response to seed treatment and germination environment was essentially the same as that of the freshly cured seed, except that the effect of seed treatment was not significant in either germination environment (Table 3). The sandbed gave 20% more dormant seed than the germinator. Some genotypes responded to a greater extent than others to the different germination environments.

However, dormancy of 1969 stack cured treated seed of 15 of these Virginia genotypes averaged 30% higher in the sandbed (49.6%) than in their germinator (38.6%). Some genotypes reacted more than others to the germination environments.

When 1970 stack cured seed of the 19 Virginia genotypes were planted in a sandbed without treatment, dormancy averaged 104% higher than for comparable treated seed tested in the germinator (44.1% vs 21.6%). Some varieties responded more than others to these contrasting treatments.

In addition, we obtained information on the extent to which seed treatment influenced dormancy of the Florunner cultivar when four tests of each of two different seed lots were planted in the sandbed. In all eight tests dormancy was higher for the untreated seed, ranging from minimum average increases of 17 and 22% up to averages of 80, 90, and 100%, with an overall average increase of 52%.

Table 1. Dormancy of Seed of 13 Promptly Cured Spanish and Valencia Peanut Genotypes When Tested Under Different Conditions

	<u>Percent Dormant Seed When Tested In</u>		
	<u>Germinator</u>	<u>Sandbed</u>	<u>Average</u>
Seed treated	20.8 ^{1/}	37.7	29.2
Not treated	33.6	47.8	40.7
Average	27.2	42.8	

LSD for averages (main effects) = 5.32

^{1/} Each value based on 1,300 seed - 100 seed of each of 13 genotypes

Table 2. Dormancy of Seed of 19 Promptly Cured Virginia Peanut Genotypes When Tested Under Different Conditions

	<u>Percent Dormant Seed When Tested in</u>		
	<u>Germinator</u>	<u>Sandbed</u>	<u>Average</u>
Seed treated	78.3 ^{1/}	91.3	84.8
Not treated	87.4	90.9	89.1
Average	82.8	91.1	

LSD for averages (main effects) = 3.62

LSD for individual treatment combinations = 3.58

^{1/} Each value based on 1,900 seed - 100 seed of each of 19 genotypes

Table 3. Dormancy of Seed of 17 Promptly Cured Virginia Peanut Genotypes After Storage at 40 F for 178 Days and Tested Under Different Conditions

	<u>Percent Dormant Seed When Tested in</u>		
	<u>Germinator</u>	<u>Sandbed</u>	<u>Average</u>
Seed treated	32.0 ^{1/}	39.3	35.7
Not treated	33.8	39.7	36.8
Average	32.9	39.5	

LSD for averages (main effects) = 5.6

^{1/} Each value based on 1,700 seed - 100 seed of each of 17 genotypes

DISCUSSION

Under conditions of our tests, dormancy of seed of promptly cured Spanish and Valencia genotypes was influenced substantially by germination environment and seed treatment. Dormancy of treated seed of 1969 stack cured Virginia genotypes was influenced similarly by germination environment. Dormancy of seed of 1970 stack cured Virginia genotypes was modified strikingly by contrasting seed treatment and germination environment combinations. However, promptly cured Virginia genotypes responded not at all or to only a limited extent to germination environments and seed treatments when tested 2 weeks after completion of curing or after 178 days in cold storage. All Spanish and Valencia genotypes responded in a similar manner to the germination environment and seed treatment variables. Not all of the Virginia genotypes were affected to the same degree by the germination environments, but all responded in a similar manner to seed treatment. The contrast in the response of promptly cured Spanish and Valencias and stack cured Virginias to the response of promptly cured Virginias is striking. Further tests will be required to determine whether such a contrasting response to germination environment and seed treatment is typical for the genotypes involved.

We have no logical explanation for the results obtained in our tests. If ethylene given off by seed that germinate inside a germinator stimulates peanut seed to germinate that would remain dormant otherwise, why was not such a response evident for seed of the 19 promptly cured Virginia genotypes when tested after 178 days in cold storage? Only 17% of the promptly cured seed of these genotypes germinated when tested in the germinator 2 weeks after completion of curing, but after 178 days in cold storage 67% of the seed germinated. The seed protectant, when effective in influencing dormancy, probably altered the balance between growth-promotion and growth-inhibiting substances within the seed that determines whether a seed will germinate or remain dormant when placed in an environment that is favorable for germination. An explanation for the results of our tests probably must await the elucidation of the molecular basis for dormancy in peanut seed. Our results indicate the importance of full identification of conditions under which tests are run in publication of results of research on peanut seed dormancy.

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MICROBIAL INFESTATION OF PEANUTS AS RELATED TO WINDROW-CURING CONDITIONS ¹⁾

by

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ABSTRACT & PAPER

Fungal and bacterial damage to peanuts during windrow-curing was determined by: visual examination of pods and kernels, noting the degree of kernel infestation, and determination of germination percentages. Peanuts removed from the field at digging time and cured on the vine under cover were superior in quality. Infestation and physical damage to windrow-cured peanuts by fungi and bacteria were found to be related to: inoculum potential of specific species, degree of pod damage before and during harvest, pod location within the windrows, and climatic conditions during curing. Peanuts which were cured on the soil surface or inside the windrow during shower periods were more severely infested with bacteria and fungi compared to those cured in the upper part of the windrow. Peanuts from inverted windrows dried more uniformly under adverse drying conditions and were less severely infested with fungi. Drying peanuts within the field in random or inverted windrows under high temperatures and/or low humidities caused an increased level of sound splits when shelled. There was an inverse relationship between bacterial infestation and percent germination.

INTRODUCTION

Loss of peanut quality during windrow curing is of considerable concern to the peanut industry. These losses may lower yields and also render the processed products less suitable for food and feed because of lowered nutritional value and possible presence of mycotoxins. Reduction in nutritional value is primarily caused by soil-borne microbial agents capable of utilizing the peanut as a nutrient source. The degree of such damage is influenced by those factors which restrict plant growth and favor microbial activity. For example, environmental factors such as temperature and humidity level influence peanut susceptibility, microbial growth rate, and mycotoxin accumulation (8).

The extent of microbial damage in the windrows has been reported to be reduced by placing the peanut pods in an exposed position (inverted windrow) as opposed to placing them in a random windrow (3, 5). Inverted windrow peanuts are in a more favorable drying position since air movement around them is greater, humidities are lower several inches above the soil surface, and temperatures are lower within these kernels. Thus improved quality appears to be related to field exposure time since it has been shown that peanuts dry faster and more uniformly in inverted windrows compared to those dried in random windrows when favorable drying conditions are interrupted by rain (5, 7).

Susceptibility of peanuts within the windrow to *Aspergillus flavus* and other fungi has been found to be related to the kernel moisture, extent of pod damage,

and is time dependent (3, 4, 6). Rapid drying is desirable from the standpoint of reducing microbial activity; however, when the drying rate is excessive considerable physical damage to the kernels may result (1, 2). An intermediate drying rate, rapid enough to prevent microbial damage and slow enough to limit physical damage appears to be a necessary requirement for quality maintenance.

The objectives of these experiments were to relate drying methods and kernel moisture levels to degree of kernel infestation by bacteria and fungi and changes in quality as measured by aflatoxin analyses, germination counts, and sound splits obtained in shelling.

PROCEDURES

Peanuts used in these studies were grown in South Central Texas at Yoakum and in North Central Texas at Stephenville using recommended agronomic practices. They were dug with a conventional two-row digger-shaker or a commercial digger-inverter unit. In some tests the inverted windrows were established by hand where the inverter was unavailable. In either case the pod arrangements were similar.

Temperature records were obtained by inserting thermocouples inside the basal kernels of pods located at specific positions in each windrow type. All readings were recorded on a Class 16 Honeywell Recording Potentiometer located in the field.

Treatments included the following: partially cured in random and inverted windrows, partially cured in random and inverted windrows with drying completed in bags left in the field (1970 only) and completely cured in random and inverted windrows. Control samples were obtained from peanuts which were removed from the field at digging time and dried on the vine in forced-air dryers, with one exception. At Stephenville in 1970 control samples were obtained from peanuts combined 24 hours after digging and dried in forced-air dryers. Within these forced-air dryers heat was added when the relative humidity was above 70%, and the temperature was maintained below 97° or 14° above the outside air.

Peanut samples partially field-cured in random and inverted windrows were combined when the peanut moisture reached approximately 20%. These partially cured peanuts were dried to a safe moisture level for storage (7-10%) in forced-air dryers and in 1970 they were placed in burlap bags and left in the field to continue drying. Drying rates were calculated by measuring the moisture levels at specific intervals in the curing process and dividing these values by expired time.

Representative samples for microbial and germination analysis were collected throughout the harvest season and analyzed as follows. Kernels for microbial analysis were surface-sterilized by successive one minute immersions in 70% ethyl alcohol, 10% commercial bleach (5.25% active sodium hypochlorite) and sterile distilled water. These kernels were then plated on rose bengal-streptomycin agar and incubated at 30 C for 7-10 days.

Germination tests were conducted by placing kernels in rolled towels within a germinator set at alternating temperatures (68 F, for 16 hours and 86 F for 8 hours). Germination percentages were determined after 14 days.

Sound splits were determined by using the standard procedure of the Consumer and Marketing Service (9). All kernels which had been split or broken by the sample sheller and were not dirty, discolored, sprouted or damaged by molds and/or insects were included in the sound splits.

RESULTS AND DISCUSSION

The degree of fungal and bacterial infestation in kernels harvested from the Yoakum windrows in 1967 was influenced by several showers immediately following digging. Drying rates during the first four days after digging were only 0.014 %/hr and 0.017 %/hr in the random and inverted windrows respectively, a 22% more rapid drying rate for inverted windrow peanuts. Consequently, in order to reduce possible mold damage, the random windrows were turned. As the drying conditions improved the random windrow drying rates increased to 0.11 %/hr and the inverted to 0.13 %/hr, during the final four days of curing. This represents an 18% increase in drying rates of the inverted windrows over the random windrow treatments even though the random windrows were again turned during the last four days of curing.

These low drying rates during the first four days appeared to be conducive to the growth of *Rhizopus*, especially in those pods in contact with the soil surface. Random windrow samples exposed for four days in the field and then dried within forced-air dryers had a 12% infestation of *Rhizopus*, a level considered above normal (Table 1). In comparison 4.5% of the kernels from peanuts completely field cured in random windrows were infested with *Rhizopus*. Also increased levels of *Aspergillus* and *Penicillium* infestation appeared to have developed within these forced-air dryers. The degree of infestation in kernels from peanuts dried on the vine with forced air for eight days (Table 1, column 1) was comparable to the infestation in those kernels from the inverted windrows (Table 1, column 4). Also bacterial infestation was highest (7.0%) in those kernels from the forced-air dryer. Evidently bacterial activity was restricted by turning the random windrows to speed drying. It is thought that bacterial infestation may be related to the degree of physical damage to the kernels. In some cases bacterial invasion appeared to occur after fungal invasion. When bacterial growth became extensive within a kernel, fungal growth was restricted. When these kernels are plated out on a nutrient medium fungal growth may be inhibited. Consequently when bacterial growth becomes extensive the degree of fungal infested kernels appeared to decrease, thus fungal counts alone do not always reflect actual infestation levels.

The extent of bacterial damage to peanuts is believed to be quite extensive during adverse drying conditions. The most frequently isolated bacterial are *Bacillus subtilis* Cohn Prazmowski and *Bacillus megaterium* de Bary. In addition other bacterial species (or species groups) have also been identified. These bacteria are *Bacillus pumilus* Gottheil, *Bacillus cereus* Frankland and Frankland, *Bacillus polymyxa* (Prazmowski) Migulo, *Arthrobacter citreus* Sacks, some Flavo-bacteria species, and members of the *Alcaligenes-Achromobacter* group.

The degree of bacterial and fungal infestation within a given kernel sample generally influenced the germination count. As noted in Table 1, where the fungal infestation was the greatest (22.5%) the germination count was the lowest (90.7%).

Bacterial and fungal infestation was slightly higher in peanuts harvested at Yoakum in 1968 compared to those harvested in 1967. Peanuts completely dried in the field for 171 hours in inverted windrows (Table 2, column 8) contained 14% fungal infested kernels and 42% bacterial infested kernels. In comparison peanuts cured for 77 hours in inverted windrows and then forced-air dried for 79 hours contained 11.5% fungal and 8% bacterial infestation. The increased bacterial infestation is believed to be related to physical changes in

Table 1. Degree of fungal and bacterial infestation in kernels harvested from random and inverted windrow plots at Yoakum, Texas, 1967.

Fungi isolated and other qualities	Forced-air dryer ^{1/} 8 days %	Random Windrow 4 days dryer 3 days %	Random Windrow 8 days %	Inverted Windrow 8 days %
<u>Alternaria</u>	0	0.5	0.5	0
<u>Aspergillus</u>	0.5	1.7	0.8	0.5
<u>Chaetomium</u>	3.0	2.0	1.2	1.5
<u>Cladosporium</u>	0	0	0	0.5
<u>Fusarium</u>	0.7	1.2	1.5	0.5
<u>Macrophomina</u>	0.7	0.7	2.0	1.5
<u>Mucor</u>	0	0	0.7	0
<u>Nigrospora</u>	0.2	0	0	0
<u>Penicillium</u>	1.7	3.5	1.2	2.7
<u>Rhizopus</u>	2.5	12.0	4.5	2.0
<u>Sclerotium</u>	0.2	0.5	0.2	0.5
<u>Thielavia</u>	0.2	0.2	0	0
<u>Trichoderma</u>	0	0.2	0	0.5
Total Fungal Infestation	9.7	22.5	12.6	10.2
Total Bacterial Infestation	7.0	5.2	4.0	1.2
Germination Percent	98.2	90.7	93.1	96.2
Sound Splits	1.9	2.9	2.2	3.9
Aflatoxin ppb	Trace	5.9	Trace	0

^{1/} Peanuts removed from the field attached to the vine and dried under cover with forced air and supplemental heat.

^{2/} Aflatoxin levels reported in parts per billion (ppb).

kernel structure and seed coat damage after prolonged exposure in the field. The second highest level of bacterial infestation was detected in those kernels dried with forced-air after having been combined immediately after digging (Table 2, column 2). Excessive physical pod damage may occur when high moisture peanuts (30-45%) are combined. Consequently excessive bacterial and fungal invasion of kernels may occur in forced-air dryers.

Kernels examined after 97 hours of windrow exposure and 46 hours of cold storage (40°F) contained an abnormally high level of *Aspergillus* isolates, 20.5 and 16.0%. However, bacteria failed to grow from these kernels following cold storage.

All levels of infestation observed in the kernels from the seven treatments were higher than that observed in the vine-dried check kernels (Table 2, column 1) which contained an average of 5% fungal infested kernels and no bacterial infested kernels. Similar results have been obtained for several years where the peanuts dried on the vine under cover with forced-air are superior as far as degree of microbial infestation, germination levels, and extent of sound splits when shelled are concerned. Peanuts dried in the field or in forced-air dryers are generally inferior in quality compared to those dried on the vine under cover.

The extent of fungal and bacterial infestation in 1969 (Table 3) indicated that exposure for 80 hours, where the drying rates were above 0.40 %/hr, can result in considerable damage. The extent of such damage is best noted by the high level of bacterial infestation detected in kernels from random and inverted windrows.

The highest bacterial infestation (59%) was detected in peanuts cured within the random windrows. Because of excessive bacterial activity only 7% of these kernels had fungi growing from them. Such increased levels of bacterial infestation occurred following a curing period when kernel temperatures (Table 5) were above 90 F, the maximum level recommended to prevent excessive physical damage. Kernels exposed to direct sunlight had an average day temperature of 107 F and maximum of 123 F. Even higher temperatures (up to 132 F) were recorded in those kernels in contact with the soil surface. As a result drying rates during the first 52 hours of windrow exposure (Table 3) averaged 0.59 and 0.60 %/hr, levels capable of causing excessive kernel shrinkage during curing. Peanuts harvested after 80 hours of windrow exposure had 6.2 and 7.5% sound splits and germination counts were between 70 to 72% compared to 2.4% sound splits and 93% germination for the check treatments. Losses in quality were greater in those kernels harvested from the random windrows because more peanuts were in contact with the soil surface.

In comparison to the peanuts collected from Yoakum in 1969, the Stephenville peanuts were subjected to different climatic conditions. Kernel temperatures were lower because of overcast conditions, several light showers, light winds, and an average day temperature of 68 F and an average night temperature of 50 F (Table 5). Relative humidities during the windrow curing period ranged from a low of 16% to a high of 70% with an average of 41%. Under these conditions initial drying rates (during the first 95 hours) averaged 0.14 %/hr and after 269 hours averaged 0.074 to 0.085 %/hr (Table 4, column 3). Such slow drying rates during the windrow exposure period provided desirable conditions for fungal and bacterial activity. The highest levels of infestation were detected in those kernels from the bottom of the random windrows. Kernels taken from peanuts completely dried within the random windrows had a 12 % infestation of fungi and a 40% infestation of bacteria. Even

Table 2. Degree of fungal and bacterial infestation in kernels harvested from random and inverted windrow plots at Yoakum, Texas, 1968.

Fungi isolated and other qualities	Control Vine dried 77 hrs.	Freech dug and combined dried 174 hrs.	Partially windrow cured Random 97 hrs.		Partially windrow cured Inverted 77 hrs.		Windrow 171 hrs.	
	%	%	Dryer 79 hrs %	Gold store % 46 hrs	Dryer 79 hrs %	Gold store % 46 hrs	Random %	Inverted %
<u>Alternaria</u>	0	0	0	0	0	0	0.5	0
<u>Aspergillus</u>	0	1.0	0.5	20.5	0.5	16.0	1.0	0.5
<u>Chaetomium</u>	0.5	8.5	4.0	0	5.5	0	1.5	5.0
<u>Cladosporium</u>	0	0	0	0.5	0	0.5	1.0	0.5
<u>Fusarium</u>	0	0	1.0	0	0	1.0	0.5	0.5
<u>Macrophomina</u>	1.0	0	1.0	0	0	0	2.0	1.0
<u>Nigrospora</u>	1.0	3.0	1.5	0	0.5	0.5	0.5	4.5
<u>Penicillium</u>	0.5	2.5	0.5	2.0	2.0	3.0	2.0	0.5
<u>Phisopsis</u>	0	0	0	0	0	0	0.5	0
<u>Sclerotium</u>	1.5	0.5	0.5	2.5	2.5	4.0	1.0	0
<u>Thielavia</u>	0.5	0.5	0.5	0.5	0.5	0	0	1.0
<u>Trichoderma</u>	0	0	0	0.5	0	0	0	0.5
Other	0	0.5	2.5	0.5	0	0	0	0
Total Fungal Infestation	5.0	16.5	12.0	26.0	11.5	25.5	10.5	14.0
Total Bacterial Infestation	0.0	19.0	13.5	0.0	8.0	0.0	11.0	42.0
Germination percent	93	-	86	-	93	-	81	89
Sound split %	1.4	-	2.1	-	2.0	-	4.9	6.1

1/ Peanuts removed from the field attached to the vine and dried under cover with forced air and supplemental heat.

Table 3. Characteristics of peanuts harvested from windrow tests conducted at Yoakum, 1969.

Treatments ^{1/}	Field Exposure hrs	Peanut moisture ^{2/} following field curing %	Average field drying rate %/hr	Kernel moisture following drying %	Sound splits %	Germination %	Fungal Infestation %	Bacterial Infestation %
Vine-dried with forced air	0	-	-	8.1	2.4	93	14	6
Partially field cured in random windrows	52	18.1	0.59	8.0	3.3	78	13	11
Partially field cured in inverted windrows	52	17.7	0.60	8.0	4.2	83	20	2
Completely field cured in random windrows	80	10.8	0.47	8.1	7.5	70	7	59
Completely field cured in inverted windrows	80	11.4	0.47	7.9	6.2	72	14	26

1/ Drying completed in forced air dryer with supplemental heat when the relative humidity of the atmospheric air was above 70 percent.

2/ Initial peanut moisture when dug 48.9%.

those samples from inverted windrows were becoming infested with bacteria and fungi when harvested. Those peanuts partially dried in the inverted windrows and then forced-air dried were superior in quality compared to those dried completely in force-air dryers or those dried completely in the windrows.

Drying rates during the 1970 harvest season at Yoakum were somewhat lower compared to 1969. After 70 to 72 hours of windrow exposure the drying rates were 0.40 and 0.41 %/hr for the random and inverted windrow samples respectively (Table 6). This drying rate was slowed after 144 hours by a 0.7 inch rain which raised the peanut moisture level and high humidities (for 48 hours), *Cladosporium* grew over the vines and pods giving the whole windrow a gray-green cast. After 244 hours of windrow exposure the kernels had become infested with fungi and bacteria to levels ranging from 14 to 36%. Those pods in contact with the soil surface were the most severely damaged and infested with fungi. Some increase in the degree of fungal infestation was noted within those samples harvested from the inverted windrows; however most appeared quite sound. These increased levels of microbial infestation appeared to have exerted an adverse effect on germination. All kernels germinated poorly with a maximum of 81%, noted in those samples cured on the vine with natural air (Table 6). The lowest germination levels were recorded in kernels from the windrow tops where the random samples averaged 54% and the inverted samples 59%.

In addition some of the partially windrow-cured peanuts were combined and placed in new burlap bags and left in the field for completion of drying. Shortly after placement within these bags the 0.7 inch rain occurred. A check of the moisture levels within the bagged peanuts indicated that very little increase occurred. Apparently the new burlap acted as a protectant to the peanuts. Under these drying conditions the peanuts reached a moisture level of 11 to 12% approximately 30 hours before the same levels were reached in the random windrow-cured peanuts on the soil surface. Also these peanuts were less severely infested with bacteria compared to the partially field cured samples which were dried further in forced-air dryers. While in the dryers bacterial infestation increased indicating that the air stream may have contained viable bacterial spores which were forced into damaged peanut pods.

Drying conditions at Stephenville in 1970 were even less desirable than in 1969. After 430 hours of windrow exposure the peanut moisture levels reached 8 and 9% (Table 7, column 2). However with these slow drying rates less microbial damage occurred as evidenced by the higher germination percentages and lack of bacterial infestation. The lowest germination was noted in the check samples where peanuts with a moisture level of 31.8% were combined and dried in sacks within a forced-air dryer. These check samples were also severely infested with bacteria. Such increased infestation is attributed to physical damage of the pods during combining which allowed penetration by bacteria and fungi. In general these Stephenville peanuts had less sound splits and higher germinations, compared to Yoakum peanuts, even though up to 20% of some kernel samples contained fungal infestation.

Again the partially cured samples, where curing was completed in burlap bags, were equal in quality to those harvested from the windrows and superior to the check samples. The low level of sound splits in the bag-cured samples (2.1 and 2.5% compared to 7.8% for the check samples) indicated that higher quality peanuts may be obtained when drying is completed in bags.

Table 4. Characteristics of peanuts harvested from windrow tests conducted at Stephenville, 1969.

Treatments ^{1/}	Field exposure hrs	Peanut moisture following field curing %	Average field drying rate %/hr	Kernel moisture following drying %	Sound splits %	Germination %	Fungal infestation %	Bacterial infestation %
Vine dried with forced air	0	-	-	7.4	7.3	99	6	12
Partially field cured in random windrows	95	24	0.14	7.3	4.3	97	Top 12 Bottom 21	0 2
Partially field cured in inverted windrows	95	24	0.14	7.5	4.3	98	17	0
Completely field cured in random windrows	249	17	0.074	7.7	3.7	81	Top 19 Bottom 12	20 40
Completely field cured in inverted windrows	269	14	0.085	7.2	3.7	89	17	17

^{1/} Drying completed in forced air dryer with supplemental heat when the relative humidity of the atmospheric air was above 70 percent.

^{2/} Initial peanut moisture when dug 36.9%.

Table 5. Kernel temperatures in peanuts located at different points within the random and inverted windrows cured at Yukus and Stephenville, Texas, 1969.

Pod Location	Yukus temperatures				Stephenville temperatures			
	Average Day °F	Average Night °F	Maximum °F	Minimum °F	Average Day °F	Average Night °F	Maximum °F	Minimum °F
Direct sunlight on soil surface	114	80	132	72	68	50	86	30
Direct sunlight at top of windrow	107	79	123	72	68	50	87	23
Shaded within the windrow	104	80	123	73	67	51	87	26
Dry-bulb temperature of ambient air	92	80	102	71	66	52	82	28

^{1/} Average dry temperatures were between 8 AM and 6 PM.

Table 6. Characteristics of peanuts harvested from windrow tests conducted at Yukus, 1970.

Treatments ^{1/}	Field exposure hrs	Peanut moisture following field curing %	Average field drying rate %/hr	Kernel moisture following drying %	Sound splits %	Germination %	Fungal infestation %	Bacterial infestation %
Vine dried with forced air	0	-	-	8.0	0.8	81	18	14
Partially field cured in random windrows	70	20.2	0.40	8.4	1.3	65	14	25
Partially field cured in inverted windrows	72	18.6	0.41	7.7	1.4	68	6	28
Completely field cured in random windrows	244	Top 6.5 Middle 9.1 Bottom 12.0	0.17 0.16 0.15	6.5 9.1 12.0	1.9 1.6 1.8	54 77 66	14 25 36	30 11 13
Completely field cured in inverted windrows	246	6.6	0.17	6.6	2.4	59	20	18
Partial random windrow and sacked cured	214	12.0	0.16	12.0	1.1	69	10	12
Partial inverted windrow and sacked cured	216	11.0	0.17	11.0	1.0	60	11	18

^{1/} Drying completed in forced air dryer with supplemental heat when the relative humidity of the atmospheric air was above 70 percent.

^{2/} Initial peanut moisture when dug 48.3 percent

Table 7. Characteristics of peanuts harvested from windrow tests conducted at Stephenville, 1970.

Treatments ^{1/}	Field Exposure hrs	Peanut moisture ^{2/} following field curing %	Average field drying rate %/hr	Kernel moisture following drying %	Sound drying splits %	Germination %	Fungal infestation %	Bacterial infestation %
Combined and dried with forced air	26	31.8	0.43	10.7	7.8	89	18	15
Partially field cured in random windrows	95	Top 25.1 Bottom 23.5	0.19 0.20	10.1	1.2 1.2	95	10 13	0 3
Partially field cured in inverted windrows	95	24.6	0.19	9.9	2.5	97	17	1
Completely field cured in random windrows	430	Top 8.5 Bottom 8.9	0.08 0.08	8.5 8.9	2.1 1.6	98 98	20 14	0 2
Completely field cured in inverted windrows	430	8.4	0.08	8.4	2.1	98	13	4
Partial random windrow and sack cured	334	10.9	0.09	10.9	2.1	96	20	0
Partial inverted windrow and sack cured	334	10.2	0.10	10.2	2.5	98	11	13

^{1/} Drying completed in forced air dryer with supplemental heat when relative humidity of the atmospheric air was above 70 percent.

^{2/} Initial peanut moisture when dug 42.1 percent.

CONCLUSIONS

1. Peanuts dried in inverted windrows are generally less severely damaged by bacteria and fungi compared to those dried in random windrows.

2. Bacterial infestation of peanuts can be quite serious in peanuts on the soil surface in random windrows and in peanuts combined at high moisture levels and cured in forced-air dryers.

3. Germination levels are more adversely affected by bacterial infestation compared to fungal infestation.

4. Peanuts which absorb moisture after having dried to levels below 20% may become severely infested with bacteria and fungi if drying rates are slowed.

5. The most suitable method for drying peanuts was on the vine under cover with forced natural air and supplemental heat added when the relative humidity was above 70% and air temperature was controlled.

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**EFFECTS OF DIGGING TIME ON PEANUT RECOVERY YIELD,
SALVAGED YIELD AND QUALITY -
A PROGRESS REPORT**

by

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INTRODUCTION

The initial peanut harvesting operation consists of digging which uproots the plants, dislodges the soil, and deposits the plants in a windrow to partially field cure and dry before combining. Peanut digging losses consist of pods which have shed from the plants by disintegration of the pegs, plus those which become separated in the uprooting, lifting and windrowing operation. Further losses may occur during the combining and curing operation but this study is concerned only with losses related to the digging operation.

Studies of peanut digging losses with Va. 61R variety were conducted in 1967, 1968 and 1969. When dug approximately 2 weeks before normal digging date, at normal digging date, and 2 weeks after normal digging date, average field losses were 10, 16 and 28 percent, respectively. The 3-year study showed that approximately 80 percent of the pods lost were below the soil surface. These results were obtained from 216 plots, each consisting of two 36-inch spaced rows, 7.2 feet long. Limited studies showed that about 40 percent of the losses are 2 to 4 inches below the soil surface.

Peanuts are an indeterminate plant. Seed maturity begins in August and continues until the crop is dug or killed by disease or frost. As each peanut matures, the peg connecting it to the plant may deteriorate due to age, disease, insect damage or other causes. The quantity of peanuts lost is influenced greatly by time of digging and physical condition of the pegs and plants. Peanut digging in Virginia normally begins about Sept. 20 and continues until about Oct. 20.

Optimum digging date is that time when the crop should be dug to give the maximum recovery yield and highest quality. Digging too early is one way to avoid high field losses but may also result in low yield and quality. Digging later than the optimum date results in higher field losses and lower recovery yield due to additional shedding of the mature peanuts. Some of the factors that influence the optimum time of digging are (1) ratio of mature peanuts to immatures; (2) physical condition of the plants, pegs, and peanuts; (3) variety; (4) disease; and (5) weather.

A peanut digger that will significantly reduce field losses below that of present commercial diggers is desired. Field digging losses may be substantially reduced by developing peanut digging equipment which recovers the peanuts which are lost, or by developing varieties having peanuts well attached to the plants at the time of digging. If current field losses with existing varieties and conditions are to be greatly reduced, equipment must be designed to save peanuts already shed, in addition to those that become separated from the plants when digging. Equipment to meet this requirement is expected to have higher initial, operating, and maintenance cost and less field operating capacity than the present digger. To justify this equipment there must be a demand for the extra

peanuts, their quality must be acceptable, and the total recovery cost should not exceed their value.

An experiment was initiated in 1970 to evaluate both the quantity and quality of peanut losses from two digging methods.

PROCEDURE

Peanuts were grown at the Tidewater Research Station using practices currently recommended by the Virginia Agricultural Experiment Station. Three varieties of peanuts were included in the study, Va. 61R, Florigiant, and NC 17. Each variety was planted on May 13 in rows spaced 36 inches apart. Each plot consisted of two rows, 14.52 feet long (.002 acre), and treatments were randomized with three replications.

Digging dates were at 3-day intervals commencing Sept. 29 and ending Oct. 20. On each of the eight different digging dates, three replications of each variety were dug with a two-row commercial digger-inverter. A 6-foot wide USDA plot salvager followed the digger to collect the detached peanuts on and below the soil surface. Also on each of these same digging dates, three replications of each variety were dug with USDA's recently developed experimental equipment which combines digging and salvaging in one operation.

This study determined the quantity of peanuts attached to the vines after digging and the quantity collected by salvaging with each of the two digging methods. Thus, four samples were collected consisting of (1) vine yield from the commercial digger, (2) salvaged yield from the commercial digger, (3) vine yield from the digger-salvager and (4) salvage yield from the digger-salvager. The salvaged peanuts were collected at the time of digging or within 24 hours after digging to avoid possible post-digging deterioration.

Peanuts attached to the vines after digging were picked off by hand. The collected salvage samples contained good quality peanuts, soil particles, clods, leaves and damaged peanuts. The foreign material was separated by hand and discarded. All plot samples were kept separated and were dried with ambient air. Quantity and quality of the peanuts were determined after drying to equilibrium moisture or about 8 percent wet basis.

In order to provide adequate size samples and reduce by one-half the number of samples for quality evaluations and analysis by cooperators, it was necessary to combine plot yields after drying as follows:

(1) For each peanut variety, all peanuts picked from the vines on a given day were mixed to make one composite vine sample. Thus, three varieties and eight digging dates yielded 24 composite samples that were picked from the vines.

(2) All salvaged peanuts from each variety on a given day were likewise combined and yielded 24 composite samples for analysis.

Quality evaluations included farmers' stock grade, price per pound, germination, molds, aflatoxin, rancidity, fat acidity and CLER flavor. Peanuts used for farmers' stock grade were delivered unshelled. All other samples were shelled with a Federal-State sample sheller before delivery for quality evaluations. Soil moisture was determined daily throughout the digging period.

RESULTS

The 6-ft wide peanut salvager which followed the commercial peanut digger collects about 98 percent of the peanuts left on and in the soil. Peanuts recov-

ered with this salvager effectively represent normal digging losses with considerable accuracy. The two-row combination peanut digger-salvager collects soil and peanuts from a 28-inch width band per row. Thus, its salvaging efficiency is less than that of the 6-foot salvager. The conveyor bar speed on the digger-salvager exceeds the equipment ground speed to enable lifting soil at a faster rate for increasing machine capacity. Although this difference in speed separates more peanuts from the plants than the commercial digger, a high percentage of these detached peanuts is collected by the salvaging components.

Soil sifting with both types of salvaging machines performed best in dry, sandy soil. When operated in damp soil, screen congestion occurred, and the equipment became inoperative. All salvaged peanut samples contained excessive quantities of foreign material consisting of peanut leaves, soil and clods.

Soil Moisture

Soil moisture percentages, d.b., are shown graphically in Figure 1. Moisture ranged between .8 and 15.0 percent with an overall average of 7.2, 6.6, and 5.4 percent in the Va. 61R, Florigiant, and NC 17 test areas, respectively. Average moisture in the NC 17 test area was significantly different from the moisture in the Va. 61R and Florigiant test areas. September and most of October were dry except on September 28, 1 day before the test, 1.37 inches of rainfall occurred. From September 29 to October 20 rainfall was .36 inch on October 16 and .04 inch on October 17.

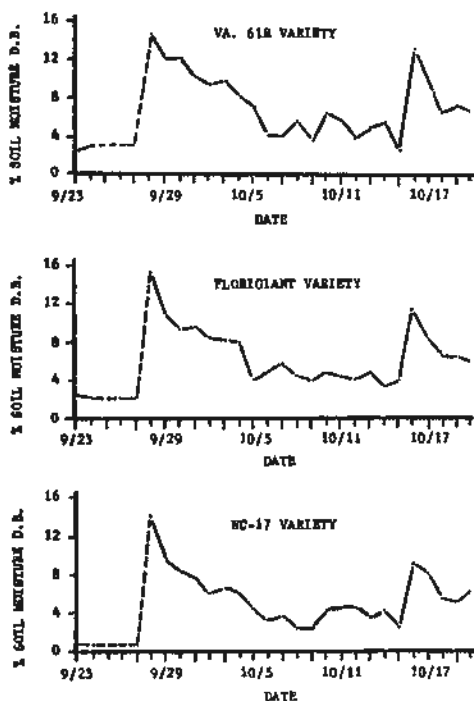


Figure 1. Soil moisture. Holland, Va. 1970

Peanut Yield

Vine and salvage yield from the three varieties, eight digging dates and two digging methods are shown in Table 1.

Commercial digger vine yield: Peanut vine yield from the commercial digger showed no significant differences attributed to any of the eight digging dates with Va. 61R or Florigiant varieties. NC 17 variety showed a significant vine yield difference due to dates. Yield from those peanuts dug September 29 through October 14 was significantly higher than those dug on October 17 and 20.

Digger-salvager vine and salvage yield combined: Yield from the digger-salvager did not show a significant difference due to either of the eight digging dates with any of the three varieties. The digger-salvager yield from the eight digging dates gave a highly significant increase over the yield from the commercial digger with all three varieties of peanuts. Average yield increase exceeded 500 lb/a with each variety.

Commercial peanut digger losses are not excessive if the peanuts are dug before pegs have deteriorated and are of a variety adapted to machine harvesting. For example, the bunch variety, NC 17, dug early (September 29 and October 2) with a commercial digger resulted in a loss of only 3.7 and 3.9 percent, respectively. Losses from late digging of this same variety (October 17 and October 20) were 26.2 and 34.2 percent, respectively.

The percentage of peanut losses from a commercial digger that may be saved with a digger salvager is determined as follows:

$$\frac{(\text{Digger-Salvager Total Recovery Yield}) - (\text{Commercial Vine Yield}) \times 100}{\text{Commercial Digger Losses}}$$

Application of the formula to the test results is:

Va. 61R variety = 67 percent
Florigiant variety = 88 percent
NC 17 variety = 85 percent
Average = 80 percent

The digger-salvager recovers approximately 80 percent of the expected losses occurring with a commercial digger.

Farmers' Stock Grade

Farmers' stock grades are shown in Tables 2, 3, and 4. No appreciable grade or price per pound differences were found between the vine and salvaged samples. No Segregation III peanuts were found in any of the vine or salvaged samples of either variety. 1) Va. 61R variety contained one sample of Segregation II (from salvaged peanuts) and 17 samples of Segregation I. Florigiant variety contained two samples of Segregation II (from salvaged peanuts) and 16 samples of Segregation I. NC 17 variety contained two samples of Segregation II (from salvaged peanuts) and 16 samples were of Segregation I.

Germination

Peanut seed germination percentages are shown in Table 5. Germination of the peanuts from the salvaged samples was about equal to those from the vine samples.

Table 1. Peanut yield (lb/a). Holland, Va. 1970

Digging Date	Commercial Digger			Digger-Salvager		
	Vine Yield	Salvage Yield	Total	Vine Yield	Salvage Yield	Total
<u>Va. 61R Variety</u>						
9/29	4073	552	4625	3270	581	3851
10/2	3652	518	4170	3114	532	3646
10/5	3165	692	3857	2717	804	3521
10/8	3916	464	4380	3178	854	4032
10/11	3367	830	4197	3061	806	3867
10/14	3172	1204	4376	3031	1144	4175
10/17	2869	1044	3913	3012	1399	4411
10/20	3166	1081	4247	2711	1437	4148
Avg	3422	798	4220	3014	945	3959
<u>Florigiant Variety</u>						
9/29	4509	312	4821	4085	821	4907
10/2	4583	384	4967	4255	662	4917
10/5	4642	570	5212	3930	673	4603
10/8	4512	633	5145	4039	925	4964
10/11	4500	823	5323	4134	906	5040
10/14	4795	670	5465	3887	1257	5144
10/17	4240	592	4832	4418	1162	5581
10/20	4412	887	5299	4279	1036	5335
Avg	4524	608	5132	4128	932	5060
<u>NC 17 Variety</u>						
9/29	4456	175	4631	4608	150	4758
10/2	4399	182	4581	4278	234	4532
10/5	4506	339	4845	4509	183	4692
10/8	4266	290	4556	4493	398	4891
10/11	4359	673	5032	3912	881	4793
10/14	4247	486	4733	3726	913	4639
10/17	3572	1271	4843	3390	918	4317
10/20	3169	1653	4822	3745	944	4689
Avg	4121	633	4754	4083	580	4663

Table 2. Farmers' stock grade, price per pound, and segregation, Va. 61R variety. Holland, Va. 1970

Digging Date	Fancy	ELK	Moisture		OK	SS	SMK	VD	CD	V+C	Hulls	Price/lb	Segregation
	%	%	%	%	%	%	%	%	%	%	%	c	
<u>Vines</u>													
9/29	73	27	5	4	1	68	1	0	1	26	13.56	I	
10/2	67	25	5	2	3	65	1	0	1	29	13.18	I	
10/5	75	23	5	3	1	67	0	0	0	29	13.21	I	
10/8	67	25	5	2	0	71	1	0	1	26	13.74	I	
10/11	69	29	4	1	2	68	1	0	1	28	13.57	I	
10/14	70	31	4	1	3	68	0	0	0	28	13.81	I	
10/17	72	33	4	3	1	67	1	0	1	28	13.43	I	
10/20	60	27	4	4	1	68	0	0	0	27	13.56	I	
Avg	69	27.5	4.5	2.5	1.5	67.7	0.6	0	0.6	27.6	13.50		
<u>Salvaged</u>													
9/29	66	60	4	1	1	76	0	0	0	22	15.56	I	
10/2	81	25	4	2	2	65	4	0	4	27	12.45	II	
10/5	80	26	4	1	2	70	2	0	2	25	13.75	I	
10/8	87	42	4	1	2	70	1	0	1	26	14.23	I	
10/11	86	32	4	1	3	71	1	0	1	24	14.38	I	
10/14	85	29	4	1	2	70	1	0	1	26	13.94	I	
10/17	84	31	4	3	1	70	1	0	1	25	13.95	I	
10/20	81	29	4	1	1	70	2	0	2	26	13.59	I	
Avg	81.2	34.5	4	1.3	1.7	70.2	1.5	0	1.5	25.1	13.98		

Table 3. Farmers' stock grade, price per pound, and segregation, Florigiant variety.
Holland, Va. 1970

Digging Date	Fancy	ELK	Moisture	OK	SS	SMK	VD	CD	V+C	Hulls	Price/lb	Segregation
	%	%	%	%	%	%	%	%	%	%	c	
<u>Vines</u>												
9/29	87	44	5	2	2	69	1	0	1	26	14.17	I
10/2	83	45	4	2	1	78	1	0	1	28	15.65	I
10/5	75	37	5	3	1	68	0	0	0	28	13.71	I
10/8	88	47	4	2	1	71	0	0	0	26	14.42	I
10/11	85	51	4	1	1	74	0	0	0	24	14.98	I
10/14	83	48	4	1	2	74	0	0	0	23	15.10	I
10/17	83	44	5	1	1	72	1	0	0	25	14.46	I
10/20	86	57	4	1	1	77	0	0	0	21	15.67	I
Avg	83.7	46.6	4.3	1.6	1.2	72.8	0.3	0	0.3	25.1	14.77	
<u>Salvaged</u>												
9/29	84	40	4	1	1	70	2	0	2	26	13.84	I
10/2	87	35	4	1	2	70	2	0	2	25	13.91	I
10/5	86	42	4	1	3	71	0	0	0	25	14.60	I
10/8	90	44	4	1	1	66	6	1	7	25	10.36	II
10/11	87	40	4	1	1	73	1	0	1	24	14.56	I
10/14	89	43	4	2	1	67	5	0	5	25	12.35	II
10/17	91	49	5	1	1	74	1	0	1	23	14.94	I
10/20	88	45	4	1	2	74	1	0	1	22	15.93	I
Avg	88	42.2	4.1	1.1	1.5	70.6	2.2	0.1	2.3	24.3	13.81	

Table 4. Farmers' stock grade, price per pound, and segregation, NC 17 variety.
Holland, Va. 1970

Digging Date	Fancy	ELK	Moisture	OK	SS	SMK	VD	CD	V+C	Hulls	Price/lb	Segregation
	%	%	%	%	%	%	%	%	%	%	c	
<u>Vines</u>												
9/29	67	61	4	1	1	76	0	0	0	22	15.58	I
10/2	66	62	4	1	1	76	0	0	0	22	15.61	I
10/5	74	62	4	0	2	75	1	0	1	22	15.54	I
10/8	57	65	4	1	1	75	0	0	0	23	15.48	I
10/11	67	64	4	1	1	77	0	0	0	21	15.83	I
10/14	67	57	4	1	1	76	0	0	0	22	15.49	I
10/17	69	63	4	1	1	77	1	0	1	20	15.81	I
10/20	81	34	4	1	2	70	1	0	1	26	14.05	I
Avg	68.5	58.5	4	0.8	1.2	75.2	0.3	0	0.3	22.2	15.42	
<u>Salvaged</u>												
9/29	71	55	5	1	2	72	2	0	2	23	14.73	I
10/2	86	52	4	1	2	69	3	0	3	25	13.93	II
10/5	88	62	4	1	1	72	3	0	3	23	14.52	II
10/8	83	60	4	1	2	74	1	0	1	22	15.37	I
10/11	86	62	4	1	2	76	0	0	0	21	15.73	I
10/14	90	67	5	1	1	78	0	0	0	20	16.08	I
10/17	91	58	4	1	1	75	0	0	0	23	16.10	I
10/20	85	64	4	1	1	76	0	0	0	19	16.20	I
Avg	85	60	4.2	1	1.5	74.3	1.1	0	1.1	22	15.34	

Molds, Aflatoxin, Rancidity and Fat Acidity

These analyses for each variety are shown in Tables 6, 7 and 8. A report from the National Peanut Research Laboratory stated, "As shown by the test results, none of the samples showed rancidity or any appreciable fat acidity, and they were free of aflatoxin and visible mold."

Decayed and Shriveled Kernels

Decayed and shriveled kernel samples were analyzed for aflatoxin contamination and results are as follows:

Aflatoxin Analysis of Decayed and Shriveled Kernels

	Va. 16R	Florigiant	NC 17
Vine Sample			
Decayed	None	None	None
Shriveled	"	"	"
Salvaged Sample			
Decayed	None	None	None
Shriveled	"	"	"

PEANUT FLAVOR

Peanut flavor evaluations were made only on the vine and salvage samples collected from alternate digging dates - - October 2, 8, 14 and 20. These results are shown in Tables 9, 10 and 11. The peanut flavor ratings show that the salvaged peanuts are not appreciably different from those picked from the vines.

CONCLUSIONS

The feasibility of mechanically salvaging peanut digging losses involves economics such as initial, operating, and maintenance cost of the equipment; capacity and efficiency of the equipment; soil type and moisture; and quantity and quality of the salvaged peanuts. If the peanuts are of edible quality, price per pound is expected to be about equal to that of windrow harvested peanuts. If the salvaged peanuts are contaminated with aflatoxin, they may be a potential source for seed, or if sold for oil stock, their value is expected to be about one-half of the price of windrow harvested peanuts.

Peanuts as salvaged in these trials require recleaning before drying to remove foreign material such as clods, damaged peanuts, etc. Equipment to reclean salvaged peanuts must be provided.

Salvaged peanuts contain high moisture - - 50 percent or more. The cost of artificial drying to 8 to 10 percent moisture will exceed the cost of drying semi-cured, windrow harvested peanuts.

The width of the soil band over the row, which must be sifted to recover a high percentage of the peanuts, depends upon the variety. Preliminary studies have shown that a high percentage of the runner type peanuts is distributed within 15 inches of the primary root; with the bunch type, distribution from the primary root is considerably less. A digger-salvager designed for bunch type peanuts is expected to operate at a faster ground speed than one designed for

Table 5. Peanut germination percentages, Holland, Va. 1970

Digging Date	Variety		
	Va. 61R	Florigiant	NC 17
<u>Vines</u>			
9/29	91	90.5	88
10/2	86	94.5	82.5
10/5	92	87	92
10/8	94	95	89.5
10/11	94	96	93.5
10/14	92.5	94	91.5
10/17	91.5	88.5	91
10/20	97.5	96	92.5
Avg	92.3	92.6	90.1
<u>Salvaged</u>			
9/29	91.5	75	91
10/2	89	93.5	88
10/5	88.5	91	87.5
10/8	95	93.5	89
10/11	96	95.5	95
10/14	96	98.5	88.5
10/17	94	90.5	90.5
10/20	92.5	96	93
Avg	92.8	91.7	90.3
Overall Avg	92.6	92.2	90.2

**Table 6. Peanut quality evaluation, Va. 61R variety,
Holland, Va. 1970**

Digging Date	Molds	Aflatoxin	Rancidity	Acidity
<u>Vines</u>				
9/29	0	0	1.5	0.20
10/2	0	0	1.4	0.30
10/5	0	0	0.8	0.25
10/8	0	0	1.4	0.20
10/11	0	0	0.6	0.20
10/14	0	0	0.6	0.20
10/17	0	0	0.6	0.25
10/20	0	0	0.8	0.20
Avg	0	0	0.96	0.22
<u>Salvaged</u>				
9/29	0	0	1.1	0.20
10/2	0	0	1.4	0.20
10/5	0	0	1.4	0.30
10/8	0	0	0.6	0.30
10/11	0	0	0.6	0.20
10/14	0	0	1.5	0.35
10/17	0	0	1.0	0.20
10/20	0	0	1.0	0.25
Avg	0	0	1.07	0.25

Table 7. Peanut quality evaluation, Florigiant variety.
Holland, Va. 1970

Digging Date	Molds	Aflatoxin	Rancidity	Fat Acidity
<u>Vines</u>				
9/29	0	0	0.6	0.25
10/2	0	0	0.9	0.20
10/5	0	0	1.1	0.20
10/8	0	0	0.6	0.25
10/11	0	0	0.6	0.20
10/14	0	0	0.6	0.20
10/17	0	0	0.7	0.15
10/20	0	0	0.6	0.20
Avg	0	0	0.71	0.20
<u>Salvaged</u>				
9/29	0	0	1.4	0.20
10/2	0	0	1.0	0.35
10/5	0	0	1.8	0.25
10/8	0	0	1.1	0.45
10/11	0	0	1.0	0.25
10/14	0	0	0.8	0.20
10/17	0	0	1.0	0.20
10/20	0	0	1.2	0.20
Avg	0	0	1.16	0.26

Table 8. Peanut quality evaluation, NC 17 variety. Holland, Va.
1970

Digging Date	Molds	Aflatoxin	Rancidity	Fat Acidity
<u>Vines</u>				
9/29	0	0	1.3	0.25
10/2	0	0	1.5	0.35
10/5	0	0	0.8	0.20
10/8	0	0	1.4	0.15
10/11	0	0	2.2	0.20
10/14	0	0	1.3	0.20
10/17	0	0	1.4	0.35
10/20	0	0	1.2	0.25
Avg	0	0	1.38	0.24
<u>Salvaged</u>				
9/29	0	0	0	0
10/2	0	0	0	0
10/5	0	0	1.5	0.30
10/8	0	0	0.6	0.30
10/11	0	0	0.6	0.25
10/14	0	0	0.6	0.25
10/17	0	0	1.8	0.30
10/20	0	0	1.8	0.25
Avg	0	0	1.15	0.27

Table 9. Flavor evaluation, Va. 61k variety. Holland, Va. 1970

Digging Date	Flavor Evaluation (*)					Comments
	CLER	%BOP	%LOF	%LPF	%GPF	
<u>10/2</u>						
Vines	47	5	25	65	5	Slight grading, fair. Sweet, starchy, dry, astringent, woody flavor notes. Overall flavor quality fair to poor.
Salvaged	45	5	25	70	0	Slight grading, fair. Sweet, starchy, haylike, sour flavor notes.
<u>10/8</u>						
Vines	56	0	25	55	20	Slight grading, medium. Slight sweet, dry, woody, flavor notes. Some shrivels. Overall flavor quality, fair.
Salvaged	52	0	25	65	10	Slight grading, fair. Dry, sweet, sour, bitter, astringent flavor notes. Some shrivels. Overall flavor quality fair.
<u>10/14</u>						
Vines	47	5	30	55	10	Slight grading, fair. Some shrivels. Sour, astringent, bitter, woody, flavor notes. Overall flavor quality, fair.
Salvaged	49	5	25	60	10	Slight grading, fair. Some shrivels. Dry, mostly, saw dust-like, bitter, astringent flavor notes. Overall flavor quality, fair.
<u>10/20</u>						
Vines	52	0	25	65	10	Slight grading, medium, slight sweet, sour, woody, astringent flavor notes. Overall flavor quality, fair.
Salvaged	51	0	20	70	10	Slight grading, medium. Slight sweet, sour, astringent, hay-like flavor notes. Fair overall flavor.

(*) BOP = Bad off flavor.
 LOF = Low level off flavor.
 LPF = Low peanut flavor.
 GPF = Good peanut flavor.
 CLER = Critical laboratory evaluated roast.

Table 10. Flavor evaluation, Floridian variety. Holland, Va. 1970

Digging Date	Flavor Evaluation (*)					Comments
	CLER	%BOP	%LOF	%LPF	%GPF	
<u>10/2</u>						
Vines	43	5	25	7	0	Slight grading medium. Sour, hay-like flavor notes. General peanut flavor quality, poor.
Salvaged	41	5	30	65	0	Sour, bitter, astringent, soapy, hay-like, woody, chemical off-flavor notes. Slight grading, medium. General flavor quality, poor.
<u>10/8</u>						
Vines	38	10	30	60	0	Slight grading, medium, sour, hay-like, bitter, astringent, beany flavor notes. General flavor quality very poor.
Salvaged	38	10	30	60	0	Slight grading, poor. Soapy, chemical-off, sour-bitter-astringent flavor notes. General flavor quality very poor.
<u>10/14</u>						
Vines	40	10	25	65	0	Slight grading, medium. Sour, bitter-astringent, woody dry, flavor notes. General flavor quality, poor.
Salvaged	35	15	30	55	0	Slight grading, fair. Soapy chemical-off, astringent, hay-like flavor notes. General flavor quality, very poor.
<u>10/20</u>						
Vines	38	10	30	60	0	Slight grading, medium. Woody, dry, sawdust-like, astringent flavor notes. General flavor quality, very poor.
Salvaged	33	10	30	60	0	Slight grading, medium. Woody, dry, hay-like, astringent flavor notes. General flavor quality, very poor.

(*) BOP = Bad off flavor.
 LOF = Low level off flavor.
 LPF = Low peanut flavor.
 GPF = Good peanut flavor.
 CLER = Critical laboratory evaluated roast.

Table 11. Flavor evaluation, NC 17 variety. Holland, Va. 1970

Digging Date	Flavor Evaluation (*)					Comments
	CLER	%BOF	%LLOF	%LFF	%GPF	
<u>10/8</u>						
Vines	45	5	30	60	5	Sight grading, fair. Some dark color, spotted skins. Hay-like, woody, sour, bitter flavor notes. General flavor quality, fair.
Salvaged	42	10	30	55	5	Sight grading, fair. Several dark spotted skins. Dry, sour, mealy, astringent flavor notes. Overall flavor quality poor.
<u>10/14</u>						
Vines	44	0	35	65	0	Sight grading, fair. Some dark spotted skins. Woody, hay-like, bitter-astringent flavor notes. Overall flavor quality, fair.
Salvaged	46	0	30	70	0	Sight grading fair. Some dark spotted skins. Woody, hay-like bitter-astringent flavor notes. Overall flavor quality, fair.
<u>10/20</u>						
Vines	50	0	30	60	10	Sight grading, fair. Slight sweet, hay-like, woody, astringent flavor notes. Overall flavor quality, fair.
Salvaged	46	0	35	60	5	Sight grading, fair, hay-like, woody, sour, bitter, astringent flavor notes. Overall flavor quality, fair.

- (*) BOF = Bad off flavor.
 LLOF = Low level off flavor.
 LFF = Low peanut flavor.
 GPF = Good peanut flavor.
 CLER = Critical laboratory evaluated roast.

runner type peanuts because about one-third less soil requires lifting and sifting.

Detached peanuts collected with the digger-salvager may be cured, dried, stored and processed independently of those on the vines. Peanuts attached to the vines may be left in a windrow to partially cure and dry prior to combining. The salvaging operation does not affect or alter the presently accepted windrow method of harvesting peanuts.

Approximately 340,000 acres of large seed type peanuts are grown, and some are dug early with light losses. On an estimated 15 percent of this acreage, digging losses may be in excess of 500 lb/a. Salvaging these could increase recovery yield by about 25 million pounds.

SUMMARY

Peanut varieties grown in Virginia mature their seed over a period of several weeks, some maturing before normal digging time. Many of the early maturing peanuts may shed before digging and others may have weak pegs due to age, insects or disease damage. Both peanuts with weak pegs and some of normal vigor become separated from the plant during the digging operation. When peanuts are dug at the optimum time, losses do occur and are estimated to range between 3 and 15 percent of the total yield. If digging is delayed several days beyond the optimum digging date, field losses may range up to one-fourth or more of the total yield.

A study was made to determine the effects of digging time on peanut recovery yield, salvaged yield and quality. Three varieties of peanuts were dug at 3-day intervals over a 22-day period using (1) a commercial digger followed with equipment to recover the losses and (2) an experimental plot harvester that combined digging and salvaging in one operation. With Va. 61R and Florigiant varieties, yield data analyses did not show a significant difference due to digging dates by either digging method. With NC 17 variety, digging dates significantly influenced vine yield with the commercial digger and those dug September 29 October 14 gave the highest vine yield. With the combination digger-salvager, digging dates did not significantly influence vine and salvage yield combined.

The peanut digger-salvager recovered an additional 500 lb/a over the vine yield from the commercial digger with each of the three varieties. The digger-salvager recovers approximately 80 percent of the expected losses that may occur with the commercial digger. Average commercial digging losses over the 8-day period exceeded 600 lb/a.

Farmers' stock grade and price per pound of the salvaged peanuts were about equal to that of the peanuts picked from the vines. Average value of the additional peanuts collected with the digger-salvager ranged between \$70 and \$82 per acre.

Germination of the salvaged peanuts was about equal to that of the peanuts picked from the vines. Average germination of the salvaged peanuts and those from the vines exceeded 90 percent with all three varieties.

Neither the vine nor salvage samples showed any appreciable rancidity or fat acidity and all samples were free of aflatoxin and visible molds. There was no aflatoxin contamination in the decayed or shriveled kernels of any of the samples.

CLER flavor evaluations were slightly higher from the vine samples but no appreciable differences were noted between them and the salvaged samples.

The 1-year evaluation of peanut digging losses and quality is from peanuts grown only on the experiment station and is no assurance that tests conducted off the station would give equal or similar results.

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- 1) Segregation I - less than 2 percent damage and no A. flavus.
Segregation II - over 2 percent damage and no A. flavus.
Segregation III - over 1 percent RMD and/or contains A. flavus.

MODERN FERTILIZER PRACTICES FOR MAXIMUM PRODUCTION OF HIGH QUALITY PEANUTS

by

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The average yield of peanuts in North Carolina has continually increased from about 1200 lbs. per acre prior to 1940 to 2670 lbs. in 1970. However, individual yields in excess of 4000, including 6000 lbs./A have been recorded.. These remarkable increases have been due to improved genetic seed stock and to improvement of various agronomic practices. A substantial part of these increases can be ascribed to the improvement of soil fertility and better use of fertilizers based on soil and plant analyses. For the maintenance of maximum production of high quality peanuts it is essential to make use of modern soil test technology and to adapt fertilizer practices in accordance with the recorded soil test information.

Research results for the past 30 years have denoted the various nutrient factors which are essential for maximum yield and quality of peanuts. These factors include: (1) nutrient requirements in relation to rooting and fruiting media, (2) mechanism of calcium absorption by the peanut fruit, (3) yield and quality of peanuts in relation to nutrient balance.

Nutrient requirements of rooting and fruiting media

Burkhart and Collins (1942) were the first to demonstrate the need for studying the environmental conditions of the peanut plant in terms of the rooting and fruiting media separately. Middleton et. al. (1945) and Brady and Colwell (1945) studied the influence of potassium (K), magnesium (Mg), and calcium (Ca) on yield and quality of field grown peanuts. The treatments by Middleton et. al. included: a) control, b) 400 pounds gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) applied on the foliage at early bloom, 58 to 70 days after planting (June 17-July 2), c) as b) plus 37 pounds K as muriate of potash (KC1) at the time of emergence, 20 to 21 days after planting (May 10-11), d) 400 lbs. dolomitic limestone added in the row at time of planting (April 20-23) plus 37 pounds K as under c). The effect of these treatments on the average yields of four varieties of peanuts on four soils are recorded in Table 1.

Yields of Va. Bunch and N. C. Runner varieties were significantly increased by the addition of gypsum. The gypsum plus K combination gave further increases, but they were not significant. The limestone plus K treatment failed to increase yield. The Spanish varieties increased yield due to gypsum and gypsum plus K only slightly. The lime plus K treatment failed to increase yield with Spanish 2B and it was slightly higher than the control with the White Spanish variety.

The authors point out that the beneficial effects of K in the Va. Bunch and N. C. Runner varieties were related to an increase in plant size and not in the filling of fruit as measured by a decrease in shelling percentage and the percentage of ovarian cavities filled. Gypsum invariably increased both true shelling percentage and percentages ovarian cavities filled over control, including Spanish 2B.

Middleton et. al. also reported the effect of these treatments on the yield of oil. The data recorded in Table 2. showed highest oil yields with gypsum plus K

Table 1 - The effect of calcium sulfate, potassium and dolomitic limestone on yield of four varieties of peanuts (After Middleton et. al., 1945)

Variety	Control	CaSO ₄	CaSO ₄ + K lbs./acre	Lime + K
Va. Bunch	434	1149	1438	447
N. C. Runner	701	1166	1281	720
Spanish 2 B	1152	1431	1626	1053
White Spanish	1048	1094	1208	1212

LSD .05 = 396

Table 2 - The effect of calcium sulfate, potassium and dolomitic limestone on oil yields of four varieties of peanuts (after Middleton et. al., 1945)

Variety	Control	CaSO ₄ lbs. oil/acre	CaSO ₄ + K (av. from 4 locations)	Lime + K
Va. Bunch	127	350	435	133
N. C. Runner	212	355	396	214
Spanish 2B	346	439	502	313
White Spanish	323	346	388	367

followed by gypsum and lowest in the control and the lime plus K treatments. The highest oil yields were obtained with Spanish variety 2B under control and the gypsum and gypsum + K treatments. The White Spanish variety produced fairly high oil yields under all conditions, while the Va. Bunch and N. C. Runner varieties produced high oil yields only where gypsum was used.

Middleton et. al. also reported on the oil contents of kernel sizes of four varieties of peanuts there was very little difference in the percentage oil content of the peanuts due to the above treatments in the large and medium size kernels. However as recorded in Table 3 the percentages of oil are highest in the large size kernels, they fall off slightly in the medium size kernels and very drastically in the smaller kernels in all varieties. The results of a comprehensive investigation on the effect of macronutrients on yield and quality of peanuts under field conditions has been reported by Piggott (1960) in Sierra Leone. A summary of the main effects on yield shelling percentage, percent cavities filled and kernels per fruit are reproduced in Table 4.

Addition of magnesium (Mg), sulfur (S) and potassium (K) failed to increase yield and decreased the various quality factors, while addition of calcium (Ca) increased yield, shelling percentage, percentage ovarian cavities filled and kernels per fruit. The combination, Ca S Mg further increased yield and maintained the other quality factors. However, the highest yields were obtained with the further addition of phosphorus and K in combination with CaSMG.

Macronutrient effects applied specifically to the rooting and fruiting media were reported by Brady (1948), Brady and Colwell (1945) and others. Brady and Colwell (1945) made the following treatments to Va. Runner variety peanuts grown on Kalmia sandy loam: rooting media at time of planting 3 to 5 inches below the level of the seed: a) control, b) 39 lbs. K/a as K_2SO_4 , c) 9 lbs. Mg as $MgSO_4 \cdot H_2O$, d) 94 lbs. Ca as $CaSO_4 \cdot 2H_2O$; the same treatments were applied to fruiting media at early blooming stage July 5 by broadcasting on the foliage.

The results recorded in Table 5 show yields to decrease over control with $KMgCa$ in the rooting media and with KMg in the fruiting media. Highest yields were obtained only with Ca in the fruiting media.

The effects of K, Mg and Ca in the rooting and fruiting media on yield are largely due to variations in the shelling percentages and the percentage ovarian cavities filled. These data, recorded in Table 6, show the highest shelling percentage and the highest percentage of ovarian cavities filled with additions of Ca to the fruiting media.

Mechanism of nutrient absorption

The macronutrient contents of foliage and pods of N. C. 2 variety peanuts after 16 weeks growth are recorded in Table 7. The data show N and P lower and sulfur (S), K, Ca and Mg higher in the foliage than in the pods (the pods included in mature fruit only). The macronutrient contents of N, K, Mg and Ca only in mature shells and kernels of N. C. Runner variety peanuts are shown in Table 8. These analyses, reported by Colwell et. al. (1945) on shells having 2, 1 and 0 kernels decrease in the order N, K, Mg, Ca. The same order follows in the kernels, except that N, K and Mg are higher and Ca is lower in the kernels than in the shells producing 2 kernels instead of 1 or no kernel. Addition of $CaSO_4$ to the fruiting media resulted in none to slight reductions in $NKMg$ and slight increases in Ca in all these groups of pericarps.

Table 3 - Influence of kernel size on the oil content of four varieties of peanuts (after Middleton et. al., 1945).

Variety	Large*	Medium** percent oil	Remainder (small)
Va. Bunch	52.5	46.4	36.4
N. C. Runner	54.0	51.1	40.1
Spanish 2B	54.0	51.0	39.6
White Spanish	54.5	54.7	46.8

* held on screen with 20/64 inch perforation

** passing above, held on screen with 15/64 inch perforations

Table 4 - Influence of various macronutrients on yield, shelling percentage, percent cavities filled and kernels per fruit of peanuts (after Piggott, 1960).

Macronutrients	Fruit yield lbs./a	Shelling percentage	Percentage ovular cavi- ties filled	Kernels per fruit
Control	500	57	40	1.0
MgSK	540	42	23	0.6
Ca	830	71	76	1.9
CaSMg	1110	66	76	1.6
CaSMgPK	1380	67	76	1.7
LSD 0.05	132			

Table 5 - Influence of potassium, magnesium and calcium on yield of Va.

Runner peanuts applied to rooting and fruiting media of Kalmia
fine sandy loam (after Brady and Colwell, 1945).

Nutrients in Rooting Media	Nutrients in Fruiting Media			
	Control	K	Mg	Ca
	yield, lbs./acre			
Control	420	228	267	842
K	291	154	286	1073
Mg	233	103	283	981
Ca	334	376	284	1028

LSD .05 = 271

Table 6 - Influence of potassium, magnesium and calcium on shelling percentage
and percentage ovarian cavities filled (after Brady and Colwell,
1945).

Nutrients in Rooting Media	Nutrients in Fruiting Media			
	Control	K	Mg	Ca
	True Shelling percent			
Control	31.7	29.5	27.9	60.3
K	21.8	16.5	26.6	58.5
Mg	27.6	19.4	29.0	58.4
Ca	31.9	27.5	28.1	56.8

LSD .01 = 11.0

	Ovarian Cavities Filled, percent			
Control	26.5	19.6	17.7	59.8
K	13.0	11.6	18.9	68.6
Mg	17.2	12.0	18.7	63.7
Ca	19.7	20.9	15.2	70.7

LSD .01 = 12.4

The increased content of Ca in mature pericarp with additions of CaSO_4 applies also to Va. Bunch, Spanish 2B and White Spanish varieties as shown in Table 9. Where no CaSO_4 was added the shells without kernels were consistently higher in Ca than the shells having 1 or 2 kernels. It appears therefore that the shells supplied a portion of the Ca required for kernel development. There appears to be no deficiency in the shell Ca where Ca was supplied as CaSO_4 .

The pericarp of the N. C. Runner variety had the lowest Ca content, followed by Va. Bunch and Spanish 2B. The Ca level in the shells of the White Spanish variety was highest in both the control and the CaSO_4 series. The failure of the White Spanish variety to respond to additions of CaSO_4 with respect to yield (Tables 1 and 2) may in part be due to the high Ca content in the shells or the ability of the shells to absorb Ca from lower concentrations of Ca and from the fruiting media. There is also the further possibility that Ca is translocated into the developing fruit from other parts of the plant. The various possibilities for meeting the Ca requirements of the White Spanish variety without the need for high concentrations of CaSO_4 in the fruiting media apparently have not been investigated.

A large number of investigations with large seeded peanuts have shown the need for Ca to be present in the fruiting media in soluble form (Burkhart and Collins, 1941; Brady et. al 1949; Bledsoe et. al., 1949; Harris, 1949; Skelton and Shear, 1971). A major source of the soluble Ca is CaSO_4 (gypsum or landplaster). The solubility of limestone is too low to serve as a direct source of soluble Ca, however, following reaction of limestone with exchange acidity of the soil complex, Ca becomes available for absorption by the peanut shells on hydrolysis. The rate of hydrolysis was shown by Mehlich and Colwell (1946) and Mehlich and Reed (1947), when based on fruit quality, to be influenced by type of soil colloid, cation exchange capacity and percentage Ca saturation. For any given level of Ca, fruit quality (percentage cavities filled) was higher when the colloid was predominately kaolinitic rather than montmorillonitic or organic. This difference was explained by Mehlich and Reed as being due to the position of Ca on the surface of the different colloids. The Ca on the Kaolinite is held largely extracellular from which it can readily enter into the soil solution while in the montmorillonitic and organic type it is largely intracellular.

Mehlich and Reed (1947) tested this concept on a kaolinite and organic soil at the conclusion of an experiment involving measurements of fruit quality, and Ca content of pericarp, foliages and the Ca in a 1:1 soil: water extract after a shaking period of 30 minutes. The results of this study, reproduced in Table 10 showed for the same concentration of Ca the H_2O extract and pericarps to contain less Ca and a lower percent cavities filled with the organic soil. When, however, the peanuts were grown on the organic soil containing about 10 times more Ca, the Ca content of the H_2O extract and the pericarps as well as the percent cavities filled were essentially the same as the values for the kaolinite colloid.

The data in Table 10 show the Ca content of the foliage to be higher when the peanuts were grown in the organic than in the kaolinite colloids, which indicates that the organic colloid supplies Ca to the roots of peanuts as readily as the kaolinitic colloid. The authors therefore postulated that the transport of Ca into the roots and into the pericarps involves different mechanisms. Earlier studies by Mehlich (1946) established a close correlation between the uptake of Ca by plants and the release of Ca by H ions ($\text{HC}1$). Hence, it was postulated that mobilization of Ca into the pericarp took place without a measurable H ion

Table 7 - Macronutrient content of foliage and pods of N. C. 2 variety peanuts
after 16 weeks growth

Parts of Plant	N	P	S percent	K	Ca	Mg
Whole plant	2.46	0.20	0.29	2.78	1.28	0.41
Pods	3.40	0.28	0.17	1.02	0.16	0.18

Table 8 - Macronutrient content of mature pericarps of N. C. Runner variety
having 0, 1 and 2 kernels per pod (after Colwell, Brady and Filand,
1945).

Rooting-fruiting Media	Kernels	N	K percent	Mg	Ca
O, K, Mg	2	.998	.480	.103	.070
	1	1.36	.596	.149	.054
	0	1.68	.820	.145	.066
Ca-Ca	2	0.79	.484	.083	.122
	1	1.07	.588	.110	.096
	0	1.58	.736	.116	.086
Kernels No CaSO_4		5.01	.60	.17	.034
Kernels Plus CaSO_4		4.59	.62	.16	.036

Table 9 - Calcium content of mature pericarps of four varieties of peanuts
(after Colwell, et. al., 1945).

Treatment	Kernels per shell	Variety			
		Va. Bunch*	N.C. Runner	Spanish 2B	White Spanish
percent Ca in air-dry pericarp tissue					
Control	2	.074	.050	.070	.088
	1	.074	.052	.072	.084
	0	.084	.072	.086	.108
CaSO ₄	2	.112	.080	.102	.130
	1	.108	.086	.098	.148
	0	.110	.098	.142	.144

* Va. Bunch, average from 4 locations, all other varieties from 2 locations.

Table 10 - Effect of type of colloid and Ca level on Ca in H₂O extract,
foliage and pericarps and on fruit quality (after Mehlich and
Reed, 1947).

Type of colloid	Calcium			Peanuts		Fruit quality cavities filled
	Soil Initial	Final	H ₂ O Extract	Foliage	pericarp	
	meq./100g			%	%	%
Kaolinitic	0.39	0.26	0.045	0.88	0.14	83
Organic	0.38	0.26	0.015	1.06	0.10	32
Organic	3.80	2.76	0.043	1.06*	0.13	85

* Data from plants grown on soil containing initially 0.76 meq. Ca/100g

exchange mechanism. Experience has shown that during the period a maximum development of fruit quality requires that the fruiting environment contains an adequate concentration of Ca ions. Furthermore, for the production of high quality peanuts, Ca is the only nutrient needed in the fruiting media, while increasing concentrations of Mg and particularly K reduce peanut quality (Brady, 1948).

All other mineral nutrients needed for normal fruit development are being supplied through the rooting media, while the need for carbohydrates is met by translocation from photosynthetic action of the plant. This phase of the growth cycle is as important as the mineral nutrient supply. The relationship between translocation of carbohydrates out of the peanut leaves is a function of stage of development apparently has not been studied, although loss of dry weight of foliage in relation to increasing pods and fruit filling has been reported (unpublished).

A study by Thrower (1962) with soybeans may have general application to peanuts. By employing radioactivity he found that during early leaf expansion translocation from older leaves was all important. When the leaf reached approximately 50% of its final size the leaf was essentially self-sufficient, followed by an outward transport at a high rate as leafage increased to its final size. In consequence of these activities labile pods of carbohydrates are established in plant tissues for use in respiration, storage and synthesis. The major practical application of these observations lead to the conclusion that translocation of carbohydrates from the labile pool are in competition between the requirements of the developing fruit and the requirements for new leaf development. Hence, any cultural practices which are likely to stimulate new leaf growth at a stage when the carbohydrate requirement for fruit development is critical, maximum yield and quality will suffer.

Excessive stimulation of vegetative growth of peanuts can be achieved with additions of nitrogen or nitrogen and manganese. The effect of such treatments in relation to time of application on yield and quality of peanuts is recorded in Tables 11 and 12. These results were obtained at various location in North Carolina using a suspension application technique with landplaster, landplaster-urea and landplaster-urea-manganese. The experiment in Courtland Co. Va. was, however, obtained with solid materials (Table 11). The figures under rate refer to the quantity of landplaster (94% CaSO_4) ground for 95% to pass a 100 mesh sieve and 100% to pass a 80 mesh sieve. Urea was added at the rate of 28 lbs. N per application. Manganese was applied at the rate of 3 lbs./a in the form of manganese sulfate in Northampton Co. and in the form of suspension grade manganese oxide in Washington Co.

Since an alternative objective of these trials was to supply the nutrients as a time and economy measure all suspension materials contained a fungicide for the control of leaf spot diseases. This was successfully accomplished through the inclusion of Coperoid, added at the rate of 1 1/2 lbs. Cu per application. A good dispersion was obtained by adding the requisite quantity of Coperoid to about 3/4 of the total volume of water required, followed subsequently by the addition of suspension grade landplaster or landplaster-urea. The capacity of the applicator tank was 100 gallons and the urea covered per operation was 12 feet or 4 rows of peanuts. The maximum quantity of landplaster was 100 lbs/25 gallons of water.

Table 11 - Effect of time and quantity of CaSO_4 (CaS) and CaSO_4 -Urea (CaSN) applications on yield, value and quality of peanuts (1969).

Rate lbs/a	Nutrient	Date	Yield lbs/a	Value \$/a	ELK %	HK %	SMK %
Variety, N. C. 2, Chowan Co., N. C.							
Control		—	2162	254	15	46	61
2 x 400	CaS	7/8- 8/20	2492	314	20	45	65
2 x 400	CaSN	7/8- 8/20	2240	279	15	49	64
Variety, N. C. 5, Perquimans Co., N. C.							
600	CaS	7/1	3495	444	29	36	65
600	CaSN	7/29	3058	387	30	35	65
600	CaSN	7/1	3808	494	31	35	66
600	CaS	7/29					
Variety, N. C. 5, Bertie Co., N. C.							
400	CaS	7/9	3683	500	30	40	70
400	CaSN	7/9	3745	511	31	39	70
2 x 400	CaS	7/9- 8/18	3903	520	32	36	68
2 x 400	CaSN	7/9- 8/18	3983	538	27	43	70
Variety, 61R, Courtland Co., Va.*							
Control		—	4536	621	22	50	72
600	CaS	8/12	4556	618	22	49	71
600	CaSN	8/12	4525	602	20	49	69
1200	CaSN	8/12	4134	534	17	51	68

* Nutrient materials added as dust, all others in suspension

Table 12 - Effect of CaSO_4 , CaSO_4 -Urea and CaSO_4 -Urea-Manganese (CaSNMn) on yield, value and quality of peanuts (1969).

Rate lbs/a	Nutrient	Date	Yield lbs/a	Value \$/a	ELK %	HK %	SMK %
Variety, mixed NC 2, Florigiant, Northampton Co., N. C.							
400	CaS	7/17	2986	367	27	34	60
400	CaSN	7/17	2879	360	27	35	62
400	CaS	7/17	3100	387	25	38	63
400	CaSN	7/17	2657	349	22	45	67
400	CaSNMn	7/17	2488	319	20	46	66
400	CaS	8/13	2115	258	13	49	62
400	CaSNMn	7/17					
400	CaSN	8/13					
Variety NC 2, Washington Co., N. C.							
400	CaS	7/8	2910	348	24	35	59
400	CaSNMn	7/8	2660	324	24	35	59
400	CaS	7/12	3233	390	25	34	59
400	CaSN	7/12	2633	312	22	37	59
400	CaSNMn	7/8	2980	374	26	36	62
400	CaS	8/12	2620	316	23	37	60
400	CaSNMn	7/8					
400	CaSN	8/12					

The results with variety N. C. 2 in Table II show the addition of N at two dates reduced yield value and quality, in terms of extra large kernels (ELK) over CuS only. Additions of N also reduced yield and value with N. C. 5 in Perquimans Co. when applied late (July 29); however, the highest yield and value was obtained with CaSN applied July 1 and followed by CaS on July 29. Similar treatments with N. C. 5 in Bertie Co. do not show any reduction in yield and value due to N although doubling the rate of Ca S and CaSN also increases both yield and value. Additions of 600 lbs. CaSO_4 or CaSO_4 -urea, in solid form failed to increase yield or value over control with 61R in Courtland Co., Va., however, addition of 1200 lbs. CaSO_4 -urea substantially decreased yield, value and quality (ELK).

Manganese was included in the Northampton and Washington counties sites because of the prevalence of manganese deficiency symptoms of the foliage. The results in Table 12 show, that although Mn corrected the visual symptoms of the deficiency, yield, value or quality were not improved over the CaS or CaSN treatments. Substantial decreases occurred at both sites when the CaSNMn combinations were followed by CaSN rather than CaS combination, notably in Northampton County.

The effect of calcium sulfate-urea on yield and value of peanuts, applied at planting, were studied at 5 locations during the 1970 season. The material was granulated calcium sulfate-urea furnished by the United States Gypsum Company. The application rate was 600 lbs. landplaster equivalent (94% CaSO_4) and 34 lbs. N per acre. The materials were broadcast in a 14-16 inch band either before planting and in one case at the Newsoms site (Table 13) in the same way at emergence (6 days after planting). The yield and value of peanuts on these treatments (CaSN) compared with 600 lbs. landplaster (CaS) applied as dust on the foliage at early flowering as shown in Table 14. The only significant increase in yield was obtained with the NC2 variety at the Bertie County site. At all other locations the CaSN treatment failed to reach significant increases or decreases when compared to the CaS treatment. The increase at the Bertie Co. location was obtained on an acid soil, with pH's ranging between 4.8 and 5.1.

Nutrient requirements in relation to soil pH and nutrient index values

An effective program of fertilizer use for maximum production of high quality peanuts requires adequate knowledge of nutrient content and nutrient availability in soil and nutrient requirements of crop. Mehlich (1946) proposed equations for the prediction of cation content of plants from measurements of the concentration and distribution of metal cations in soil when the total and proportionate metal cation requirement of a specific crop was established. The equation also took into account the influence of type of colloid and cation exchange capacity. Following establishment of the optimum Ca/Mg, Ca/K and in some cases Ca/Na ratios in a specific plant under optimum conditions of yield. The desired corresponding cation ratios in soil could be used for lime and fertilizer recommendations based on soil analysis.

Since Ca contributes the major metal cation on the exchange complex it is used as reference point to the other metal cations. Hence, when the level of exchangeable Ca in soil is known, the concentration of exchangeable Mg and K (necessary to provide the desired cation content in the peanut plant) can be calculated as follows:

$$\text{Mg (meq/100 g soil)} = \frac{\text{Ca (meq/100 g soil)}}{\text{Ca/Mg (plant)} \cdot \text{cMg(C)}}$$

$$\text{K (meq/100 g soil)} = \frac{\text{Ca (meq/100 g soil)}}{\text{Ca/K (plant)} \cdot \text{cK(C)}}$$

where $\text{CMg} = \text{C/Mg (soil)}/\text{Ca/Mg (plant)}$;

$\text{cK} = \text{Ca/K (plant)}$ and C = correction factor for cation exchange capacity and type of colloid.

Although cation ratios and c-factors have been established for a number of crops (Mehlich, 1946); Mehlich and Reed, 1948, 1949 and Millan and Mehlich, 1954), similar data on peanuts are not available. An application of those principles is however possible on the basis of the data in Table 7. To do this it is necessary to convert the conventional percentage figures into milliequivalents (meq) per 100 g since the cations in the soil are likewise expressed on a meq/100 basis. (In fact, this form of expressing results in more characteristic of the exchange reactions in soil and the nutrient uptake by plants than the conventional weight basis). This conversion is obtained by multiplying per cent by 1000 and dividing by the equivalent weight of each cation. This calculation has been carried out for Ca (EW, 20), Mg (EW, 12.16) and K (EW, 39.1) from the whole aerial plant data in Table 7 and the results are recorded in Table 14. The table also includes the concentration of the exchangeable cations, the mm of cations in the plant, the Ca/K and Ca/Mg ratios of plant and soil as well as the CK and cMg values. Since the cCa coefficient is taken as one, cK devotes a proportionate K uptake of 12.6 and cMg a proportionate Mg uptake of 2.7 in relation to Ca. In view of this tendency, which is characteristic of most crops, fertilizer practices should be directed towards obtaining an adequate concentration and also optimum cation ratios or nutrient balances for maximum yield and quality of crops.

To suggest to the farmer and advisor the forms and quantities of lime and fertilizer needed to achieve the desired production, soil or plant test diagnostic techniques must be designed to convey this information in an uncomplicated and easily communicable form. The North Carolina Soil Testing Service has achieved this through the employment of index values for each nutrient. These index values are based on standardization of instrumentation from 0 to 100 in terms of concentration of each nutrient and with respect to metal cations also in relation to their desirable ratios. The index values of 100 correspond to 5, 1 and 0.4 meq/100 g soil of Ca, Mg and K, respectively. Hence, any parallel index value conforms to a Ca/Mg ratio of 5 and a Ca/k ratio of 12.5. These ratios have been found optimum for the majority of crops grown on light textured soils and they are expected to serve as very useful guidelines, even though narrower ratios apply with crops grown on highly sandy soils and wider ratios for crops grown on organic and heavy textured mineral soils. These variables are however incorporated in the lime and fertilizer recommendations.

An application of the relationships between soil pH, index values and responses to various nutrients on yield and value of peanuts is shown by the data in Table 4. The rates refer to landplaster equivalent (94% CaSO_4). The treatment labeled CaS was landplaster, dusted on the foliage at early flowering. The CaSCu treatment was a copper landplaster mixture applied as fungicide for the control of leaf spot and dust at the rate of 250 lbs. landplaster and 4 lbs. Kocide, 101 (86% CuO or 56% metallic Cu, 14% inert material). The nutrients CaSN consisted

Table 13 - Equivalent concentration and ratios of K, Ca, and Mg in peanut tops and soil

Substance	K	Ca	Mg	$\frac{K}{Na}$	Ca/K	Ca/Mg	cK	cMg
meq/100g								
Peanut Tops	71.10	64.0	33.70	168.8	0.9	1.9	12.6	2.7
Soil	0.16	1.8	0.55	2.3	11.3	5.1	--	--

Table 14 - Relationship between soil pH, index values and responses to various nutrients on yield and value of peanuts

Rate lbs/a	Nutrient	Yield lbs/a	Value \$/a	Soil	Index Values					S _{0.5} -S lbs/a
					P	K	Ca	Mg	Mn	
Variety, Florigiant, Martin Co., N. C. (1970)										
Control		2639	380	5.6	80	19	32	26	11	20
250	CaSCu	3070	436	5.4	87	22	32	22	10	76
600	CaS	3174	453	5.5	82	20	45	17	11	90
600	CaSN	3496	494	5.5	92	23	34	18	11	72
600	CaSNEK	3660	524	5.4	89	22	40	17	12	92
LSD, 0.05%		496								
Variety, NC2, Bertie Co., N. C. (1970)										
Control		2125	270	5.0	100+	58	22	17	16	40
250	CaSCu	2196	264	5.1	91	49	18	12	15	36
600	CaS	2979	415	4.8	100+	62	33	11	17	78
600	CaSN	3422	483	5.0	100	62	30	14	19	102
600	CaSNEK	3583	476	4.9	100	57	29	12	16	72
LSD, 0.05%		217								
Variety, Florigiant, Newsoms, Va. (1970)										
Control		3417	377	5.8	78	65	44	32	7	18
250	CaSCu	3757	456	5.8	81	60	57	34	7	36
600	CaS	4604	641	6.0	77	64	67	22	8	40
600	CaSN	4529	616	5.9	72	63	46	23	7	56
600	CaSNEK	4475	580	5.8	100+	66	52	21	7	98
LSD, 0.05%		451								
Variety, NC 17, Chowan Co., N. C. (1970)										
600	CaS	2158	302	5.4	100+	25	56	30	10	124
1200	CaS	2468	344	5.3	100+	23	40	20	9	136
1200	CaSN	2474	351	5.4	100+	29	60	29	10	160
1200	CaSNEK	3214	455	5.3	100+	31	50	26	7	146
LSD, 0.05%		471								
Variety, NC5 Bertie Co., N. C. (1970)										
600	CaS	3648	529	5.1	100+	65	61	18	17	104
1200	CaS	3536	502	5.1	100+	78	62	15	17	136
1200	CaSNEK	3672	535	5.0	100+	86	63	17	21	140
LSD, 0.05%		N.S.								
Variety, NC5, Bertie Co. N. C. (1969)										
400	CaS	3683	500	6.1	100+	45	49	25	9	--
800	CaS	3903	520	6.0	100+	42	58	22	10	--
1200	CaS	4080	570	6.0	100+	41	64	20	8	--
Variety, NC2, Chowan Co. N. C. (1969)										
Control		2162	254	5.5	100+	22	25	26	8	--
800	CaS	2492	314	5.5	100+	22	40	13	6	--
Variety, NC2 Pitt Co., N. C. (after Perry & Sullivan, 1970)										
Control		2250	308	5.3	100+	33	33	11	9	0
600	CaS	1876	263	5.2	100+	29	41	8	9	70
600	CaSK	1772	169	5.1	100+	30	48	9	8	64

of a United States Gypsum granular material containing 5% N in the form of urea. The N rate was 34 lbs./a applied past prior to planting in a 14 to 16 inch band, except at the Newsoms site where it was applied at emergence. The treatment labeled CaSNPK was the same as CaSN but was mixed prior to the application with granular 0-10-20 to supply 30 lbs. P_2O_5 (13.2 lbs. P) and 60 lbs. K_2O .

Soil samples were collected at the time of harvesting peanuts and the chemical properties recorded in Table 14 measured. The data represent averages from 2 to 4 replications.

The various sources of landplaster did not effect phosphorus (P), potassium (K) or manganese (Mn). They decreased pH very slightly at the Martin and Bertie Co. locations and increased the exchange acidity (Ac) slightly only at the Martin Co. site. The landplaster treatments increased calcium (Ca) and sulfate sulfur (SO_4-S) over control (No. 1) at all locations, and decreased Mg.

The chemical data probably explains the increased yield and value for the materials containing urea and supplemental P and K. The pH's were probably too low, particularly at the Bertie Co. location, for optimum nodulation and nitrogen fixation with the result that the inclusion of nitrogen produced larger increases. Although the pH's at the Martin Co. site are not excessively low, those soils are too high in exchange acidity and low in organic matter for adequate nitrogen supply and thereby giving responses to additional nitrogen. At the Newsoms location, soil organic matter, pH and exchange acidity are optimum and no response to additional nitrogen is indicated.

The phosphorus level at the Martin Co. site is high, but the potassium level is low which leads to the conclusion that the main increases in yield and value were probably mainly due to the addition of K. At the Bertie Co. location the P level is high and the K level is medium to high, hence, additions of P and K did not increase yield or value of peanuts. The addition of P and K at the Newsoms location failed to increase yield and value since the P and K levels in the soil are already high. The P levels at the Chowan Co. site are high and the K levels are on the border line between low and medium. The large increases in yield due to PK and value were probably mainly due to the addition of K. Additions of CaSNPK at the Bertie Co. location (1970) failed to increase yield or value over CaS alone.

According to the soil tests all index values for P are high and responses to this element in peanut yield are not to be expected. The range of K, however, is considerable and responses to this nutrient were indicated when the index values were below 23 at the Martin Co. location and below 32 at the Chowan Co. site. Additions of K did not increase yield or value at the Newsoms location with index values in the range 60-66. Data from Perry and Sullivan in Pitt Co. showed the addition of K to decrease yield and quality with index values in the range 29-33.

The ranges of Ca-index values in Table 14 were considerable. With an index value of 32 for the control at the Martin Co. location, yield and value was increased at the 250 lbs. rate of landplaster without reaching significance but reaches significance at the 600 lb. rate. At the Bertie Co. site with a Ca-index value of only 22 for control, the 250 lb. rate failed to increase yield and value, but resulted in significant increases at the 600 lb. rate. Additions of 250 lbs. landplaster increased yield and value of peanuts at the Newsoms location, however, significant increases were obtained only at the 600 lb. level, when the Ca-index, values of the control plot was 44.

At the Chowan and Bertie Co. locations (1970 harvest) the control plots were lost, hence comparisons between a 600 and 1200 lb. rate of landplaster is availa-

ble. Under these conditions no further increases in yield and value over the 600 lb. rate were obtained with index values in the range 40 to 63. Table 14 also includes data from a 1969 harvest for Bertie and Chowan counties. At the Bertie site additions of 800 and 1200 lbs. landplaster produced slight increases in yield and value over a 400 lb. rate with Ca-index values of 49 to 64. At the Chowan Co. site, 800 lbs. of landplaster resulted in moderate increases in yield and value although the Ca-index value of control was only 25. The lack of effectiveness of landplaster in this case may be attributed to a deficiency of K as indicated by the low index values for K. Landplaster decreased yield and value of peanuts in the Pitt Co. experiment carried out by Perry and Sullivan. This negative effect is suspected to be due to a deficiency of Mg as indicated by the very low index values. The inclusion of K further decreased yield and value indicating enhanced competition with Mg.

Since those studies did not include the use of Mg materials, the significance of the ranges of index values for Mg in relation to yield and value cannot be evaluated. However, from the standpoint of the previously discussed importance of maintaining optimum cation ratios, the index values for Mg should be approximately within the same order as those for K and Ca. Hence, Mg was probably a limiting factor for optimum nutrient composition on all locations and a limiting factor for yield at the Pitt Co. site.

There was no evidence of Mn deficiencies in any of the locations recorded in Table 14, although index values less than 8 may be suspected of becoming limiting and particularly if the pH's are adjusted above 5.8 as recommended.

The S levels are generally shown to be increased with additions of calcium sulfate and the quantities used are sufficient to meet the S requirements of the crop.

Practical Applications

The main objective of this contribution was to evaluate the importance of both level or concentration and balance of nutrients for maximum yield and quality of peanuts. A major key towards achieving this objective is through soil and plant diagnostic techniques and in the expression of the results to be easily commutable between advisor and user of the information. For this purpose, the North Carolina Soil Testing Division has instituted a system of soil test information based on index values. These index values cover the range of deficiency to sufficiency for each nutrient on a numerical scale 0 to 100. This range of values relates to level or concentration of nutrient. However, as pointed out before there is likewise need for expressing the results in terms of balanced nutrition. This has been achieved by letting a unit index value be equal to the desired optimum nutrient ratio. This principle is particularly applicable to the metal cations, K, Ca, and Mg.

The lb/acre corresponding to index values of 100 are shown in Table 15. This table also provides information on the quantities of fertilizer materials equivalent to 10 index units.

From the soil test data in Table 14 it appears that the index values for K should be greater than 30 in order to avoid yield limitations due to a lack of K. On the basis of nutrient balance, the index values for Ca and also Mg should be greater than 30 and in near proportion to the index values of K. These proportions would be adequate for the vegetative requirements of the peanut plant. Additional quantities of Ca, as CaSO_4 (landplaster) are required, however, for

the fruiting environment. As pointed out previously, an equal index value for Ca and K indicates a Ca/K ratio of 12.5. This applies to the total extractable Ca and K, but does not necessarily apply to the Ca/K ratios in the solution phase of the fruiting media. Studies by Mehlich and Reed (1946) have shown these ratios to be narrower in the solution phase than on the exchange complex. The magnitude of these differences is indicated by some of the data reproduced in Table 16, together with the calculated index values. The data selected involved 3 levels of K and 2 levels of Ca including the addition of gypsum equivalent to approximately 400 lbs. per acre.

The data show that by increasing the Ca level from an index value of 27 (soil pH 5.0) to an index value of 40 (soil pH 5.9) increases the Ca in solution slightly. This treatment difference had little effect on K. Potassium in solution however increased largely in proportion to the K in the soil. The significance of these interactions is well reflected by the Ca/K ratios which were found to increase with increasing Ca in the soil and decrease with increasing K in the soil. Since it is considered desirable to obtain in the solution phase Ca/k ratios 10 or above, the Ca present in the Ruston soil plus the 400 lbs. gypsum added were adequate when the K-index values corresponded to 10 and 20, but they were insufficient at the 40 index level. The deficiency of Ca for the attainment of a Ca/K ratio of 10 in the solution phase can be calculated from the data in Table 16 using the pH 5.9 soil. The calculations involve the difference between the meq. K $\times 10 = 0.79 - .53$ meq. Ca) $= 0.26 \times 1.9$ (efficiency factor based on the Ca/K ratio of the soil divided by the corresponding Ca/k ratio of the solution) $= 0.49$ meq/100 g soil. This corresponds to a Ca index value of 10. Hence, in order to obtain an optimum level of Ca in the fruiting media with a minimum interference by K, sufficient CaSO_4 should be added to this soil to correspond to a Ca-index of 50 (40 of the original soil plus 10). The quantity of CaSO_4 needed to supply the requisite Ca-index unit of 10 is shown in Table 15.

To provide a similar Ca level for the acid soil with Ca-index 27 and K-index 40 would require enhancement by 23 Ca-index units, requiring 1668 lbs. landplaster (94% CaSO_4) when broadcast or 750 lbs. placed in a 14 to 16 inch band. Evidently, for greatest production efficiency a soil should first be limed based on soil test recommendation.

Cation distribution studies in the solution phase of soils having K-index values greater than 40 have not been performed. However, if the trend for K to enter the solution phase with increasing K levels continues as indicated in Table 16, the Ca concentration will likewise require a proportionate increase. Since 600 lbs. landplaster (banded) corresponds to a Ca-index value of 20, this rate should be considered adequate for all soils with K-index values less than 40 and Ca-index values not lower than 20 units of the K indexes. In view of the greater intensity of competition with increasing concentrations of K, 20 Ca-index units corresponding to 600 lbs. landplaster are not expected to meet the requirements for Ca for the developing fruit. In the absence of factual data the following tentative suggestions are indicated from an extension of the data in Table 16. The 600 lbs. rates of landplaster (banded) per 20 index units for Ca is to be increased to 700, 800, 1000, 1250 and 1500 lbs. corresponding to K-indexes greater than 60, 70, 80, 90 and 100, respectively.

Although the objective of these suggestions is the achievement of balanced nutrition there is no evidence to indicate that peanut production levels can be substantially increased with K-indexes greater than 50. There is, however, evidence to show the high levels of K lead to pod breakdown and that this effect

Table 15. Conversion of Index Values to lbs/A of Nutrient and Fertilizer Materials Equivalent to 10 Index Units

	NUTRIENT					
	<u>P</u>	<u>K</u>	<u>Ca</u>	<u>Mg</u>	<u>Mn</u>	<u>S</u>
Index Value	100	100	100	100	100	100
lbs/Acre	150(340 P ₂ O ₅)	303(380 K ₂ O)	2000	243	80	200
lbs/Index V. of 10	15(34 P ₂ O ₅)	30(38 K ₂ O)	200	24	8	20

Nutrient Materials Equivalent to Index Value of 10 in lbs/A*

P	74 lbs. Concentrate Superphosphate (46% P ₂ O ₅)
K	63 lbs. Muriate of Potash (60% K ₂ O)
Ca	500 lbs. Limestone (CaCO ₃) 900 lbs. Limestone (Dolomitic, supplies 114 lbs. Mg) 725 lbs. Landplaster (94% CaSO ₄), broadcast, supplies 152 lbs. S 300 lbs. Landplaster (94% CaSO ₄), applied in 14-16 inch row, 63 lbs. S 375 lbs. Epsom Salt (MgSO ₄ ·7 H ₂ O), also supplies 20 lbs. S
Mg	200 lbs. Epsom Salt (MgSO ₄ ·7 H ₂ O), also supplies 20 lbs. S 200 Dolomitic limestone, also supplies 42 lbs. Ca 46 lbs. Magnesium Oxide (52% Mg.)
Mn	16 lbs. Manganese Oxide (48-52% Mn.) 28 lbs. Manganese Sulfate (28% Mn.)
S	93 lbs. Landplaster (94% CaSO ₄), also supplies 25 lbs. Ca 200 lbs. Epsom Salt, also supplies 24 lbs. Mg

* To effect a change in 10 index units the equivalent quantities of materials should be multiplied by a suitable factor for each nutrient based on the known efficiency of utilization; viz. P = 3, K 1.5.

Table 16 - Influence of levels of K and Ca in soil on their concentration and Ca/K ratios in solution (Ruston sandy loam)

K-level in soil		Ca index value				Ca/K ratios			
Index Value	Meq/100g	Cations in solution				solution		soil	
		27 (pH 5.0) 40 (pH 5.9)							
		Ca	K	Ca	K	pH 5.0	pH 5.9	pH 5.0	pH 5.9
meq./100 g basis									
10	.04	.27	.013	.42	.012	20.8	35.0	34.0	50.0
20	.08	.45	.042	.52	.039	10.7	13.3	17.0	25.0
40	.16	.44	.083	.53	.079	5.3	6.7	8.5	12.5

can be partially alleviated by high rates of landplaster (Hallock et. al., 1968). Sound economics dictates to refrain from adding potash fertilizers for peanuts when the soil is well supplied with this nutrient, which applies to the nutrient phosphorus as well.

Magnesium should be applied whenever the Mg index values fall below 30 either in the form of dolomitic limestone if lime is required or suitable forms of Mg, such as the sulfate, or if K is also needed in the form of potassium-magnesium sulfate, or magnesium oxide, used in conjunction with fertilizers.

If need for manganese (Mn) is indicated by the soil test it should be applied at the rate of 7-12 lbs. of actual Mn prior to planting peanuts. These include manganese sulfate (about 24% Mn), manganese oxide (26-50% Mn) or manganese shelite (5-20% Mn).

Nitrogen should be applied at planting or prior to planting, but only if the soil is acid (below pH 5.5 or if the soil is sterile with respect to nitrogen fixing organisms and particularly if the peanuts have not been inoculated. The suggested rate is between 20 to 30 lbs. nitrogen per acre.

The precise suggestions for quantity and kind of material required can be provided by the Soil Testing Division provided the soil samples are submitted well in advance of planting. The best period for sampling is in the fall, immediately following the removal of the preceding crop. This step is of particular importance in connection with lime, and P and K fertilizers which should be incorporated in a plow-down operation, well in advance of planting.

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SEED PEANUTS - POTENTIAL VS. ACTUAL GERMINATION PERCENTAGES

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The planting value of seed peanuts is largely based on the soundness of embryo characteristics which permit seeds to be transformed into acceptable plants especially on the application of suitable fungicides to prevent critical infestions. The required embryo qualities cannot be directly observed. Their presence must either be assumed from the history of seed lots or by special seed evaluation tests.

The presence and nature of the essential embryo qualities can be evaluated from various viewpoints. In commercial practice the qualities of seed lots are traditionally evaluated by a rather narrow concept -- that of total germination percentage under favorable testing conditions. The assumption is commonly made that the higher the germination percentage the better the planting quality. But this assumption is not necessarily correct. Other information is needed. We need to gain information about the soundness of seeds that are capable of germinating.

The object of this paper is to introduce and discuss various concepts of seed life that could be useful to the seed industry. A knowledge of the concepts will permit the elimination of many of the mysteries now associated with storage life, germination tests, and field emergence. Application of this knowledge could greatly increase the profitableness of peanut production.

Germination Potential

Each seed has an inherent potential or capability either to be or not to be transformed into an acceptable seedling. A seed lot in turn possesses a capability to produce a certain percentage of acceptable seedlings under favorable germination conditions. The measure of this capability could be called the potential germination capacity. This potential germination percentage represents a ceiling for actual germination percentages.

The true value of the germination potential is usually unknown when seeds are evaluated only by growth tests. It is only when the germination is 100% that the potential is actually known in a growth test.

Tetrazolium tests currently provide the most accurate estimates of germination potential. Such tests are rapid and relatively free of numerous and variable environmental influences that commonly cause trouble in growth tests.

A knowledge of germination potential can be very helpful in detecting unsuspecting troubles in growth tests. Such information, when used to supplement growth test results, is especially useful in checking effectiveness of fungicide applications.

Total Germination

Total germination percentages are usually determined from growth tests in paper towels. In order to obtain near maximum percentages, the tests are usually conducted under favorable testing conditions. In practice, however, the condi-

tions often vary in levels of favorableness. The results obtained always reflect an interaction between seed and the environment of the test. Results frequently vary with the environment.

Growth tests at best can only transform the germinable seeds into countable seedlings. Seeds that were initially non-germinable usually become liquid logged, decay, or produce abnormal or diseased seedlings. In case of dormancy even germinable seeds may fail to produce seedlings without special treatment.

In growth tests the potentially germinable seeds may fail to produce countable seedlings and thus give the impression that a seed lot has a much lower germination percentage than expected. Common causes for malfunctioning of germinable seeds in growth tests include excessive dryness of seeds, excessive initial supply of water in germination environment, lack of or inadequate fungicide treatment, poorly managed testing conditions, etc. Inadequate fungicide application is a common source of trouble that is usually preventable by suitable precautions.

A common type of discrepancy occurring between a potential germination percentage obtained by a tetrazolium test and the actual germination percentage from a standard growth is provided by the following example: A sample of seed submitted for tetrazolium and growth test was found by one laboratory to have a 93% potential and 92% total germination percentage. Another laboratory reported a 64% total germination. A retest of a new subsample two weeks later received similar tetrazolium and growth test results from the first laboratory. The second laboratory reported 69% germination in place of the earlier 64%. On another retest, the second laboratory reported a germination percentage of 94% which was all that could be expected from the inherent potential of 93%. The 64 & 69% germination reports were misleading estimates of the soundness of the seed lot. The seed lot could easily have been rejected by this false information.

Cases of a different nature occasionally come to light. In samples of seed where *Rhizopus* infection is a problem, the commonly used fungicides seem inadequate for suitable protection of germinable seeds against *Rhizopus*, Table 1. In this case the correction of the discrepancy between the potential and actual results awaits the desired fungicide.

The knowledge to be gained by striving to obtain agreement between potential and actual germination results provide many new concepts concerning the nature of germination problems. The time of testing for potential germination and for total germination can be important. In one series of tests the potential and actual germination percentages as first obtained in October were in good agreement. The second growth test results obtained in March were distinctly below the earlier percentage. A reevaluation of the samples showed a distinct reduction in both the potential and actual germination percentages during the 5 months of laboratory storage. The most severely-injured germinable seed in October had become non-germinable during storage.

Germination Tendencies

Tetrazolium tests commonly reveal that commercial seed lots consist of a wide array of embryos that show varying amounts of mechanical injuries and other forms of deterioration. One end of this array usually consists of embryos that are essentially sound with no more than minor injuries. The other end of the array is usually represented by seeds that are injured seriously enough to prevent germination even under the most favorable conditions. Between these

two extremes of soundness are to be found a variable distribution of seeds with wide differences within intermediate levels of soundness. Within this range there exists a division line between germinable and non-germinable seeds.

The distribution of levels of seed soundness among seed lots varies considerably. In seed lots of superior quality a high percentage of seeds contain no more than minor injuries and only a small percentage of seeds with major injuries, Table 2. A low quality lot of seed may contain the same general types of injuries as superior lots. The percentages of seeds with major injuries, however, tend to be increased.

The magnitude of potential or actual germination percentages does not necessarily reflect the patterns or levels of soundness of the majority of germinable embryos. Embryo soundness, nevertheless, has an importance on performance in storage, germination tests, and field emergence.

Seed lots that contain a high percentage of sound or nearly sound embryos tend to perform well under a wide range of environmental conditions. Germination occurs rather promptly and satisfactorily under a wide range of environmental conditions. Seedling vigor is fairly uniform and good. Regardless of the germination percentage we can consider that such seed lots have a stable germination tendency.

Seed lots that contain a high percentage of deteriorated, germinable embryos tend to store poorly, and to germinate erratically in growth tests and under field conditions. Such seed lots place a rigid demand upon storage and germination conditions being favorable. Even slight shifts in the degree of adversity of environmental conditions can result in wide differences in storage or germination response. Replicates of a test, or repeated tests, often give divergent results. Such seed lots can be considered as having an unstable germination tendency.

It is important to know whether a seed lot possesses a stable or unstable germination tendency. The usual growth tests conducted under favorable conditions are not very appropriate for evaluating germination tendency. The cold test is much more informative. Of even greater value is the tetrazolium test. The tetrazolium test permits by differential staining the evaluation of normal, weak, and dead tissues. A study of the presence, location, and extent of the abnormal tissue permits classification of embryos by extent and nature of soundness, Table 2.

The extent and nature of soundness is closely related to germination tendencies. The weak and necrotic tissues provide leachates and colonizing bases that stimulate infection by numerous saprophytic fungi. Even without infection these disturbed areas enlarge readily and are usually the first and main causes for premature loss of seed soundness and germination.

Table 1. Tetrazolium and growth test evaluations of seed samples showing no *Rhizopus* infection and samples with heavy infections that were not adequately controlled in growth tests by commonly used fungicides.

Samples tested	Condition of Samples	Tetrazolium evaluation		Total germination in growth tests		
		Germination Potential (1-5)	Germination Energy (1-3)	Arasan 75	Captan-Maneb	Captan-Maneb + Cercap
		%	%	%	%	%
18	No <i>Rhizopus</i>	78	60	77	--	--
11	<i>Rhizopus</i>	84	66	--	45	--
7	<i>Rhizopus</i>	84	64	--	42	58

Table 2. Tetrazolium seed quality evaluations of stable and unstable seed lots.

Seed Condition	Embryo soundness	Variety Lot	NC 5 Stable	NC 5 Unstable
			%	%
Germinable	1 (Best)		50	2
	2		30	14
	3 (av.)		6	40
	4		3	24
	5 (Poorest)		1	10
	Germination potential (1-5)*		90	90
	Germination energy (1-2)		80	16
	" " (1-3)		86	56
	" " (1-4)		89	80
	Main trouble**		M.	M.A.
Non-Germinable	6		3	1
	7		7	9
	8 (Dead)		0	0
	Main trouble		M.	M.A.

*Potential germination is an estimate of maximum germination percentages to be expected from standard growth test.

**M = Mechanical injury

A = Aging

THRIPS CONTROL; EFFECT ON YIELD AND GRADE OF VIRGINIA - TYPE PEANUTS IN VIRGINIA

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ABSTRACT & PAPER

Thrips control experiments involving 10 separate tests from 1965-1970 demonstrated yield increases in only one test. Thrips control, based on visual ratings, percentage of injured leaflets, and immature/mature thrips counts, was significant in all tests. Sound Mature kernels (SMK) contents had significant differences in 3 of 10 tests, but did not favor thrips control. Value per acre favored thrips control only in a 1967 test. This value increase was probably achieved through southern corn rootworm control by the insecticide formulations employed in the test. On a farm with a history of nematode problems, the effective systemic thripicides, carbofuran, aldicarb, disulfoton, and phorate failed to increase yields over untreated controls. However, when dibromochloropropane (Nemagon®) was injected as a sidedress treatment in addition to the insecticide, there was a trend toward higher yields. Plots treated with the insecticide/nematicide, carbofuran (Furadan®), and sidedressed with the nematicide had the highest yield and value per acre. Plots receiving only the nematicide had the second highest yield and value.

INTRODUCTION

Thrips injury to peanuts was first reported by Watson (1922). Poos (1941) demonstrated that the disease-like symptom known as "pouts" was caused by the rasping-type feeding of tobacco thrips, *Frankliniella fusca* (Hinds), in the unopened leaflets of seedling peanuts. Thrips injury to peanuts occurs annually, although its degree of severity depends on many factors such as population numbers, timing of occurrence, and general growing conditions.

Thrips have been effectively controlled by sprays and dusts (Poos and Batten, 1937; Poos, 1945; Poos et al., 1948; Arant, 1956; Arthur and Hyche, 1959). Systemic insecticides applied in granular form or as drenches have been particularly effective (Howe and Miller, 1954; Arthur and Arant, 1959; Morgan et al., 1970).

However, irrespective of effective control and severity of damage, the effects of thrips control on yield and grade have been difficult to demonstrate. Early attempts to demonstrate the value of thrips control usually resulted only in increased vine weight.

The following report presents results of thrips control experiments on peanuts in small plots at or near the Tidewater Research Station, Holland, Virginia from 1965-1970.

METHODS AND MATERIALS

Standard plot size of 12-ft. width (4-36 in. rows) x 20-ft. length was employed in randomized tests with 4 to 6 replications. Soil types varied from well drained light sandy soils to somewhat poorly drained fine sandy loam soils.

Only minor variations in application procedure occurred in tests from 1965-1970. In general, candidate materials were applied as granular formulations in the seed furrow in predetermined rows with a hand-operated Gandy® Mod. 901-2 applicator. The granular insecticides were then incorporated by a gradient-type rotary tiller or by the planter shoe during planting. All candidate granular insecticides possessed a degree of systemic activity. Some foliar sprays were included in tests for comparison of control. The sprays were usually limited to 1 application at a solution rate of 50 gallons per acre. Sprays were applied after thrips injury first became apparent. In the 1969 and 1970 tests, randomly selected plots were fumigated for 24 hours with methyl bromide gas, applied under a plastic tarp, at the rate of 1 lb. per 120 sq. ft. Other plots were injected with dibromochloropropane (Nemagon®) at 8 lb. active/acre.

Thrips control was evaluated by a number of parameters: (1) Percent actual injury was determined by examining 12 leaflets per plant in 10 randomly selected plants per plot. (2) A visual control rating was assigned with a grade of 1 showing little damage and a grade of 5 having severe damage. (3) Thrips counts were made by pulling 10 unopened leaves from each plot, placing them in alcohol and later counting mature and immature thrips with a microscope. (4) Yields were determined by picking peanuts with a stationary picker after field curing. (5) Standard grading procedures were employed to determine percent sound mature kernels (SMK) and percent extra large kernels (ELK). (6) Value per acre was based on grade value x yield.

All data were tested for significant treatment means differences at the 5% level by Duncan's multiple range test.

RESULTS

A summary of significant differences measured in thrips control tests from 1965 through 1970 is presented in Table 1. Thrips control was achieved in all tests when comparison was made with untreated controls. Significant differences in untreated- and treated-plot yields resulted in only 1 of 10 tests during the 6 year period (Table 2). Conversely, although differences were not significant, there was a trend toward higher yields from plots with no thrips control in 1965 and in test 1970b.

When significant differences occurred in grade (1967a, 1970a, 1970c), they tended to favor no treatment (1967a, 1970a) or the nematode treatment in the 1970c test (Tables 2 and 3).

Value per acre was significantly influenced by treatments in test 1967a and test 1970c. Per acre values favored treatment with carbofuran, phorate, phorate-zinophos, and Dasanit® in 1967a (Table 2).

Neither species nor population level of plant parasitic nematodes which probably inhabited the test plots in 1969 and 1970 were known, although one possible interpretation of results strongly indicates that damaging numbers of nematodes might have been present. In the split-plot test of 1969 (Table 4), yields were significantly higher from plots fumigated with methyl bromide than from plots treated with systemic insecticide then sidedressed with Nemagon®. Differences were not significant, but % SMK and % ELK were highest from plots that received only the methyl bromide treatment. The results from test 1970b indicated an unfavorable interaction of chemicals when carbofuran-, aldicarb-, and phorate-treated plots were sidedressed with Nemagon®. Although differences were not significant, the highest yields came from untreated plots. Test 1970c indicated probable damaging infestations of nematodes in the test plots. The

highest yield and value per acre was obtained from plots treated with carbofuran and sidedressed with Nemagon®. Plots treated with Nemagon® (only) were second highest in yield.

The hypothesis that thrips control was not responsible for yield benefits of 1967 treatments (Table 2) appears valid since results indicate that the yield response was probably due to southern corn rootworm control. Carbofuran, aldicarb, phorate, phorate-zinophos, disulfoton and Dasanit® are all effective against thrips. Disulfoton has never been effective against rootworms in my tests, thus low yields in untreated and disulfoton-treated plots were probably due to rootworm infestations that were severe in 1967. Low yields of the aldicarb + diazinon plots are difficult to explain, as they were not significantly different from untreated plots.

DISCUSSION AND CONCLUSIONS

Generally, entomologists experimenting with thrips control on peanuts have concluded that thrips control per se is not economically important nor practical. With the advent of effective chemical weed control, the need for rapid seedling growth to contribute competition, shading and subsequent weed control is doubtful.

However, most peanut researchers and practically all commercial peanut growers continue to practice chemical thrips control. The aesthetic value of pretty peanuts and subsequent grower pride appear to be the most important factors remaining to overcome before the discontinuance of thrips control can begin.

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Table 1.

THRIPS TESTS RESULTS, HOLLAND, VA., 1965 - 1970.

Year	Significant Differences			
	% Control	Yield	Grade	Value/Acre
1965	Yes	No	-	-
1966	Yes	-	-	-
1967a	-	Yes	Yes	Yes ^{1/}
1967b	Yes	No	No	No
1968a	Yes	No	No	No
1968b	Yes	No	No	No
1969	Yes	No	No	No
1970a	Yes	No	Yes ^{2/}	No
1970b	Yes	No	No	No
1970c	Yes	No	Yes	Yes ^{2/}

^{1/} Value Favored Treatment^{2/} Value Favored No Treatment

Table 2.

INFLUENCE OF THRIPS CONTROL ON
GRADE, YIELD, AND VALUE, HOLLAND, 1967.

Treatment-lb, AI/acre	% ELK ^{1/}	% SMK	Yield ^{1/}	Value/Acre ^{1/}
1. Carbofuran G @ 2.0	5.0a	52.5	3176bc	322abc
2. Aldicarb G + Diazinon G @ 1.0 + 2.5	14.8c	54.5	2813a	289c
3. Phorate + G @ 1.0 + 2.0	8.0ab	58.5	3485c	379a
4. Phorate-Zinophos G @ 1.5 + 1.5	5.5a	53.5	3176bc	325abc
5. Disulfoton G + Diazinon @ 1.0 + 2.5	8.5ab	52.0	3176bc	317bc
6. Disulfoton G @ 1.0 + 2.0	11.0bc	49.5	2868ab	274c
7. Dazanit G @ 1.0 + 2.0	11.0bc	57.8	3176bc	355ab
8. Untreated	13.5bc	52.8	2650a	270c

^{1/} Treatment means not sharing a common letter are significantly different.

Table 3.

GRADE, YIELD, AND VALUE ON VIRGINIA-TYPE PEANUTS
TREATED FOR THRIPS CONTROL, COURTLAND, 1970.

Treatment-lb AI/Acre	Average Percent		Yield	Value ^{1/} \$/Acre
	ELK ^{1/}	SMK ^{1/}		
1. Carbofuran 10G @ 1.0	32.3d	72.5a	4289	611ab
2. Carbofuran + Nemagon	34.5bcd	73.0a	4960	714a
3. Aldicarb 10G @ 1.0	33.0cd	72.3ab	4516	642ab
4. Aldicarb + Nemagon	37.3bcd	74.3a	4579	672ab
5. Disulfoton 15G @ 1.0	40.5abc	72.3ab	4606	662ab
6. Disulfoton + Nemagon	33.8bcd	72.0ab	4080	579b
7. Phorate 10G @ 1.0	34.5bcd	73.5a	4380	635ab
8. Phorate + Nemagon	34.0bcd	71.5ab	4447	627ab
9. Untreated	36.0bcd	72.8a	4443	639ab
10. Nemagon @ 8# AI/Acre	44.5a	74.5a	4661	694ab

^{1/} Treatment means not sharing a common letter are significantly different.

Table 4.

EFFECT OF THRIPS CONTROL ON PEANUT YIELDS.
SMITHFIELD, VIRGINIA, 1969.

		Average Yield - lb/plot ^{1/}	
Insecticide (only)		Insecticide + Nemagon	Insecticide + Methyl Bromide
Phorate	11.10	9.42	11.70
Disulfoton	10.98	10.34	12.78
Carbofuran	9.36	9.30	11.32
Aldicarb	10.44	8.62	10.52
Untreated	9.98	Nemagon 10.56	Methyl Bromide 12.16

^{1/} Differences in treatment means were not significant.

SANITARY CONSIDERATIONS IN THE PRODUCTION AND USE OF RAW SHELLED PEANUTS

by

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A discussion like this commonly begins with a definition of terms. Sanitation is a word that can cover so many different concepts that it is desirable to indicate what we intend to cover in this discussion.

Sanitation, for our purposes, consists of the cumulative objective of the actions and the precautions, aimed at producing a finished product that is wholesome i.e. does not contain microorganisms or substances of a kind or in a concentration such that it is an actual or potential hazard to health.

The elimination of potential hazards to health is emphasized because it is this facet of sanitation that has become a major concern of practically every segment of the food industry.

The potential hazard consists of microorganisms or trace substances none of which are obvious i.e. visible to the naked eye in the process or in the finished product. These factors are detectable only by laboratory tests, often of a very sensitive and sophisticated kind. To complicate matters there are other organisms and substances not specifically hazardous but regarded as indicators of possible contamination and hence of potential hazard.

This emphasis upon sanitary factors that are detected or measured only by laboratory tests in effect forecasts a new look, a changing concept or even a revolution for many segments of the processed food industry.

It is appropriate at this point to bring up the subject of Good Manufacturing Practice or GMP as it is called. Some time ago the Food and Drug Administration published in the Federal Register a general statement of GMP. This is the one that has been described as the "umbrella" GMP i.e. a regulation applicable to all food processing operations.

It is logical to ask whether this regulation or something like it might not represent a complete guide to sanitation. In this connection, Panel 2 of the National Conference on Food Protection, on Prevention of Contamination of Commercially Processed Foods, observed in its report "Experience in recent years . . . has demonstrated that although conventional good manufacturing practice is necessary it is not always sufficient to prevent the occurrence of incidents of putative health hazard and very costly regulatory actions.

The report goes on to say, "The panel was unanimous in agreeing that new dimensions must be added to good manufacturing practice and that these new dimensions depend on laboratory tests . . ."

To sum up: to avoid both health and regulatory hazards, attention must be given to certain traditional or obvious considerations plus some that are newer and not so obvious.

RAW PEANUT SHELLING

For raw peanuts in the shell; good sanitation requires that they be sorted under conditions that will prevent insect and rodent infestation. The procedures for accomplishing this, including fumigation are fairly well known and not within the scope of this discussion. Mold contamination can however be a serious problem if the in-shell peanuts are not completely or uniformly dried before

being placed in storage. Even more important may be the leaking roofs, condensate drip and high humidity due to poor ventilation. We are informed that this is why, in one producing area, at least, some shellers experienced difficulty with aflatoxin in 1970 even though none of the peanuts delivered to their buying points were found to contain *A. flavus* growth.

After shelling and grading, all peanuts are subjected to aflatoxin testing, and consequently contaminated lots will be diverted from food channels. In this way contamination of the food supply is prevented but it should be recalled that it is axiomatic that a heavy or massive input of contamination will strain almost any screening procedure and thus increase the chance of contamination getting through to later stages of the food processing chain.

RAW SHELLLED PEANUTS

After shelling and grading, the raw shelled peanuts are usually placed in cool storage until shipped to the user or manufacturer. Shelled peanuts are still highly susceptible to insect and rodent infestation as well as mold growth. Again the safeguards required are well known and will not be detailed at this point. However, as the peanuts move from the sheller, via truck or rail to the user or manufacturer some additional and not so well known sanitary considerations come into play. Even before aflatoxin was heard of, or before there was serious concern over presence of certain newly prominent microorganisms in foods, good manufacturing practice dictated that the buyer inspect the goods upon receipt. Statistics are not available regarding the proportion of user-buyers who make a systematic inspection of raw peanut receipts but there is a consensus that it is much higher than it was a few years ago.

Peanuts constitute a raw agricultural commodity and the sheller must meet USDA grade specifications with respect to foreign material, damaged nuts, etc. To this we must now add the pre-testing for aflatoxin contamination.

The inspection given to the incoming shipment of peanuts allows a recheck of the grade factors, not only to confirm the original grade certificate, but a check of the protection accorded the peanuts during transportation.

Instances of infestation in transit are too numerous to mention and to these we must add the incidence of mold damage. The Voluntary Code of Good Practices for Purchasing, Handling, Storage, Processing and Testing of Peanuts published by the National Peanut Council advises the manufacturer: "The carrier and the outside of all bags should be examined for mold, dampness, and must or unusual odors. Peanuts from moldy bags should not be used in edible products." These precautions are aimed at mold damage but when combined with a recheck of grade factors will serve to assure the user that the incoming material meets the sanitary standards appropriate to a raw agricultural commodity.

Mention is made of "standards appropriate for a raw agricultural commodity" because of the necessary distinction between food materials as harvested from the fields and finished food products. This distinction is recognized in several sections of the umbrella GMP of the FDA, mentioned earlier. It is recognized, for example, that raw materials entering a plant may contain damaged or imperfect food items that will be removed in the initial stages of processing. In another section good practice requires that a physical separation be maintained between incoming raw material and finished foods or foods in process. This separation is extended to personnel and portable equipment, carts, etc. The avoidance of contact, direct or indirect, of finished food products with raw

materials is tacit recognition that raw agricultural commodities are not expected to meet the standards applied to finished food products.

SANITATION BY THE FOOD PROCESSOR

The sanitation problems of the food processors who use shelled peanuts as a raw material are not substantially different from those of other manufacturers of processed foods. The parallel is particularly close when the finished food product is not sterile i.e. not given a final thermal processing step in a sealed container. The single possible difference is the extra special attention given to the removal of mold damaged nuts.

In terms of the laboratory tests applicable to the process and particularly to the finished food product, the processor will focus his attention upon:

1. Aflatoxin
2. Extraneous matter
3. Viable microorganisms

AFLATOXIN

To judge by the volume of research and other evidence of interest it would seem reasonable to conclude that aflatoxin control is a dominant sanitary consideration in the production and use of peanuts. On the other hand if judgment is based on regulatory activity involving product recalls and the attendant publicity, not to speak of economic losses, it would appear that food processors should have equal concern with extraneous matter (insect fragments, rodent hairs, etc.) and viable microorganisms (salmonella, *E. coli*, etc.).

The Voluntary Code of Good Practices of the National Peanut Council covers the subject of aflatoxin control by the food processor in ample detail and need not be repeated here. It may be worth commenting, however, that the processor would be well advised to study these recommendations carefully and to do what is needed in order to be certain that his products meet the guidelines established by the FDA. The agency has let it be known that it will not restrict itself to the announced aflatoxin guideline in the case of products that have been produced without an evident attempt to follow the recommended procedures. Confirmation of the presence of aflatoxin is possible at levels well below the current guideline of 20 ppb.

EXTRANEEOUS MATTER

"Extraneous matter" is a euphemism for insect fragments, rodent hairs and filth. In a recent action more than 2000 cases of peanut butter were recalled from wholesale and retail levels because of "rodent contamination," according to one report. Another source reported that "FDA said peanuts used to make the peanut butter were found to contain rodent hairs, pesticide residues, and coliform contamination." Without delving into the details of the case or the curious combination of contaminants mentioned it seems probable that this was the result of a failure to apply the most elementary type of sanitation. This is the kind of sanitation problem that is usually well controlled by conventional good manufacturing practices.

The problem of traces of extraneous matter in products made under good manufacturing conditions but detectable by microscope techniques is not so

simple nor so clear. The aforementioned panel of the National Conference on Food Protection made the following observations on this subject: "Insect fragments and rodent hairs are not desired constituents of food materials but unfortunately cannot be completely avoided in many cases, especially in certain raw agricultural commodities. Although the presence of this extraneous matter is not, per se, a positive index of a public health hazard there are no recognized guidelines for discriminating between non-hazards and potential hazards."

The panel went on to make the following recommendation: "The significance of the interrelationship of detected extraneous matter and microbial contamination of processed foods should be established so that all concerned will have a means of knowing when additional testing and counter measures are required."

Most will agree with the statement of the problem and the recommendation but at the same time recognize that this aspect of sanitation merits careful attention by the food processor. In other words he will want to conduct periodic tests to assure himself that extraneous matter is maintained at the lowest practicable levels.

VIALE MICROORGANISMS

The control of viable microorganisms in finished food products by the use of raw peanuts is in no way different from the controls used by any other food processor using raw agricultural commodities to produce non-sterile foods.

Although presumably there is more than one type of organism of concern in processed foods, major attention in recent years has been given to salmonella. This organism although not a spore former, and although it can be killed by the moderate temperatures of pasteurization when in the wet condition it is remarkably durable in the dry state. It is also detectable at extremely low levels by sensitive laboratory procedures. In addition many, if not all, strains of salmonella are definitely classed as pathogens. Thus even when detected at low levels and in types of food wherein a health hazard is extremely unlikely and could probably not be demonstrated, many lots of processed foods have been condemned and destroyed. The detection of salmonella has become the predominant target of nearly every food inspection agency. No foods are exempt.

The panel mentioned above commented that it "is not aware of any non-sterile processed food . . . that can be considered totally exempt from microbiological examination by either a regulatory agency or agency investigating an outbreak of food poisoning."

To get back to raw peanuts. Not long ago certain peanut containing confections, were subjected to a national recall because of salmonella. In seeking the possible source of the contamination all raw materials were examined, including peanuts. No final report has appeared and there is no indication that any will issue. It was the opinion, however, of at least two independent experts that the most probable direct source of the contamination was the in-plant environment.

The general situation was summarized by the Technical Sub-Committee of the National Peanut Council Research Committee as follows:

1. Peanuts are not commonly contaminated with Salmonella. Tests of lots of raw shelled peanuts in the laboratories of members of the Committee have given negative results.

2. The Committee is of the opinion, however, that peanuts, like any other bulk raw food or agricultural commodity, cannot be expected to be uniformly and totally free of *Salmonella* and food operators should recognize this potential for contamination, no matter how slight or sporadic, by careful handling and treatment of all such raw, unprocessed commodities.

3. Authorities agree that peanut roasting conditions as used for salting, confections, and peanut butter and which utilize temperatures of 300°F for 5 to 10 minutes effectively destroy all viable *Salmonella*. Testing of roasted peanuts has been even more extensive than that of raw peanuts, and tests in laboratories of peanut processors have shown roasted peanuts to be uniformly negative for *Salmonella*.

4. Extensive experience in food processing operations, that involve a sterilizing step like peanut roasting, has indicated that when *Salmonella* contamination in the finished product does occur, it can often be traced to:

- a) The introduction of other ingredients which do not go through the sterilizing (or pasteurizing) step, or to
- b) A focus of contamination in the plant itself, or to
- c) Dust contamination by contact, direct or indirect, between raw unprocessed agricultural commodities and the finished food product.

Thus raw peanuts should be treated substantially the same as any other raw agricultural commodity.

As mentioned at the beginning of this discussion, sanitation i.e. the prevention of contamination of commercially processed foods, seems to be entering a new era in which new dimensions are being added. Aflatoxin testing of peanuts and other agricultural commodities, is one such new dimension and we can be sure that the peanut industry will prefer to add new dimensions like this one at a time.

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STORAGE OF RAW PRESSED PEANUTS AND ROASTED PARTIALLY DEFATTED PEANUTS

by

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For APREA, July 18, 1971

In recent years a new low-fat peanut product called partially defatted peanuts has been introduced in the markets of this country (1, 2, 3, 4). Because of its lower fat and thus lower calorie content, this concept has an appeal to many calorie conscious people who love to eat peanuts. The manufacture of these partially defatted peanuts involves the following steps: preferably blanched peanuts, with a moisture content of about 5% are cold pressed at room temperature to remove 50 to 80% oil. The pressed peanuts are expanded in hot water to essentially their original size, drained, salted, and oil or dry roasted. Commercially produced partially defatted peanuts have approximately 55% of the original oil removed and may be prepared with some modifications in the steps described.

Because of the changed nature of the peanuts caused by pressing to remove oil, a study was conducted on the shelf-life of raw pressed peanuts as well as raw full-fat peanuts and roasted products prepared from these materials. Results of this investigation are reported in this paper.

MATERIALS AND PROCEDURES

Peanuts used in this study were commercially spin (dry) blanched peanuts prepared from medium Virginia freshly harvested peanuts of the 1968 crop. The peanuts were pressed in commercial cage presses at approximately 4000 lbs. per square inch to remove 57.5% of the original oil.

Pressed peanuts were placed in polyethylene plastic bags (0.006 in. thick) and stored at four temperature conditions: (1) 100°F, (2) 100°F for 3 days and then at 35°F, (3) 75°F, and (4) 35°F. Full-fat peanuts in polyethylene bags were stored at (1) 100°F, (2) 75°F, and (3) 35°F. Exposure of peanuts to a temperature of 100°F for 3 days before storage at 35°F was done to simulate the adverse temperature to which peanuts may be exposed while in transit by truck from one location to another.

Table 1 shows the analyses of the raw full-fat peanuts and pressed peanuts. Oil content for the full-fat peanuts was 49.3% and for the defatted peanuts 29.0%, a decrease of 57.5%. The peroxide value of the oil was the same for both -- 0.5.

American Oil Chemists' Society methods were used to determine moisture, oil, free fatty acid, peroxide value, and nitrogen.

Figure 1 shows the procedures used for preparing roasted full-fat peanuts and partially defatted peanuts. For full-fat peanuts, 700 grams of peanuts were roasted in peanut oil for 4 minutes at 325°F, cooled with air, salted by adding 2% salt and 1% oil and then packed under vacuum. For partially defatted peanuts, 700 grams of pressed peanuts were expanded for 2 minutes in water at 180°F, drained, salted with 4% salt, roasted in peanut oil for 3-3/4 minutes at 325°F, cooled with air, and packed under vacuum. For each roast, fourteen cans were obtained, each containing 50 grams of peanuts. These cans of roasted peanuts were stored at 75°F.

Table 1.

ANALYSES OF RAW PEANUTS

TYPE	MOISTURE	OIL	FREE FATTY ACID	PEROXIDE VALUE	NITROGEN
	%	%	%	meq/kg	%
Full Fat	4.9	49.3	0.3	0.5	4.7
Pressed	7.1	29.0 ^{1/}	0.5	0.5	6.6

^{1/} 57.5% of original oil removed.

Fig. 1. PREPARATION OF ROASTED PEANUTS

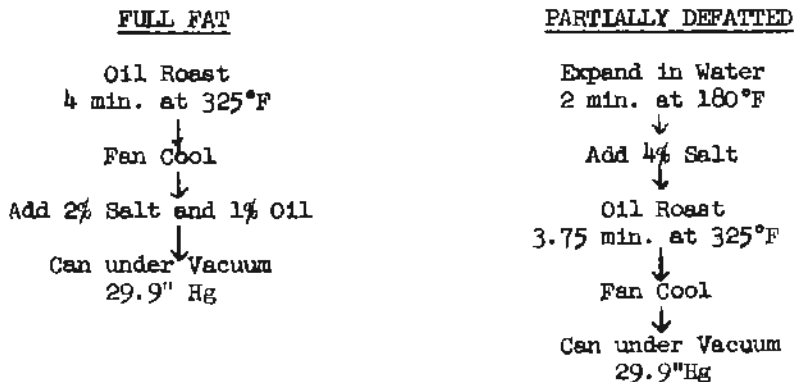


Figure 2 shows the gas fired oil roaster used in oil roasting the peanuts. It has a 160,000 BTU rating. For partially defatted peanuts, the basket must have a cover to keep the defatted peanuts submerged. Without a cover, the defatted peanuts would float to the top since they are lighter than the oil.

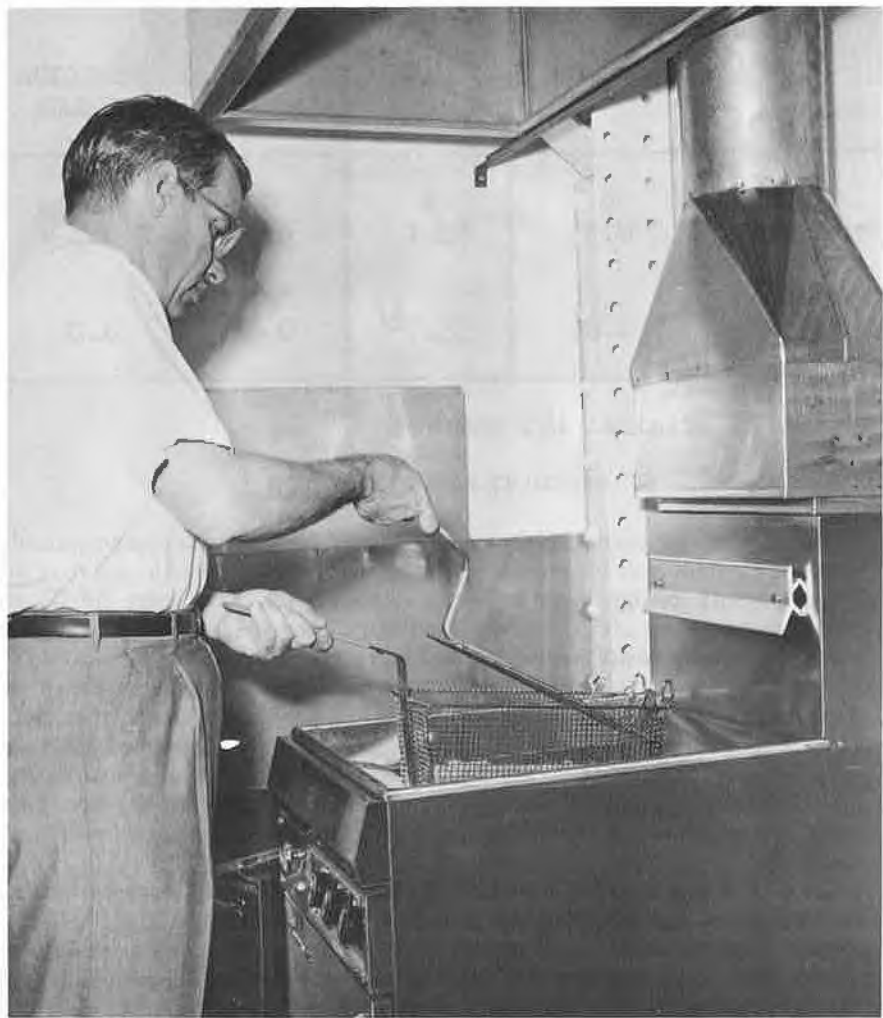


Figure 2 PEANUT OIL ROASTER

Table II shows typical analyses of the roasted peanuts. Oil content of the full-fat peanut was 52.1%. Oil content of the defatted peanuts was 33.7%. During roasting, the defatted peanuts gained 2.7% oil (dry weight basis).

Table II. ANALYSES OF ROASTED PEANUTS

TYPE	MOISTURE	OIL	FREE FATTY ACID	PEROXIDE VALUE
Full Fat	% 0.9	% 52.1	% 0.4	meq/kg 1.5
Partially Defatted	1.0	33.7 ^{1/}	0.5	1.0

^{1/} 51.7% original oil removed

RESULTS AND DISCUSSION

Shelf life of raw peanuts is shown in Table III. Shelf life was organoleptically evaluated by odor tests for rancidity. The pressed peanuts stored longer than the full-fat peanuts, perhaps because of the decreased oil content. At 100°F the full-fat peanuts were off in 5 months and had a peroxide value of 55 while the pressed peanuts were off in 6 months and had a peroxide value of 12.3. At 75°F the full-fat peanuts were off in 18 months and had a peroxide value of 45 whereas the odor of the pressed peanuts was still acceptable though they had a peroxide value of 38.7. It is to be noted that at the temperature of 35°F the peroxide values of both the pressed and the full-fat peanuts increased with time. Full-fat peanuts increased from 0.5 to 16.7. Other lots of peanuts have been stored at this temperature for 2 to 3 years with no significant change in peroxide values.

Table IV shows shelf-life tests at 75°F of roasted peanuts prepared from raw pressed and raw full-fat which had been stored at various times at 100°F. Taste tests on roasted peanuts were based on a 9 to 1 hedonic scale. Twelve months storage time were obtained for roasted peanuts prepared from full-fat and pressed peanuts stored up to 4 months at 100°F before roasting.

Both raw pressed peanuts and raw full-fat peanuts stored at temperatures of 75° and 35° F for 12 months yielded roasted peanuts with a shelf life of 12 months at 75° F.

Table V shows effects of packaging conditions on peroxide values of oil during storage of oil-roasted partially defatted peanuts. No significant differences were shown for peanuts packaged under a vacuum of 22 inches Hg as compared to peanuts packaged under nitrogen. Peanuts packaged under air and a vacuum of 14 inches Hg had rapid increase in peroxide values.

Table III. SHELF LIFE, RAW PEANUTS^{1/}

Temp °F	Full-fat P/N		Pressed P/N	
	Time Mo.	Perox. Val. meq/kg	Time Mo.	Perox. Val. meq/kg
100	5(off)	55	6(off)	12.3
100 (3 days) then 35	-	-	18+	13.3
75	18(off)	45	18+	38.7
35	18+	13.3	18+	16.7

^{1/} Peroxide value, initially 0.5 meq/kg.

Table IV. SHELF-LIFE, MONTHS

Peanuts	Raw, Stored at 100°F	Roasted ^{1/} Stored at 75°F	Taste Test ^{2/}
Full-fat	0	12+	6.6
	2	12+	5.7
	4	12+	5.4
	5(off) ^{2/}	0(off)	4.8
Pressed	0	12+	6.6
	2	12+	5.7
	4	12+	5.4
	6(off) ^{2/}	12(off)	4.5

^{1/} Raw peanuts after storage.

^{2/} Based on odor test by taste panel.

^{3/} Based on hedonic scale of 9 to 1.

Table V. STORAGE OF PARTIALLY DEFATTED PEANUTS: EFFECTS OF PACKAGING CONDITIONS ON PEROXIDE VALUES

PACKAGING CONDITIONS	PEROXIDE VALUES ^{1/} meq/kg	
	4 months	12 months
Vacuum, 22" Hg	17	17
Vacuum, 14" Hg	32	46
Nitrogen	18	18
Air	35	(45+)

^{1/} Peroxide Value, initially after roasting - 4.3 meq/kg.

Shelf-life data from one lot of peanuts has been given. Shelf life of partially defatted peanuts depend on the quality of the raw peanuts. To the best of our knowledge, there are no known chemical tests which can show with absolute certainty that a given lot of raw peanuts when processed will have a long shelf life. This is true even though raw peanuts may have a low peroxide value and a low free fatty acid.

Development of new chemical tests for raw peanuts that can be related to shelf life of raw full-fat and raw pressed peanuts are needed.

It was noted in these tests that peanuts with peroxide values as high as 30 to 40 may be acceptable organoleptically.

SUMMARY

The raw pressed peanuts had a better shelf life than raw full-fat peanuts at 75° and 100° F. and peroxide values after storage were lower for the pressed peanuts. Both raw pressed peanuts and raw full-fat peanuts may have a shelf life of over 12 months at temperatures of 75° and 35° F. and both may yield defatted peanuts which have a shelf life of 12 months at 75° F.

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OBSERVATIONS CONCERNING BLANCHING AND STORAGE EFFECTS ON THE VOLATILE PROFILE AND FLAVOR OF PEANUTS

by

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SUMMARY

The volatile-profile technique along with organoleptic evaluation was used to study effects of blanching temperature on peanuts. Three different temperature parameters were used; high, gradient, and constant. High-temperature blanching produced the most marked change in the volatile profile. Storage of blanched peanuts resulted in an increased concentration of some volatile components and in pronounced flavor changes. Results of this study suggest that storage of blanched peanuts might result in the production of off-flavored products.

INTRODUCTION

The flavor of freshly roasted peanuts is unique and desirable in the manufacture of peanut products. Mason, et al., (1966) has isolated and identified numerous compounds from roasted peanuts and proposed that a class of volatile compounds known as "pyrazines" is primarily responsible for the aroma and flavor of roasted peanuts. According to Mason, et al., (1969) reducing sugars, free amino acids, and small molecular weight peptides are precursors to pyrazine formation.

Although volatile components and nonvolatile precursors believed to be responsible for roasted peanut flavor have been investigated extensively, little information is available concerning the aroma, flavor, rheological properties, and effects of storage on the flavor of blanched peanuts. For peanuts the term "blanching" is used to indicate the process of removing the red skin or testa. The method discussed in this paper utilizes heat to lower the moisture content and loosen the skins. Peanuts are often processed immediately after blanching but in some cases are held in storage and/or shipped from the blancher to the manufacturer. Samples from some shipments of blanched peanuts had off-flavor after roasting.

This communication reports on a cooperative blanching study with a commercial blanching company. The objective of the study was to provide some explanations for the occurrence of the noted off-flavor.

EXPERIMENTAL

Materials

Two small lots of peanuts, designated "278" and "280," were commercially blanched by different treatments on March 10, 1970 and transported to the laboratory the same day. Immediately upon arrival each lot of peanuts was

divided into three parts. One part was analyzed immediately as freshly blanched peanuts. The other portions of the lot were stored for 30 days under controlled conditions or under simulated warehouse conditions (Pattee, et al., 1971) for later analysis. A third lot, designated "170," was part of a shipment of peanuts known to produce off-flavor peanut butter and for which a peanut butter sample was available for organoleptic evaluation. Samples from all lots were evaluated organoleptically. Blanching conditions for each lot were as follows:

Lot 170 - Constant temperature and sealed in metal cans (runner-type peanuts)

Lot 278 - Gradient temperature range - 100; 135; 165; 185; 175°F (Virginia-type peanuts)

Lot 280 - High temperature - 300°F (Virginia-type peanuts)

Unblanched control samples were also associated with each lot.

Component Isolation

Representative 100-g samples from each lot were quick-frozen in liquid nitrogen, ground in a blender for one minute and placed in a low-temperature high-vacuum, distillation apparatus. Five 100-gram samples were used per distillation. The distillation flask was under a N₂ atmosphere during addition of the sample to the flask. A high-vacuum distillation technique with differential cryogenic trapping (Pattee, et al., 1970) was used for isolation of the volatile.

Profile Analysis & Data Collection

The liquid N₂ trap was removed from the distillation system and equilibrated in a 70°C water bath for 30 min. A 5 ml vapor sample was used for analysis. Volatile components were separated using a Model 1840-10 Aerograph gas chromatograph equipped with dual flame ionization detectors and a 1/8" x 6' Chromosorb 102 column programmed from 125 to 200°C at 4° min.

The volatile profiles were integrated by an Infotronics CRS-100 digital integrator. The output of the integrator was fed into a teletype unit for digital data printout.

Organoleptic Evaluation

Blanched and unblanched samples were evaluated immediately upon arrival in the laboratory and after storage by individuals familiar with both raw and roasted flavor of peanuts.

RESULTS AND DISCUSSION

Data presented in Fig. 1 show the effect of blanching and storage on the volatile profile of peanuts. The volatile components with their respective peak numbers are identified as follows: (1) Methanol (2) Acetaldehyde (3) Ethanol (4) Acetone (5) Pentane (6) Methyl Formate (7) Pentanal (8) Hexanal. Immediately after blanching the volatile profile of the high-temperature blanched sample was greatly reduced (Fig. 1B). Apparently the components were volatilized by the high temperature or consumed by chemical reactions during blanching. Storage of this high-temperature blanched sample resulted in a qualitative reestablishment of the volatile profile (Fig. 1C and D). Analytical data presented in Table 1

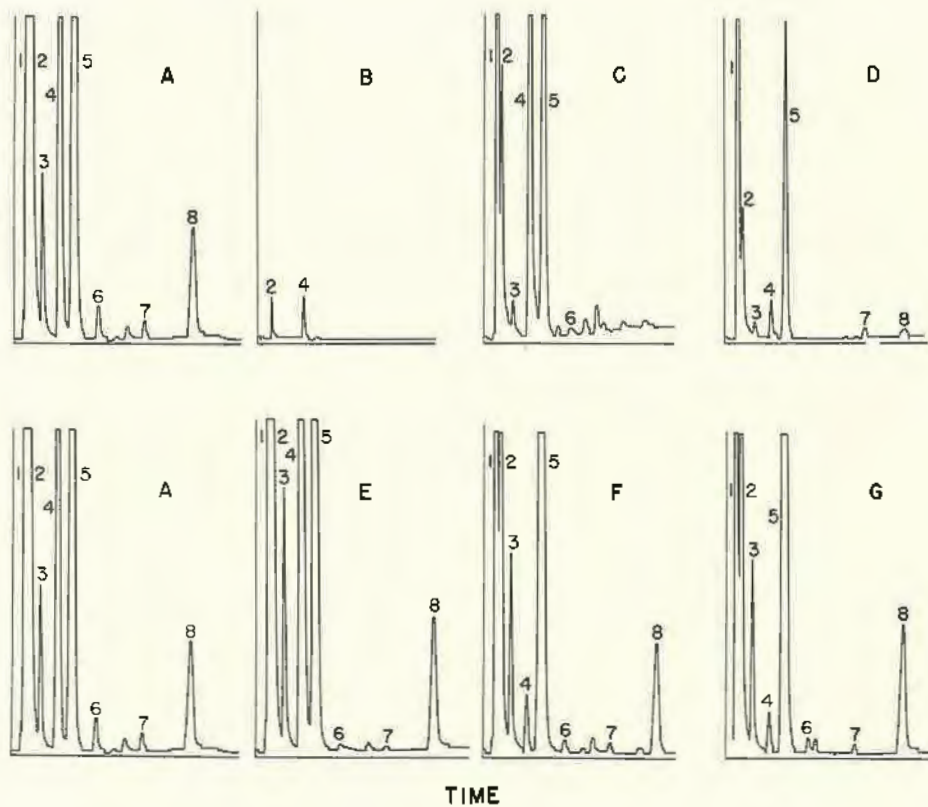


Table 1. Effects of blanching on Peanut Volatiles, Storage and Flavor of Blanched Peanuts

Sample Treatment	Component	Area Counts/gram				Flavor Components			
		Control	Freshly Blanched	Cold Room Storage	Ware-house Storage	Control	Freshly Blanched Peanuts	Stored Blanched Peanuts	Manufactured Product
High temperature blanching	methanol	483	0	132	93	typical raw peanut flavor	roast characteristic predominant	residual roast flavor notes present	Over-roast produced with extreme ease
	acetaldehyde	137	2	39	39				
	pentane	367	0.6	119	96				
	hexanal	31	0	0.0	1				
Gradient-Temperature Blanching	methanol	483	223	193	190	typical raw peanut flavor	very light roast characteristic raw flavor notes predominant	no residual roast flavor notes present flavor appeared to be "beany or grassy"	
	acetaldehyde	137	111	110	102				
	pentane	367	395	574	481				
	hexanal	31	41	36	36				
Constant Temperature Blanching Lot 170	methanol	122		200		typical raw flavor	slight roast characteristic with raw flavor notes predominant		Oily type taste
	acetaldehyde	610		82					
	pentane	275		297					
	hexanal	14		14					

reflect the quantitative differences between the profiles. These data suggest that some type of metabolism occurred during storage. These metabolic products could have been derived by enzymic reactions (Whitfield and Shipton, 1966; Pattee, et al., 1970) from the lipid fraction due to the action of lipoyxygenase and alcohol dehydrogenase. Autoxidative reactions contributed to the reestablishment of the volatile profile. The volatile content was lower in blanched peanuts stored under warehouse conditions than its corresponding analog under controlled storage. A difference in the moisture content of the blanched peanuts stored under the two different storage environments may have existed thus resulting in a lower profile from the warehouse-stored peanuts since lower moisture contents can reduce the volatile concentration of a food product (Wills and McGlasson, 1970).

High-temperature blanching of peanuts resulted in a product with definite roast flavor notes (Table 1). This suggests that blanching initiated the chemical reactions responsible for a light roasted flavor. Since the high-temperature exposure was not sufficient for a complete roast, a multitude of intermediate products were probably produced. Organoleptical evaluation of the high-temperature sample (Table 1) after storage showed that slight roast flavor notes were still present, but were partially masked due to the reestablishment of the volatile profile components (Fig. 1C and D). The ultimate effect of a partial roast on the flavor of processed peanut products has not yet been determined.

Changes in the volatile profile of the gradient blanched sample were less marked than in the high-temperature blanched sample (Fig. 1E, F and G). Analytical data presented in Table 1 show that during blanching loss of methanol and acetaldehyde occurred, while pentane increased. Storage of this sample resulted in a further increase in the pentane concentration. This was probably a result of enzymic and/or autoxidative reactions upon the lipid fraction.

When the gradient temperature-blanched sample was checked organoleptically immediately after blanching a very slight roast flavor was detected with the raw flavor notes being predominant (Table 1). After storage this sample had a "beany or grassy" flavor. Flavors of this nature are generally related to the production of carbonyl compounds (Forss, 1969).

According to Eriksson and Svensson (1970) plant enzymes differ in their responses to heat, and Eriksson (1967) found in peas that lipoyxygenase activity could be related to location within the seed. The higher activity was found near the center and lowest in the skins. With gradient-temperature blanching the internal temperature of the extra large Virginia-type kernel may have been below that necessary to inactivate the lipoyxygenase in the area of highest activity. Lipoyxygenase and alcohol dehydrogenase (Eriksson, 1968; Pattee, et al., 1970) are believed to be responsible for the production of carbonyls, alcohols, and hydrocarbon compounds; therefore further processing of peanuts stored after blanching could produce undesirable flavors in the roasted product.

Lot 170, runner-type peanuts, was subjected to a constant-temperature blanch, and the time of initial sampling and packaging was different from the previously discussed samples. The blanched nuts were sealed in metal cans and were not tested immediately after blanching. Analytical data for Lot 170 showed a decrease in acetaldehyde whereas pentane and methanol showed an increase above that amount present in the control (Table 1).

Flavor impressions from Lot 170 indicate that slight roast characteristics were present but with raw flavor notes being predominant. Organoleptic evaluation of peanut butter made from this lot of peanuts classified the product as having an

"oily" taste. The low-flavor quality of the manufactured product may have been due to incomplete development of typical roasted flavor or the flavor may have been masked by C₁₀ and higher n-alkadienals. According to Forss (1969) this class of compounds is generally responsible for the "oily" taste in food products. Due to the low threshold values of n-alkadienals they may be easily detected by organoleptic tests. The lipid fraction is believed to be the precursor for the production of n-alkadienals and these compounds can be produced both enzymatically and autoxidatively.

Results of this study suggest that blanched peanuts may have roast flavor characteristics and the degree of roast flavor development depends on the heat treatment used. Stored blanched kernels are also more susceptible to the development of undesirable flavors than raw peanuts. Thus blanched kernels should only be stored for minimal periods before processing into the final product to prevent the development of undesirable flavor characteristics caused by enzymic and/or autoxidation processes.

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**COMPARISON OF PROTEINS OF PEANUTS
GROWN IN DIFFERENT AREAS
II. PRELIMINARY IMMUNOCHEMICAL ANALYSIS
OF THE MAJOR PROTEINS**

by

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ABSTRACT and PAPER

Individual seeds of several Spanish- and Virginia-type peanuts were defatted with acetone and the proteins were extracted from the meals with phosphate buffer, pH 7.9, 10.01. Immunoelectrophoresis and immunodiffusion analyses of the soluble proteins were conducted. Based on comparisons using anti-immune serum to Virginia 56-R and Virginia 61-R peanuts grown in Virginia, very little qualitative differences were observed in the major protein precipitin reactions for the cultivars analyzed. Identical Spanish cultivars grown in Oklahoma and Texas showed differences in protein content and semiquantitative variations (double diffusion) for the major peanut globulin, *a*-arachin. Several Spanish and Virginia cultivars grown in Virginia contained all of the major proteins common to Virginia 56-R and Virginia 61-R. Semiquantitative evaluation by antibody-*in-gel* analysis of both Spanish and Virginia peanuts grown in Georgia showed some quantitative variations in the major protein, *a*-arachin.

INTRODUCTION

New ways of improving protein quantity and quality of seeds to satisfy the nutritional needs of expanding populations are increasing in importance. The protein composition of seeds are important influences on the nutritional characteristics and physicochemical properties governing the acceptance of oilseeds as dietary protein supplements. The relationship of plants and the genetic variations of plant hybrids can be readily elucidated by use of immunochemical techniques (1,2). The advantage of these methods is their ability to detect specific proteins (antigens) which are not readily distinguishable by other chemical means. A crude protein extract generally contains many separate antigens which induce the formation of distinct antibodies when injected into animals. Hence, serum obtained from animals injected with such protein extracts contains a complex array of antibodies.

The objective of this preliminary report is to determine by immunochemical techniques the quantitative and qualitative differences in the protein spectra of peanuts grown in different geographic areas. These analyses were carried out using immune-serum containing antibodies to the total proteins of either Virginia 56-R or Virginia 61-R peanuts and of the major peanut protein, *a*-arachin, grown in Virginia.

MATERIALS AND METHODS

Preparation of Samples

Individual peanut seeds were ground twice in 10 ml. of cold acetone with a mortar and pestle. After centrifugation at 39,100 g, the acetone powders were dried and the protein extracted in phosphate buffer, pH 7.9, 1.0M. Varying volumes of buffer were used depending upon the size of the seed (1.4-2.4 ml. per seed or approximately 3 ml. per gram of seed). Extracts were clarified by centrifugation at 9,100 g. The amounts of protein and antisera applied to the slides for analysis are given in the legend for each figure.

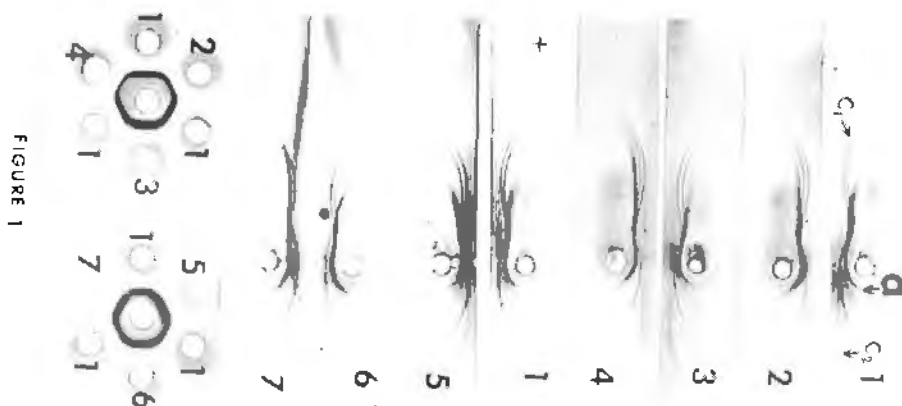
Analytical Techniques

Immunoelectrophoresis was carried out according to Grabar and Williams (3) and immunodiffusion according to Ouchterlone (4). Quantitation of α -arachin was determined according to Laurell (5). Protein estimation was made by the Lowry method (6). Antisera were prepared by Antibodies Inc., Davis, California (7).

RESULTS

Comparison of Identical Spanish Types Grown in Texas and Oklahoma

Figure 1 shows the immunoelectrophoretic (IEA) and immunodiffusion



precipitin patterns of Spanish peanuts grown in Texas and Oklahoma. The proteins identified were reported by Daussant, et al. (8). Both IEA and radial diffusion showed that all of the proteins in Virginia 56-R peanuts are present in the Spanish types; however, differences in concentration are evidenced by radial diffusion. Antisera from the Spanish types were not available in this study; therefore, the Spanish cultivars may contain other distinguishable proteins not present in Virginia peanuts. The major difference observed in this analysis is the

migration of α -arachin. In some cases, e.g., the Comet type (samples 3 and 6), the extended double arc for α -arachin (sample 6 as compared to sample 3) is readily visible. As long as the precipitin lines are continuous, any deviation from the normal patterns indicates changes in polymeric forms of the protein molecule. Such deviations have been reported previously for α -arachin (9,10). Major qualitative differences in proteins, if any, can be determined only by cross-reactions with several antisera and will be completed in future studies.

Qualitative Immudiffusion of Spanish and Virginia Peanuts Grown in Virginia

Immunodiffusion is actually more sensitive than immunoelectrophoresis. However, components with similar diffusion coefficients can sometimes overlap and become indistinguishable. Based on analyses of individual seeds, the samples examined in this study show some variations (Figure 2). The NC market types (samples 3 and 4) appear to have fewer precipitin lines than either Virginia 56-R

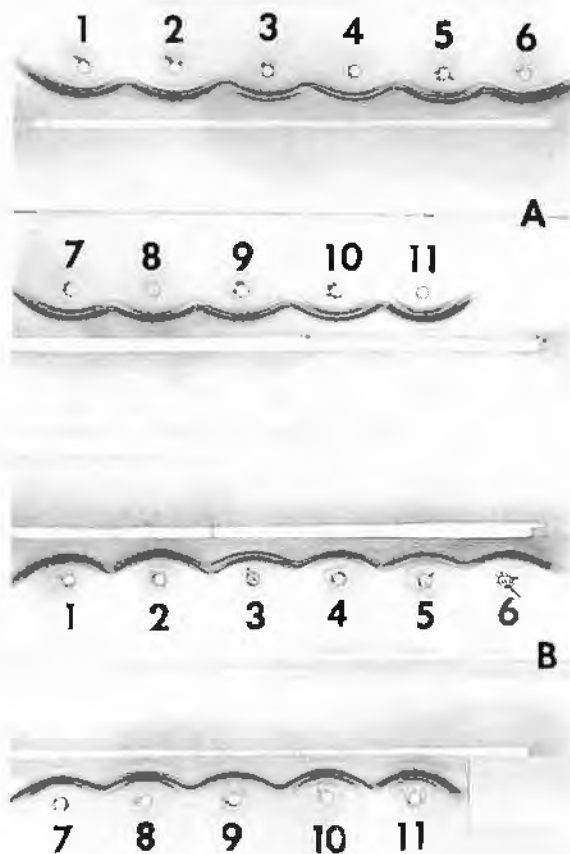


FIGURE 2

or 61-R as shown in Part A (anti-56-R immune-serum) of Figure 1. Note also, the close similarities of Florunner (Sample 5) and Florigiant (Sample 6) with these two cultivars. Differences are apparent in the minor components (functional proteins) but all of the major precipitin lines corresponding to the major globulins coalesce after using both 56-R and 61-R immune-sera. Here again, complete analysis would require cross-reactions using specific antisera from all of the cultivars under investigation.

Semiquantitative Analysis of α -Arachin by the Antibody-in-Gel Method

Several cultivars of both Spanish and Virginia peanuts grown in Georgia were analyzed for relative contents of α -arachin. This protein was characterized by IEA by Daussant et al. (8). The results in Figure 3 are based on the principle of

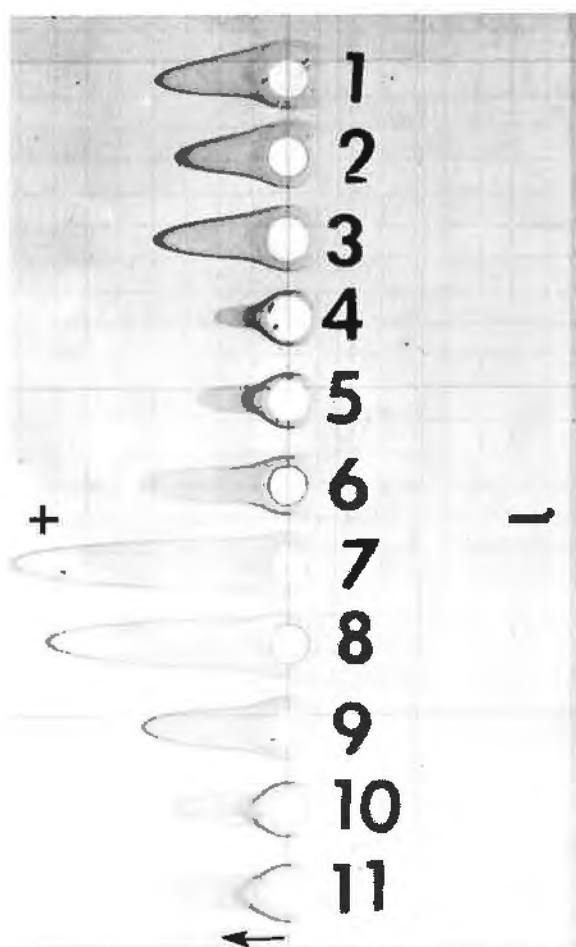


FIGURE 3

antigen-antibody complex of *a*-arachin. Two minor arachin contaminants were present in very low titer. The major precipitation frontier corresponds to the antigen-antibody complex of *a*-arachin. The amount of antigen that gives a thin distinct precipitin line is directly proportional to the length of the conical zone. Based on the protein extracted from individual seeds and assuming identical antigenicity of *a*-arachin in different cultivars, it appears that the Starr peanut (samples 7 and 8) has a slightly higher content of *a*-arachin; differences in the other samples are within experimental error.

DISCUSSION

Although limited data are presented in this communication, several inferences are warranted. In the case of *a*-arachin, e.g., differences in electrophoretic mobility while maintaining antigenic specificity suggest variations in polymeric forms of this particular protein. Perhaps in cultivated peanuts there exist "classes" of antigenically identical proteins that could have slightly different amino acid compositions which could have evolved through genetic changes. On the other hand, both qualitative and quantitative differences in seed proteins could result from environmental variations between planting sites. Differences in protein contents of leguminous plants grown in different climates and geographic locations have been reported (12).

From our results and from other studies (13, 14) it is evident that immunochemistry can be useful in detecting protein variations among closely related plants. Because cultivated peanuts are highly inbred (15), however, the task of elucidating minor variations by serological technique will require higher titers developed from purified fractions. In general, functional proteins (e.g., enzymes), as opposed to reserve or storage proteins, are of primary interest in predicting genetic relationships between seeds. In this study, total protein extracts were used as the source of antigens. It is conceivable, therefore, that proteins specific to certain genotypes could be masked by excessive storage proteins. We have ordered antisera to proteins of several other cultivated varieties and isolated fractions to obtain more complete information on this subject.

In conclusion, the data submitted show the close similarity of the major globulins in cultivated peanuts. We hope that more extensive work on enzymes responsible for protein synthesis will reveal more information on the degree of genetic variability.

ACKNOWLEDGMENT

The authors are grateful to W. K. Bailey, J. I. Davidson, R. O. Hammons, A. L. Harrison, J. S. Kirby and J. A. Harris for the generous supplies of peanuts and to Jack Bergquist for the photography.

LEGENDS FOR FIGURES

Figure 1. Qualitative immunoelectrophoretic and immunodiffusion analyses of Spanish peanuts grown in Texas and Oklahoma. Immune-serum to total proteins of Virginia 56-R peanuts grown in Virginia. Nomenclature: 1, Virginia 56-R (Virginia; 2, 3, 4, Argentine, Comet, Spanhoma, respectively (Oklahoma); 5, 6, 7, Argentine, Comet, Starr, respectively (Texas). C: α_1 -conarachin; C₂: α_2 -conarachin; A: α -arachin. Samples contained 30-70 mg. protein per ml. All wells for electrophoresis were filled to give equal amounts of protein (0.75-1.0 mg.) before electrophoresis. Troughs were filled three times with immune-serum after electrophoresis. For immunodiffusion, all wells were filled twice, including the center wells which contain immune-serum against Virginia 56-R. Electrophoresis was carried out for 2 hours in a 0.25M veronal buffer, pH 8.2, 25°C, at 4 V/Cm. Diffusion took place for 24 hours before drying and staining of the slides.

Figure 2. Qualitative immunodiffusion of Spanish and Virginia cultivars grown in Virginia. Total proteins of Virginia 56-R (a) and Virginia 61-R (b) immune-sera were employed. Nomenclature: 1, Va. 61-R; 2, NC-2; 3, NC-5; 4, NC-17; 5, Florunner; 6, Florigiant; 7, Virginia Bunch; 8, Early Runner; 9, Argentine; 10, Starr; 11, Virginia 56-R. All wells were filled with equal amounts of protein and the troughs were filled 4 times with immune-sera. Diffusion was allowed to proceed for 24 hours before drying and staining.

Figure 3. Semiquantitative analysis of α -arachin in Spanish and Virginia peanuts grown in Georgia by the antibody-in-gel method. Nomenclature: 1, Argentine; 2, Spancross; 3, Tifspan; 4, Early Runner; 5, Florunner (combined green & dried stock); 6, Florunner (foundation seed stock); 7, Starr (combined green & dried stock); 8, Starr (foundation seed stock); 9, Virginia 56-R; 10, Florigiant; 11, Virginia 61-R. All extracts were adjusted to 1.0 mg protein per ml. whereby 0.02 ml. volumes were applied to each well. The 1.5% agar plate contained 4.0% anti- α -arachin immune-serum from Virginia 56-R proteins. Electrophoresis was carried out at room temperature for 15 hours at 7.5 V/Cm. Plates were stained with 0.1% amido black in 7% acetic acid and washed in 70% acetic acid.

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DRYING COEFFICIENTS OF PEANUT PODS AND COMPONENTS

by

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INTRODUCTION

Fundamental drying research is needed for a better insight into the drying process, ultimately leading to properly designed, more efficient commercial dryers. To dry farmers' stock peanuts, three completely different materials - meats, skins, and hulls - each having completely different properties, must be dried. Tests were conducted to determine the relative drying properties of the materials and the effect of the hulls and skins on the drying rate of peanut kernels.

The drying of a product may follow two drying patterns. When the product is extremely wet, it may follow a constant-rate pattern. Once the loosely held moisture is removed from the surface of the material, the drying follows a falling-rate pattern.

Almost all agricultural products are dried by the falling-rate pattern. The moisture removed from the surface is replaced by diffusion of moisture from the interior of the material. The rate of removal steadily decreases as more and more of the moisture is removed and the difference in vapor pressure between the material and surrounding air is reduced.

Many rigorous theoretical analyses have been made concerning diffusion in the drying of agricultural products (2, 3, 8, 11, 12). These analyses usually entail many assumptions in regard to homogeneity, geometrical characteristics, temperature gradients, the variability of the diffusion coefficient, and even more important, usually require an involved numerical computer analysis.

A thorough analysis of moisture diffusion in peanuts was made by Whitaker and Young by assuming that peanuts were homogeneous spheres (9), and later by assuming the pods (complete peanuts with hulls intact) were made up of concentric spheres having different diffusivities (10). Excellent agreement was obtained from the latter analysis by numerically fitting the experimental data to the mathematical model. However, this approach does not allow simple, straightforward evaluation.

For many products, the rate of drying in thin layers has been found to be proportional to the excess moisture above equilibrium, or

$$\frac{dm}{dt} = -a (M - M_E)$$

where $\frac{dm}{dt}$ = rate of change of moisture with time

M = moisture content at time t, dry basis

M_E = equilibrium moisture content at the
condition of the drying air

a = falling-rate drying index

This relation is generally called the falling-rate drying equation, although drying can be falling-rate and still not obey the equation.

This equation was used in analyzing the drying of corn and wheat by Huxsoll and Hall (6). They stated that the equilibrium moisture content in the equation was the dynamic value, several percent higher than the experimental value, and suggested that there may be two equilibria in a drying process. Also, the first period or stages of drying did not appear to obey the relationship.

Manbeck, Nelson, and others (7) used equation [1] in evaluating vacuum drying of peanuts. Their results indicated the initial stages of drying were constant-rate followed by a brief transition period, before the data followed equation [1].

According to Henderson and Perry (4), equation [1] can be expected to hold quite well where diffusivity of moisture within the solid is high with respect to surface conductance and thickness. They stated that this is not the case, however, for grains, fruits, etc., and that a higher than true value for M_E must be postulated.

Although equation [1] did not fully describe the drying in these tests, agreement was adequate for the purposes of these tests.

MATERIALS AND METHODS

The drying tests were conducted on freshly harvested Starr Spanish, Early Runner, and Florigiant Virginia peanut pods, kernels, bald kernels, split kernels, and hulls. Drying was accomplished in a single layer in wire baskets with air at 95°F. and about 37 percent relative humidity. Air velocity through the baskets was about 20 feet per minute. Samples of each component were weighed periodically during the drying operation and all loss of weight was assumed to be moisture. After reaching equilibrium in the dryer, the samples were oven dried to determine the amount of bone-dry material.

RESULTS

A set of characteristic drying curves is shown in figure 1. The figure shows graphically the relative rates of drying of the various components. Numerical values of drying rates cannot be directly assigned to the curves because the rates continuously change throughout the moisture content range; however, a drying index may be determined for each curve by applying equation [1]. Equation [1] can be integrated to yield

$$\frac{M - M_E}{M_0 - M_E} = e^{-at}$$

where M_0 is the moisture when t equals zero. The term on the left side of the equation is referred to as the moisture ratio, MR. Data that obeys this relationship will plot as a straight line on semi-logarithmic graph paper, with a slope equal to a .

As was found by the previously cited investigators, slightly higher than true values for M_E were required to obtain straight line from the data. Also, the

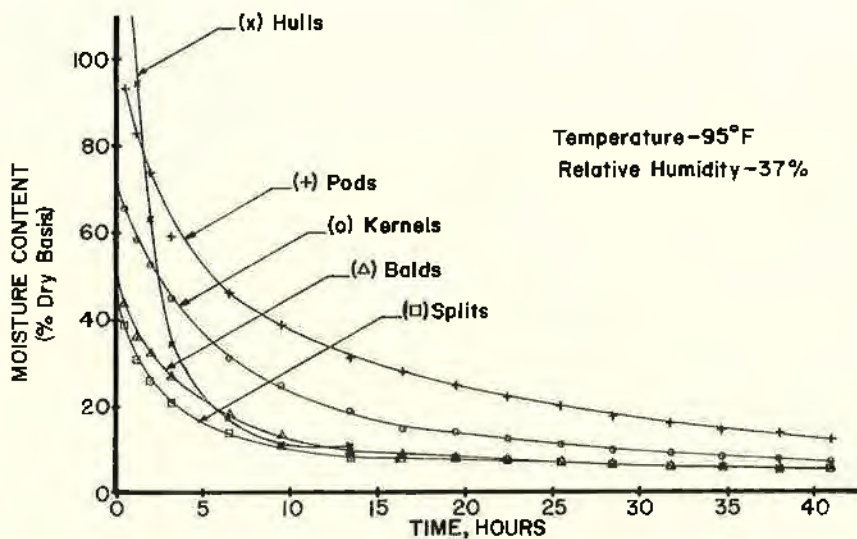


Figure 1.--Characteristic drying curves for Virginia peanut pods and components.

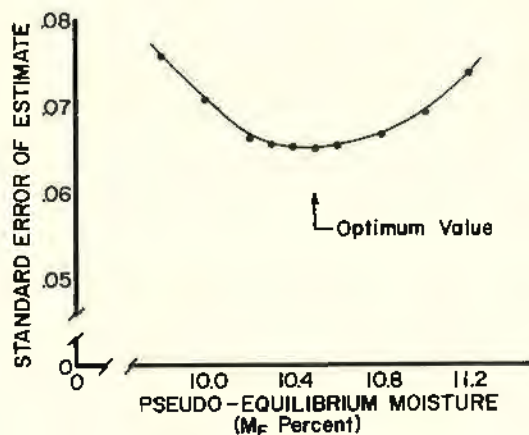


Figure 2.--Standard error of estimate versus Pseudo-equilibrium moisture for drying Runner hulls.

initial portion of the lines usually had some curvature. For this interval, the drying was either constant-rate, or falling-rate but was not in agreement with equation [2]. Equation [2] may be modified to eliminate the initial portion of the data that does not obey the equation and to provide for a higher than actual equilibrium value:

$$\frac{M-M_F}{M_A-M_F} \equiv e^{-a(t-a)}$$

M_F = pseudo-equilibrium moisture which replaces the true equilibrium value

a = time when drying rate becomes proportional to excess moisture

M_A = moisture content at time a

The point at which the data began to obey the equation was estimated from plots on semi-log graph paper.

To determine the value of M_F that gave the best-fit of the data to equation [3], the logarithm of MR was plotted against time (and linearly regressed) for a range of values of M_F . The degree of fit was indicated by the standard error of estimate, S , that has properties analogous to those of the standard deviation. Lower values of S indicate better fit of the data to the equation. Figure 2 shows a typical plot of S versus M_F , indicating that 10.5 percent was the optimum value of M_F for this instance. Although optimum values of M_F were determined mathematically in this analysis, fairly accurate values could be easily estimated.

Values of a , M_F , M_E , M_A and S are shown in table 1. An idea of the applicability of the falling-rate drying equation to the material can be obtained by comparing the values of S . Note that generally the data obtained by drying the kernel and its components showed excellent fit to the equation. Values for pods and hulls had higher S values, but agreement with the equation was adequate for comparative studies. A set of curves of MR versus time on semi-log coordinates is shown in figure 3.

Values of M_F were in close agreement with true equilibrium values for pods, and only about 1 to 2 percent higher for whole kernels and bald kernels. Split kernels and hulls required pseudo-equilibrium values 3 to 4 percent higher than actual values.

Compared with peanut pods, the falling-rate index, a , was higher by factors of about 2, 4, 6, and 20 for whole kernels, bald kernels, split kernels, and hulls, respectively. Some drying data were obtained for kernels drying within the hulls by sampling farmers' stock peanuts and determining the moisture content of the kernels as they were dried. The drying index for the kernels within the hulls was about the same as for the pods, that is, one-half the value of the loose shelled kernels. These results suggest that there is considerable merit from a drying standpoint in shelling peanuts at a high moisture condition, as suggested by Davidson and others (1), and then drying only the kernels. Not only would the kernels dry considerably faster, but storage volume would be only about one-half to one-third as much as for farmers' stock peanuts, much handling would be eliminated and insect control would be simplified.

Some tests were made on pods with cracked hulls. No significant difference in drying unbroken and cracked pods was noted, thus eliminating this type of

Table 1.--Results of drying tests

Material, type	Falling-rate index ^a	Pseudo-equilibrium moisture, M _p	Actual equilibrium moisture, M _E	Initial proportional drying moisture, K _A	Standard error of estimate, S
	<u>Per hour</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	
<u>Normal pods</u>					
Spanish:	0.0411	4.4		49.7	0.061
	.0443	5.8	6.41/	49.8	.076
Average----	.0427	5.1		49.8	.063
Runner:	.0520	7.3		55.2	.037
	.0559	6.5	6.71/	52.2	.053
Average----	.0539	6.9		53.7	.045
Virginia:	.0514	6.4		44.8	.054
	.0559	6.7	6.51/	47.2	.029
Average----	.0536	6.6		47.0	.028
<u>Cracked pods</u>					
Runner:	.0507	7.0	-	57.6	.061
Virginia:	.0546	6.3	-	46.0	.030
	.0540	6.7	-	44.6	.031
Average----	.0543	6.5		46.3	.030
<u>Kernels in hulls</u>					
Spanish:	.0451	4.0	-	59.5	.072
	.0463	5.1	-	58.2	.083
Average----	.0507	4.6		43.9	.078
Runner:	.0528	5.1	-	44.1	.082
	.0555	5.5	-	61.6	.053
Average----	.0542	5.3		52.8	.068
Virginia:	.0523	4.7	-	62.2	.115
	.0656	6.1	-	43.5	.093
Average----	.0591	5.4		52.6	.104
<u>Whole kernels</u>					
Spanish:	.123	7.7	5.5	30.5	.014
	.104	7.7	5.5	35.7	.019
Average----	.114	7.7	5.5	33.1	.016
Runner:	.0887	6.7	5.9	28.2	.027
	.0863	6.1	5.8	27.8	.027
Average----	.0885	6.4	5.8	28.0	.027
Virginia:	.0896	6.6	5.4	30.7	.055
	.100	7.0	5.6	37.2	.028
Average----	.0948	6.8	5.5	34.0	.042
<u>Half kernels</u>					
Spanish:	.167	6.2	5.6	25.6	.026
	.206	7.1	5.5	20.0	.092
Average----	.186	6.6	5.6	22.8	.014
Runner:	.188	8.0	5.3	35.7	.020
	.182	6.4	5.3	39.2	.018
Average----	.185	7.2	5.3	37.4	.019
Virginia:	.190	6.9	5.3	36.9	.017
	.219	8.1	5.0	24.1	.005
Average----	.205	7.5	5.2	30.5	.011
<u>Split kernels</u>					
Spanish:	.229	7.6	5.3	33.1	.004
	.243	7.9	5.5	15.8	.004
Average----	.236	7.8	5.1	24.4	.004
Runner:	.268	8.5	5.1	28.0	.013
	.253	8.0	5.3	57.8	.001
Average----	.262	8.2	5.2	42.9	.007
Virginia:	.369	10.6	5.5	30.5	.008
	.339	6.8	5.1	39.3	.046
Average----	.354	8.7	5.3	34.9	.027
<u>Hulls</u>					
Runner:	1.44	10.5	8.8	> 131	.065
	1.04	14.7	10.4	> 150	.051
Average----	1.24	12.6	9.6	> 140	.058
Virginia:	.642	14.5	9.4	> 165	.059
	.967	13.0	9.4	> 189	.153
Average----	.804	13.8	9.4	> 177	.106

1. Calculated from values of kernels and hulls

pretreatment from consideration for improving drying. A comparison of values of whole kernels and bald kernels shows that the absence of the skins resulted in about a 50 percent higher drying index, although the skins individually dried quite rapidly. Results of drying of the skins are not included in the table. Fast drying prevented the collection of sufficient data for a meaningful analysis. The skins were almost completely dry after about 2 hours.

The falling-rate index is dependent on physical size and shape of the particles being dried, in addition to the drying conditions - - temperature, relative humidity, and air velocity. Variation in drying conditions was beyond the scope of this work, and a correlation with particles size has not currently been investigated. Obviously, all other factors being equal, the drying index will be higher for small particles, and may account for some of the differences in the results reported. For example, the index for split kernels was about 35 percent higher than bald kernels, presumably due to the difference in particle size.

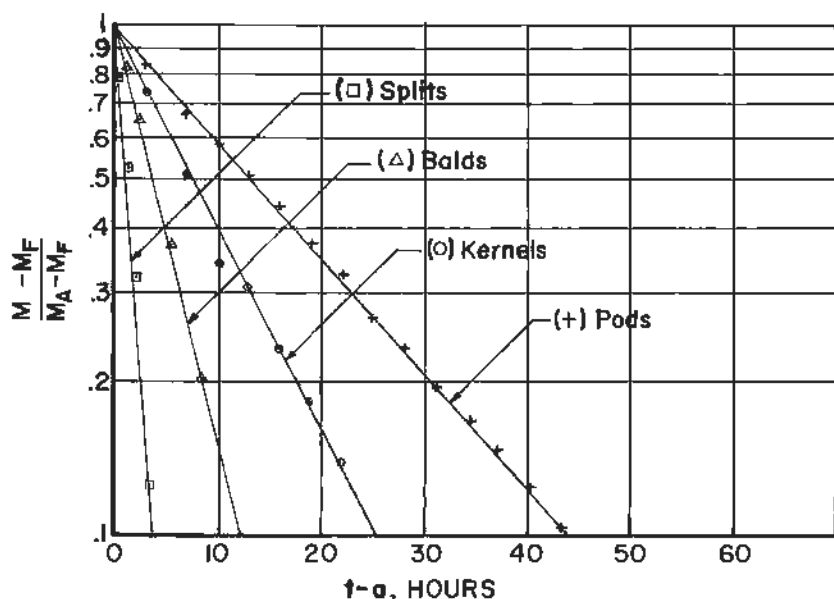


Figure 3.--Modified moisture ratio versus time for Virginia peanut pods and components.

DISCUSSION

Peanut pods and components obey a modified falling-rate drying equation reasonably well. Analysis of drying by this method is not as accurate as a more advanced analysis, but is considerably simpler to apply. Also, it is more meaningful than simpler measures of drying rate, such as points per hour, that vary throughout the moisture range.

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CONCENTRATIONS OF SOME ALDEHYDES AND KETONES FOUND IN RAW AND ROASTED PEANUTS

by

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ABSTRACT

Carbonyl compounds in oil expressed from raw and from freshly roasted runner peanuts were converted into 2, 4-dinitrophenylhydrazones (DNPH's) and separated into monocarbonyl classes by column chromatography. The DNPH's comprising each class were resolved by thin-layer chromatography. Concentrations of the DNPH's were calculated from the optical densities of their solutions in chloroform and reported as parts per million (ppm) in the expressed oil.

Data from 27 carbonyl compounds found in raw peanuts were collected. The major compounds were hexanal (0.34 ppm), octanal (0.06 ppm), and nonanal (0.12 ppm). Concentrations of hexanal and octanal exceeded their flavor threshold values. These compounds are probably responsible for the characteristic "green or beany" flavor and aroma of raw peanuts. Few, if any, of the other alkanals, 2-alkanones, 2-alkenals or 2, 4-alkadienals are probably important contributors to the flavor of raw peanuts.

Data were obtained for 33 carbonyl compounds found in roasted peanuts. Major aldehydes found were 2-methylpropanol, 3-methylbutanol, 2-methylbutanal, and hexanal. Each was present at concentrations greater than 1 ppm. The branched chain aldehydes exceeded their flavor thresholds several fold and are probably responsible for the sharp note of freshly roasted peanuts. Other carbonyl compounds exceeding their flavor thresholds included 2-octenal (0.22 ppm), 2-nonenal (0.62 ppm), 2-decenal (0.19 ppm), and 2, 4-decadienal (0.31 ppm), and several straight chain alkanals. These compounds probably contribute fatty or deep fried notes to roasted peanut flavor and aroma.

It is unlikely that any of the carbonyl compounds detected are responsible for the nutty flavor of roasted peanuts.

INTRODUCTION

The presence of aldehydes and ketones in the aroma and flavor fractions from roasted and raw peanuts has been recognized for several years (1, 2). Significant roles in the overall flavor and aroma of raw and roasted peanuts have been suggested for a few of these carbonyl compounds.

Pattee and his colleagues at North Carolina State University have published several papers relating the volatiles present in raw peanuts to storage conditions, curing conditions, and enzyme activities (1, 3, 4). They detected several compounds, including acetone, 2-butanone, ethanal, pentanal, and hexanal in raw peanuts. Pattee et al. also suggested that hexanal is responsible for the characteristic "green or beany" flavor of raw peanuts. (5).

Several aldehydes and ketones have been identified previously in roasted peanut volatiles (6, 7). The list of compounds includes the C₂ to C₁₀ straight chain aldehydes, as well as 2-methylpropanal, 2-methylbutanal, 3-methylbutanal phenylacetaldehyde, 2, 4-decadienal, and several other unsaturated aliphatic aldehydes. Research by Mason and his group at Oklahoma State University indicated that the harsh note in the aroma of freshly roasted Spanish peanuts is due to low molecular weight aldehydes and the sweet bouquet of roasted peanuts is due to the presence of phenylacetaldehyde (6).

Although volatile aldehydes and ketones are known to be important contributors to the flavor and aroma of peanuts, quantitative data for the carbonyl compounds present in the flavor and aroma fractions of raw and roasted peanuts have not been reported. The purposes of research reported in this paper were to determine the concentrations of volatile aliphatic aldehydes and ketones present in raw and roasted peanuts and to attempt to relate the concentrations of these carbonyl compounds to the flavor of raw and roasted peanuts.

MATERIALS AND METHODS

The peanuts were 1969 crop, No. 1 grade, Southeastern Early Runner peanuts. They were three-day windrowed, cured artificially at 90° F and stored at 38° F until utilized. Peanuts were roasted in a convection oven at 340° F until judged medium roasted. Results for raw and roasted treatments are based on three replicates.

The procedures for isolating and identifying the carbonyl compounds were similar to those developed by D. P. Schwartz et al. (8, 9). Carbonyl compounds present in oil cold pressed from raw and roasted peanuts were converted into their 2, 4-dinitrophenylhydrazones (DNPH's) by passage through a 2, 4-dinitrophenylhydrazine reaction column. The DNPH's of monocarbonyl, aliphatic aldehydes and ketones were separated from the DNPH's of other reaction products and from the oil by adsorption on Celite 545-Sea Sorb 43 columns and on partially deactivated alumina.

Alkanals, 2-alkanones, 2-alkenals, and 2, 4-alkadienals were separated into classes by rechromatography on Celite 545-Sea Sorb 43 columns. Individual compounds within a class were separated by chromatography on polyethylene glycol 400 impregnated Microcel T-38 thin-layer plates (7, 9). Compounds were identified by comparison with thin-layer and column chromatographic, UV, and mass spectral data for DNPH's of known aldehydes and ketones. Mass and UV spectra were obtained for unknown DNPH's after preparative chromatography on thin-layer plates.

Concentrations of individual compounds were determined after preparative chromatography of aliquots of the DNPH's comprising each class. Following preparative chromatography the DNPH'S were rechromatographed on alumina. The derivatives were then dissolved in chloroform (3-30 ml) and the absorbances were recorded at the absorption maxima (350-395 mμ) on a spectrophotometer (10). Concentrations were calculated on the basis of the molar extinction coefficients (10) and reported as parts per million (ppm) in the expressed oil.

Flavor threshold values (in paraffin oil) were taken from the literature (11, 12). Flavor threshold value as used in this report is the average minimal concentration of a compound in the solvent, below which aroma and taste is not perceptible to the receptors (11).

Mention of commercial products does not imply endorsement by the U. S. Department of Agriculture over a similar products not mentioned.

RESULTS

Polylethylene glycol 400 impregnated Microcel T-38 (PEG-T-38) TLC plates were well suited for separating and isolating the derivatives in each aldehyde and ketone class. Almost all of the common aliphatic aldehydes and ketones which are of potential interest in peanut flavor research could be separated using this system.

Figure 1 shows a preparative thin-layer chromatogram in which the DNPH's of the 2-alkenals isolated from a roasted sample were separated. The plate was developed twice in order to enhance the resolution of the lower molecular weight members of the series. In the lane at the right of the main separation, known 2-alkenal derivatives have been separated. The known derivatives are from top to bottom: 2-tetradecenal, 2-undecenal, 2-decenal, 2-nonenal, 2-octenal, 2-hexenal, and 2-butenal.

The DNPH's separated on the preparative TLC plates were easily eluted from the support phase and purified by rechromatography on alumina. In general the mass spectra of each of the DNPH's eluted from the preparative chromatograms were characteristic of the class to which they belonged. Satisfactory UV absorption maxima and absorbance readings were obtained after redissolving the residual DNPH's in chloroform.

Twenty-seven aldehydes and ketones were detected in raw peanuts. Quantitative data for 23 of the compounds were obtained. Concentrations of the major aldehydes found in raw runner peanuts are compared to their respective flavor threshold values in Figure 2. The carbonyl concentrations determined in peanut oil and their comparative flavor threshold values in paraffin oil are reported in parts per million (ppm). Only the concentrations of hexanal (0.34 ppm) and octanal (0.07 ppm) exceeded their flavor thresholds. The concentration of nonanal is somewhat lower than its flavor threshold, whereas the concentration of decanal is far lower than its threshold value.

Concentrations of some 2-alkenals in raw peanut oil are compared to their flavor threshold values in Figure 3. The concentration of 2-nonenal (0.034 ppm) approached its flavor threshold value. The concentrations of the other 2-alkenals shown in Figure 3 were well below their flavor thresholds. Concentrations of none of the other carbonyl compounds which were detected in raw runner peanuts closely approached their flavor thresholds. No evidence was found for the presence of isobutyraldehyde, 2-methylbutanal or isovaleraldehyde in raw peanuts.

Roasted peanuts contained a greater number of carbonyl compounds than did the raw peanuts, and concentrations of all the carbonyl compounds were greater in the roasted than in the raw peanuts. Thirty-three monocarbonyl compounds were detected in the roasted samples, and quantitative data for 32 were obtained. Concentrations of 12 of the aldehydes exceeded their flavor threshold values.

Figure 4 shows the concentrations of the major aldehydes from roasted peanuts. Butanal and 2-methylpropanal as well as 3-methylbutanal and pentanal were not completely resolved from each other on the PEG-T-38 thin-layer plates. For this reason the C₄ isomers were determined together, and the pair of C₅ isomers was determined together. Rechromatography on other adsorbants, i.e. silica gel or base impregnated Microcel T-38, together with mass spectral analysis demonstrated that the bands were comprised almost entirely of the branched chain isomers. Therefore, the concentrations of 2-methylpropanal and 3-methylbutanal were approximately 1.6 ppm, respectively.

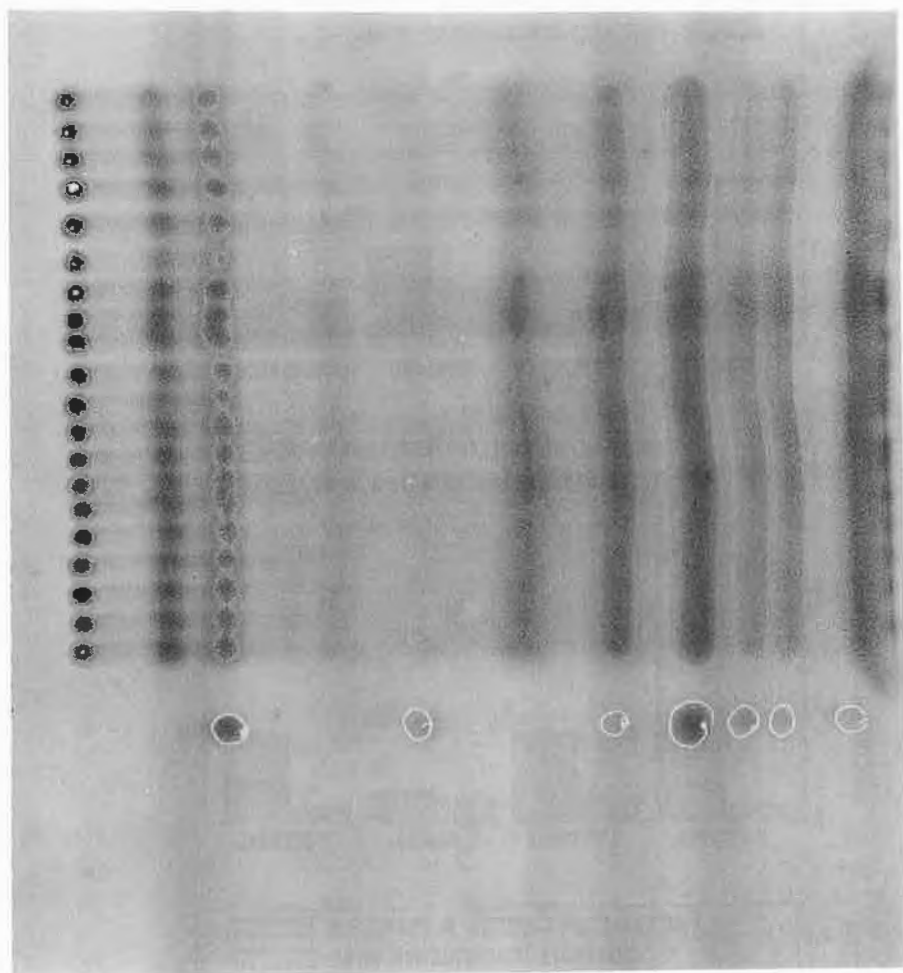


Figure 1

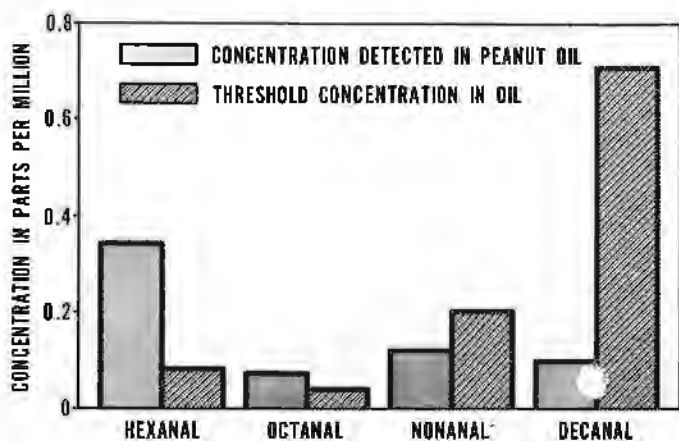


Figure 2

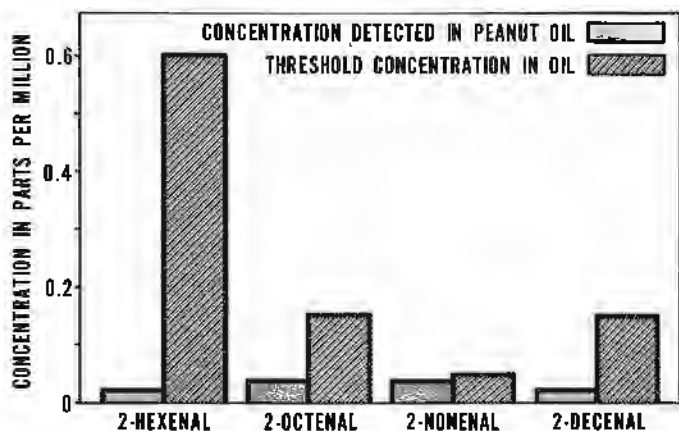


Figure 3

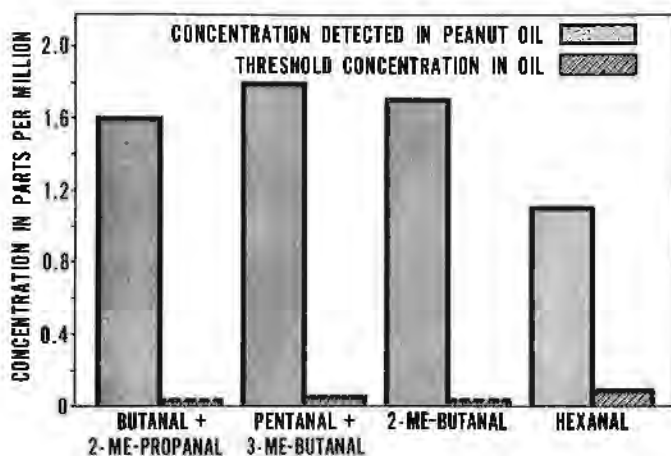


Figure 4

Threshold values for 2-methylpropanal and 2-methylbutanal in paraffin oil were not found. The flavor threshold values plotted for 2-methylpropanal (0.025 ppm) and for 2-methylbutanal (0.07 ppm) are those of butanal and pentanal valeraldehyde in paraffin oil. The true threshold values for 2-methylpropanal and 2-methylbutanal may be considerably lower, if the relationship between threshold values of branched aldehydes and their straight chain isomers in aqueous solutions (13), also holds true for oil solutions.

Concentrations of other straight chain aldehydes in roasted peanuts are compared with their flavor threshold values in Figure 5. Concentrations of octanal (0.41 ppm) and nonanal (0.68 ppm) and heptanal (0.084 ppm) exceeded their threshold, whereas the concentration of decanal (0.28 ppm) was far below its flavor threshold value.

In Figure 6 the concentrations of 2-alkenals in oil from roasted peanuts are compared with their flavor thresholds. The detected concentration of 2-hexenal (0.042 ppm) was only 1/15 of its threshold, while, concentrations of 2-octenal (0.22 ppm) and 2-decenal (0.18 ppm) were greater than their respective thresholds.

The concentration (0.25 ppm) of one other compound detected in roasted peanuts is also shown in Figure 7. This compound which was not detected in raw peanuts, had a mass number and chromatographic characteristics which indicated that it is a phenyl substituted 2-butenal. No threshold data are available for this compound. Concentrations of all the other aliphatic monocarbonyl compounds which were identified in the roasted peanut samples were lower than their threshold values.

DISCUSSION

Roasting resulted in increased concentrations of all of the aldehydes and ketones which were detected in both raw and roasted runner peanuts. The major qualitative as well as quantitative differences between raw and roasted peanuts were recorded for the branched chain aldehydes; 2-methylpropanal, 2-methylbutanal and 2-methylbutanal were not detected in raw peanuts, but in roasted peanuts their respective concentrations were 1.6, 1.7, and 1.8 ppm. These three aldehydes are probably Strecker degradation products of the corresponding free amino acids, valine, isoleucine, and leucine (6).

Another major difference between raw and roasted peanuts was the presence in roasted samples of the compound tentatively identified as a phenyl substituted 2-butenal. The origin of this compound is not known, but it probably is a pyrolysis product.

Concentrations of hexanal, octanal, nonanal, decanal, 2-octenal, 2-nonenal, and 2, 4-decadienal were greater in the roasted peanuts. These compounds are autooxidation products of oleate and linoleate. The greater concentrations of these saturated and unsaturated aldehydes can be attributed to the greatly accelerated rate of liquid autooxidation which occurs at elevated temperatures (11, 12).

Any attempt to correlated flavor with concentration of the various aldehydes and ketones detected before and after roasting is fraught with many difficulties. Flavor threshold values are affected by several parameters. The polarity of the dispersing medium and the solubility of the flavor compound or compounds in the dispersing medium affect the flavor thresholds of compounds. Generally the flavor thresholds of carbonyl compounds are lower in polar solvents than in nonpolar solvents (11). For this reason it is important to use flavor threshold

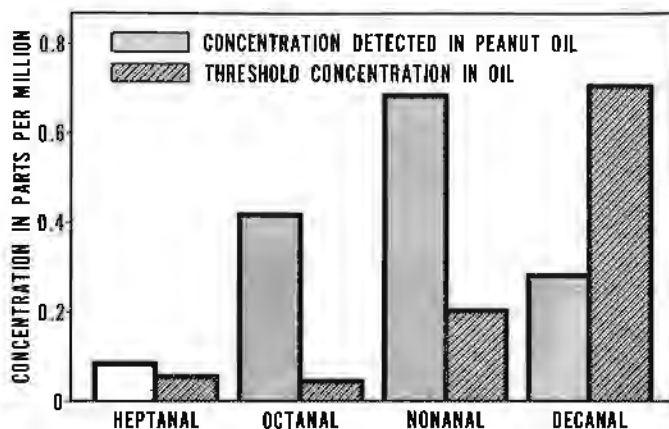


Figure 5

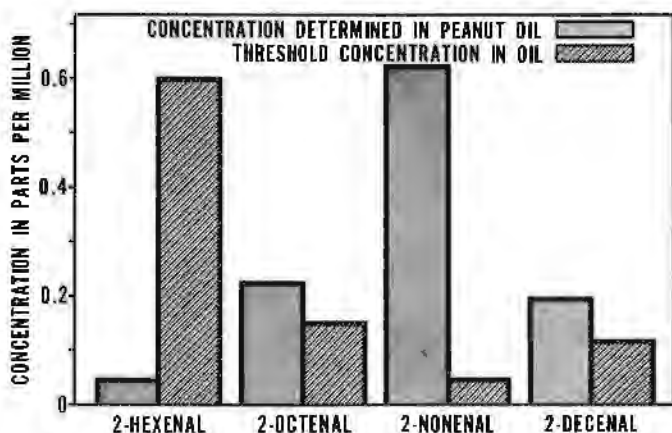


Figure 6

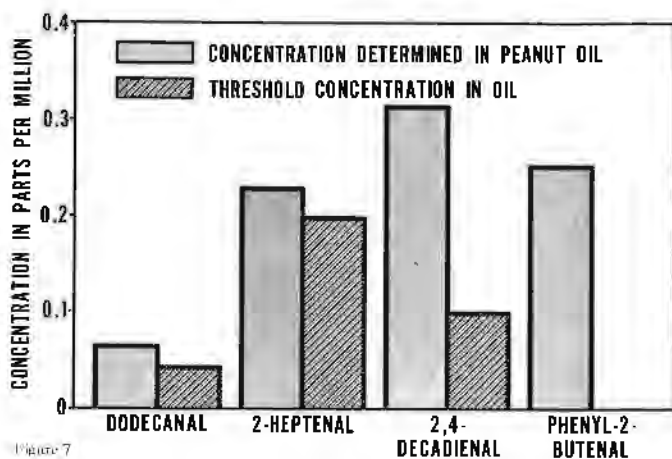


Figure 7

values obtained in a solvent similar in character to the food system of interest when drawing conclusions regarding the potential contribution of a compound to food flavor.

Despite qualitative similarities, the flavors which are perceived may vary considerably due to differences in relative concentrations of the components. Additive, synergistic, antagonistic, and masking effects are quite common among the various carbonyl compounds (11). Furthermore, a volatile component may impart a different flavor at high concentration than when it only slightly exceeds its flavor threshold value.

Nevertheless, it may still be possible to relate the flavor of raw and roasted peanuts to the concentration, flavor threshold values and the reported flavors of individual carbonyl compounds. From our data the aldehydes which most likely contribute to the characteristic "green or beany" flavor of raw peanuts are hexanal and octanal and possibly nonanal and 2-nonenal. Concentrations of hexanal and octanal in peanut oil exceed their flavor thresholds in paraffin oil, and concentrations of nonanal and 2-nonenal are just slightly less than their threshold values. The flavors of all four compounds have been described by Kinsella (11) as beany or green, and hexanal has been linked previously with raw peanut flavor (3). The flavors of 2-hexenal and some other 2-alkenals and alkanals also have been described as beany or green (11, 12). However, the concentrations of these compounds are much lower than their threshold concentrations, and consequently the possibility that 2-alkenals and alkanals other than hexanal, octanal, nonanal, and 2-nonenal contribute significantly to the flavor of raw runner peanuts seems fairly remote.

Several alkanals, alkenals and an alkadienal may play significant roles in the flavor and aroma of roasted peanuts. Mason et al. (6) suggested that low molecular weight aldehydes are responsible for the harsh aroma associated with freshly roasted peanuts. The three compounds most likely responsible for the harsh note of roasted peanuts are isobutyraldehyde, 2-methylbutanal, and isovaleraldehyde. They were detected in the oil from roasted peanuts in concentrations exceeding their flavor threshold values by a factor of 25 or more, and they are characterized by harsh or sharp aromas (12, 13).

Other aldehydes may play significant but more subdued roles in the flavor and aroma of roasted peanuts. The concentrations of hexanal and octanal exceeded their flavor thresholds by approximately tenfold, while the concentrations of heptanal, nonanal and dodecanal exceeded their flavor threshold values by smaller proportions. The concentration of 2-nonenal exceeded its flavor threshold by fifteenfold. Concentration of 2-heptenal, 2-octenal, and 2-decenal as well as 2, 4-decadienal were greater than their threshold values also. The flavor of heptanal, nonanal, decanal, and four alkenals and 2, 4-decadienal are reported to be fatty, oily or deep fried (11, 12), and these compounds, probably contribute to the fatty and deep-fried notes in the overall olfactory sensation of freshly roasted peanuts. However, it seems highly unlikely that any of the aldehydes and ketones which have been detected are responsible for the "roasted-nutty" flavor of roasted peanuts. This aspect of the flavor is probably due to one or more pyrazines in the volatile flavor and aroma fraction of roasted peanuts (14).

ACKNOWLEDGMENTS

The authors are indebted to D. P. Schwartz for the gift of several 2, 4-dinitrophenylhydrazone derivatives of 2-alkenals and 2, 4-alkadienals, to Frank McGill, Ag. Ext. Ser., Tifton, Ga. for assistance in obtaining peanuts of known history and to J. L. Butler and R. S. Hutchinson for curing, shelling, and grading. Figures drawn by John Conkerton.

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LEGENDS FOR FIGURES

Figure 1. Preparative chromatography of 2, 4-dinitrophenylhydrazones of 2-alkenals isolated from medium roasted runner peanuts on Microcel T-38 TLC plate impregnated with polyethylene glycol 400. The authentic 2-alkenal 2, 4-dinitrophenylhydrazones chromatographed to the right of the main separation are from top to bottom: C14, C11, C10, C9, C8, C6, C4.

Figure 2. Concentrations of some aldehydes detected in oil from raw runner peanuts.

Figure 3. Concentrations of some 2-alkenals detected in oil from raw runner peanuts.

Figure 4. Concentrations of some aldehydes detected in oil from roasted runner peanuts.

Figure 5. Concentrations of some other aldehydes detected in oil from roasted runner peanuts.

Figure 6. Concentrations of some 2-alkenals detected in oil from roasted runner peanuts.

Figure 7. Concentrations of selected carbonyl compounds detected in oil from roasted runner peanuts.

**FIELD EVALUATION OF INSECTICIDES FOR CONTROLLING
THE LESSER CORNSTALK BORER, ELASMOPALPUS LIGNOSELLUS
(ZELLER) IN TEXAS PEANUTS**

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ABSTRACT

Field tests were conducted during 1970 to evaluate the performance of several insecticides for the control of the lesser cornstalk borer in peanuts. Granular formulations of Bux[®], chlordane, Dasanit[®], Diazinon[®], Dursban[®], Dyfonate[®], Furadan[®], HCS-3260, parathion and Phosvel[®] were applied to irrigated peanuts, while liquid formulations of Azodrin[®], Dasanit[®], Dursban[®], Dyfonate[®], Lannate[®], N-2596, parathion and 1410 were evaluated on dryland peanuts. Granules were applied in a 12-14 inch band over the row, and immediately incorporated with rotary hoes to a depth of 1-1 1/2 inches. The treated areas received 2 acre-inches of water by sprinkler irrigation within a minimum time of 6 hours after application. Liquid insecticides were applied in a directed spray that covered only the lower 1/3 of the plant and adjacent soil tests showed Dasanit, Diazinon, Dyfonate, Dursban, parathion and Furadan granules were effective for lesser cornstalk borer larvae control in irrigated peanuts. The most promising sprayable insecticides for dryland peanuts were Azodrin, Dasanit and Dursban.

**THE BURROWING BUG, PANGAEUS BILLINEATUS (SAY):
A NEW PEST OF PEANUTS IN TEXAS**

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ABSTRACT

The burrowing bug, *Pangaueus bilineatus* (Say), Hemiptera: Cydnidae, has recently become a major pest of peanuts in certain areas of Texas. The adults invade peanut fields from mid-June through mid-July. All life stages feed on the roots and nuts. Feeding causes yellow spots, termed "pitting", on the kernel. This damage cannot be detected unless the husk and skin are removed from the kernel.

This report will include the following facets concerning the burrowing bug: biology, laboratory rearing, insecticidal control, distribution and damage description.

**RESISTANCE OF PEANUT ACCESSIONS
TO THE POTATO LEAFHOPPER, EMPOASCA FABAE HARRIS**

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ABSTRACT

Peanut accessions and varieties were evaluated for resistance to the potato leafhopper under natural field conditions. Varieties with low "hopperburn" symptoms were retested using NC 2 as the standard susceptible check. Varieties for retesting exhibited in excess of 90% less damage than the NC 2 check. Several varieties have been designated as possessing high resistance to the potato leafhopper following 10 years of selection for resistance.

The nature of leafhopper resistance was investigated by means of gross and histological examination of the foliage. Characteristics studied included the thickness of the epidermis, parenchyma thickness, and trichome number, length, and shape. Differences were observed in epidermal thickness and trichomes.

A CANDID APPRAISAL OF OUR KNOWLEDGE OF PEANUT ROT PODS

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ABSTRACT

Circumstantial evidence suggests that several soil-borne fungi can cause pre-lifting rots of peanut fruits. In the United States both *Pythium myriotylum* and *Rhizoctonia solani* have been proved capable of causing a pod rot which is not accompanied by above ground symptoms. Hence this pod rot deserves a distinctive name as a disease in itself, and it has been named "pod breakdown." The association of *P. myriotylum* or other *Pythium* spp. with a pod breakdown has been reported and studied in Israel, Libya, and Argentina. *Verticillium* sp. and *Fusarium* spp. need further study as possible pod breakdown pathogens in the United States.

Pythium myriotylum is more important than *R. solani* as a cause of pod breakdown in Virginia although some summers most of the pod breakdown is caused by *R. solani*. We are accumulating knowledge of the roles of rye green manure, other organic matter, K and Ca cations, and the general soil fertility on the ability of *P. myriotylum* to rot pods. We must wait on more of this knowledge to propose long-range control measures and to explain the erratic and possibly diminishing effectiveness of increased rates of landplaster as a control measure. Two years' field work suggests some peanut cultivars and breeding lines may be less susceptible to pod breakdown than others. Screening lines for inherent resistance to pod breakdown was greatly expanded in 1971.

SUSCEPTIBILITY OF PEANUT CULTIVARS TO LEPTOSPHERULINA CRASSIASCA

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ABSTRACT

Several peanut cultivars and advanced breeding lines growing in experimental nurseries in Virginia and North Carolina were evaluated for susceptibility to leaf scorch and pepper spot caused by *Leptosphaerulina crassiasca*. The two sets of symptoms observed indicate that this pathogen is the causal organism of two separate diseases. Within a cultivar or breeding line, there was an inverse relation of scorch symptoms to pepper spot symptoms. Florigiant, a widely grown cultivar, was extremely susceptible to pepper spot necroses caused by *L. crassiasca* but exhibited few leaf scorch symptoms caused by the same organism. Another widely grown cultivar, NC 17, was susceptible to leaf scorch necroses caused by *L. crassiasca* but exhibited few pepper spot symptoms. The susceptibility of peanut cultivars and breeding lines to *L. crassiasca* and its expression as either leaf scorch or pepper spot necrosis is apparently governed by the genetic constitution of the plant.

PROMPTNESS OF RADICLE EMERGENCE AS A MEASURE OF PEANUT SEED VITALITY

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ABSTRACT

Peanut seed, *Arachis hypogaea* L., 'Early Runner', from seed lots with different germination capabilities (standard germination) were evaluated for germination rate (promptness of radicle emergence), seedling emergence, and seedling vigor (dry weight). Daily radicle emergence for each of 3 days in a 25C germinator revealed that the portion of seed that produced emerged radicles during the 1st or 2nd day resulted in quicker and greater seedling emergence and in more vigorous seedlings than did seed with radicles that emerged during the 3rd day. Plants in soil maintained at 21 ± 2 C were more vigorous when grown from seed with radicles that emerged in 1 day; but at the warmer soil temperature (27 ± 2 C), there was no difference in vigor of plants grown from seed with radicles that emerged after 1 or 2 days in the germinator. Plants from seed with radicles that emerged in 1 day emerged quicker and had greater dry weights when seed were planted 3.8 cm deep than when planted 7.6 cm deep. Differences in plant dry weight associated with planting depth were not apparent when plants were grown from seed that required 2 or 3 days for radicle emergence.

EFFECT OF 2-CHLOROETHYLPHOSPHONIC ACID ON SEED DORMANCY OF PEANUT, ARACHIS HYPOGAEA

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ABSTRACT

2-Chloroethylphosphonic acid (CEPA) in water at a concentration of $10^{-2}M$ was highly effective in stimulating germination of dormant cured Florunner peanut seed, when seed were imbibed for 8 hours between layers of paper toweling wet with such a solution. This procedure was effective when seed so imbibed were planted in a greenhouse sandbed immediately following imbibition, or when they were dried down to normal seed moisture level (6.0-6.5%) and planted several days, or weeks later.

CEPA at $10^{-3}M$ for 8 hours, or at $10^{-2}M$ for four hours, was not as consistently effective as $10^{-2}M$ for 8 hours in inducing dormant seed to germinate. Application of the chemical at $10^{-2}M$ directly onto the seed as a mist immediately before planting in sandbed was almost as effective in inducing dormant seed to germinate as was imbibition for 8 hours. Seed treatment with tetraethylthiuramdisulfide (thiram) did not increase the effectiveness of CEPA in stimulating germination of dormant seed.

VARIATIONS IN PEANUT KERNEL MOISTURE CONTENT DURING CURING

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ABSTRACT

A knowledge of the variability in the moisture content of individual peanuts could be useful in improving methods of processing, storing, sampling, and in measuring quality.

The moisture content of single unshelled peanuts was measured by the oven dry technique during the digging season and on through early storage. Peanuts from a single plant displayed variations which were found to be related with maturity. The moisture content frequency distribution for peanuts early in the harvest season was found to be bi- and tri-modal rather than the single moded normal distribution.

The moisture content frequency distribution of individual peanuts during digging and storage compared closer to a log normal distribution than to the normal distribution. This moisture content distribution has numerous implications. Reducing the moisture content of the few highest moisture peanuts will appreciably change the average moisture content of the lot. Certain aspects of the distribution curve can possibly lead to development of a sampling characteristic which will correlate with storability better than the present characteristic, that being the average moisture content.

MAINTAINING QUALITY IN LOADS OF WET PEANUTS WAITING TO BE DRIED

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ABSTRACT

During the 1969 and 1970 harvest seasons, studies were conducted on drying plant lots in Oklahoma with financial support from the Oklahoma Peanut Commission. A total of 99 truck loads of wet peanuts were studied.

In 1969, the average loss in USDA grade value in solid bed trucks waiting longer than 12 hours was \$5.10 per ton. Factors causing the greatest losses were: (1). a high percentage of immature kernels, (2). a high initial temperature, (3). a high initial moisture content, and (4). a long waiting period. Laboratory investigations are being conducted to independently determine the effects of maturity, initial temperature, and moisture content on heating of peanuts.

In 1970 the average loss in USDA grade value in solid bed trucks waiting longer than 12 hours was found to be \$6.81 per ton. Several trucks had beds formed by covering stock racks with hardware cloth or light gage expanded metal. These vented trucks did not suffer grade loss during waiting. Peanuts in vented trucks had an average bulk temperature of 20°F lower than bulk temperatures in companion solid bed trucks after the first overnight period. The cost of venting was \$30. to \$60. per truck.

Small forced ventilation systems were installed on five trucks with solid beds. These systems were even more effective in controlling heating. The removable duct and small centrifugal fan (1,200 cfm) cost less than \$80. per truck.

These tests indicated losses in wet peanuts waiting to be dried could be as high as \$400,000. annually in Oklahoma. Both venting and forced ventilation will reduce, if not eliminate, these losses. Costs are recovered with the first two or three loads.

MUTATION BREEDING METHODS FOR CULTIVATED PEANUTS

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ABSTRACT

Three methods of mutation breeding adapted to cultivated peanuts are discussed. They are (a) the use of radiation-induced macromutants, (b) the artificial evolution of bulk populations, and (c) selection within pre- and post-hybrid irradiated populations.

The breeding value of the macromutant is assessed by comparing normal-appearing, late-generation hybrid populations derived from crosses between different M₁ families of the same macromutant (Cup) with control families. Progress reports are given on investigations of the two other breeding procedures.

THE EFFECT OF SEVERAL PROCESSING PARAMETERS ON THE SIMULTANEOUS RECOVERY OF EDIBLE PROTEIN AND OIL FROM RAW PEANUTS IN AQUEOUS SYSTEM

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ABSTRACT

There is considerable world-wide interest in the recovery of food-grade proteins from peanuts that are now used primarily as a source of commercial edible oil. Several methods for obtaining these from defatted peanut meal have been developed. A process initiated in the Central Food Technological Research Institute in India has now been commercialized in that country. The objective of this work was to evaluate the effect of several pertinent processing parameters on the yields of protein and oil products from ground raw peanuts in aqueous system.

The extractability of proteins and oil from ground raw peanuts by aqueous solutions of several mono- and di-valent salts at different concentrations over a pH range from 1.0 to 10.5 was measured. Studies of various other factors, such as the particle size, solid-solvent ratio, period of extraction, and temperature of extraction on the yield of protein and oil products were also been carried out.

It was observed that the maximum recovery of these products was accomplished by utilizing the following conditions: (1) 1.6 solid to solvent ratio. (2) 0.2% NaOH concentration, which gives suspension pH of approximately 11.5; (3) extraction temperature of higher than 40°C; and (4) precipitation pH ranging from 3.75 to 4.5.

INFLUENCE OF DRYING TEMPERATURE AT HARVEST ON VOLATILES RELEASED DURING ROASTING OF PEANUTS

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ABSTRACT

Sound mature kernels of Spanish and Runner-type peanuts harvested from two crop years were dried at four different temperatures (Stack cured, 110, 135, and 160°F).

Immediately after drying, the peanuts were shelled and roasted. The volatiles released during the roasting process were collected and quantitated. With increasing drying temperatures, increases in the following volatiles were detected: hydrogen sulfide, total base, total hydrozones (total carbonyls) and dicarbonyl compounds. Total volatile carbonyls appeared to be the best indicator of the effects of the drying temperatures. With increasing total carbonyls, the peanuts became more undesirable organoleptically.

UNIFORMITY TRIALS IN THE PEANUT, ARACHIS HYPOGAEA L. 1

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ABSTRACT

The influence of the yield level for the seed production season was evaluated for the Florigiant variety increased in 4 environments at Tifton, Ga., in 1968, and grown in uniformity trials in 1969 and 1970. Seed production environments were 3 irrigated tests contrasting high and very high yield levels on loamy sand vs. low yield on a thin soil, and an unirrigated test. Yields ranged 2962 to 5314 lbs/a, a 79% spread.

Both uniformity trials were grown in plots of constant stand to minimize seed source effect due to germination differences among sources. Fruit yield, seed size as weight per 100 seeds, and the percentage of sound and mature kernels (% SMKs) were analyzed each season. There were no significant differences (P 0.05) among seed sources for any of the variables.

The results indicate that yield level of the seed source did not have a persistent effect on yield, seed size, and shelling percentage in subsequent generations when seeds of high germinability were used.

1) For presentation at Annual Meeting, American Peanut Research and Education Assn., Raleigh, N. C., July 18-21, 1971, and to be published in the Journal. Cooperative research by the Plant Science Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the University of Georgia College of Agriculture Experiment Stations. Journal Series Paper No. 1057 of the Georgia Stations.

BREEDING FOR PEST RESISTANCE IN PEANUTS

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ABSTRACT

The search for natural resistance in peanuts to several pests 1) and the incorporation of these traits into commercial agronomic varieties is not new, but it has reached an important bench mark in interest. This interest is attested to by the various pest-resistance breeding programs now underway or under consideration at several locations.

Thus far, good resistance to some peanut pests are found only in wild species of *Arachis*. However, use of these wild species in peanut breeding programs has been hampered because of inherent barriers to hybridization. The significance of these breeding programs and some of the problems and possibilities which they present will be discussed.

1)Pest is used here to include any organism that is detrimental to peanuts including insects, fungi, bacteria, viruses, and nematodes.

CONVERSION OF AFLATOXIN B₁ TO ISOMERIC HYDROXY COMPOUNDS BY RHIZOPUS ARRHYZUS

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ABSTRACT

This study reports our investigation of aflatoxin B₁ degradation by a *Rhizopus arrhyzus* isolate from Georgia peanuts. Two fluorescent metabolites of aflatoxin B₁ accumulated as a result of aflatoxin B₁ degradation. These were identified by physical, chemical, and spectroscopic data as hydroxylated isomers derived from reduction of the ketone function on the cyclopentane ring of aflatoxin B₁. It was conclusively shown with ¹⁴C-labeled aflatoxin B₁ that these metabolites were derived from aflatoxin B₁. Two additional fluorescent metabolites appeared during purification of the hydroxy isomers. These were identified as ethyl ether derivatives of the hydroxylated compounds and apparently were formed spontaneously from either one or both hydroxy isomers.

INHERITANCE OF ALBINO SEEDLINGS IN RECIPROCAL INFRASPECIFIC PEANUT CROSSES 1

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Tifton, Georgia 31794

ABSTRACT

Ten F₂ progenies each from reciprocal infraspecific crosses between the Argentine and Early Runner varieties were grown in greenhouses at Athens and Tifton, Ga., or in the field at Tifton. At 2-4 weeks from planting 11,973 seedlings were classified at 11,406 normal green vs. 567 albino plants. All chlorophyll deficient lethal seedlings were scored as albino. These data, when tested to a proposed F₂ phenotypic ratio of 60 green: 3 albino : 1 zygotic lethal by chi-square analyses, gave non-significant chi-squares at the 5% probability level. From these results we conclude that the parental varieties differ at three loci conditioning albinism. Gene symbols C₁, C₂, and L are proposed. One dominant allele at either C locus results in green plants. The double recessive at the C loci and at least one dominant allele at the L locus results in albino seedlings. The triple recessive conditions the zygotic lethal. Reevaluated results of previous investigations with albino peanut seedlings also support our proposed trigenic model.

1) For presentation at the Annual Meeting, American Peanut Research and Education Association, Raleigh, N. C., July 18-21, 1971, and to be published in the Journal. Cooperative research by the Plant Science Research Division, Agricultural Research Service, USDA, and the University of Georgia College of Agriculture Experiment Stations. Journal Paper No. 1067 of the Georgia Stations.

DISCUSSION GROUP SUMMARIES

VARIETIES AND BREEDING DISCUSSION GROUP

by

P. H. vanSchaik, Discussion Leader
Agronomist, USDA, Holland, Virginia

After requesting suggestions from peanut breeders and agronomists around the country two topics were chosen:

1. The 1970 Plant Variety Protection Act and Federal Seed Act and their implications for peanut variety development, testing, and release by public and private agencies.

2. The need to broaden the genetic base of peanut breeding programs.

The discussion of the Federal Variety Protection and Seed Acts was led off by Dr. Paul Harvey, Head Crop Science Department, North Carolina State University. Dr. Harvey cited the history of early discussions, the "Breeders' Rights" symposium held in 1963 in Denver, Colorado during the Agronomy Society's meetings, the first bill which was proposed but did not pass in Congress in 1968, and finally the 1969 bill which was signed into law in 1970. At that time an amendment to the Federal Seed Act was also passed redefining certified seed and certifying agencies.

Dr. Harvey expressed the opinion that public agencies have no real reason to oppose the Plant Variety Protection Act and that private industry is entitled to it to protect and recoup its investment.

Different states are at present considering what policy to adopt in connection with varieties developed and released by their programs. Dr. Harvey discussed six possible alternatives North Carolina has under consideration, ranging from no change from the present policy of no restriction on availability of released varieties to a policy of complete ownership and control.

Dr. Ray Hammons asked if the registration of new varieties and germ plasm lines with Crop Science Society of America can be considered sufficient to provide protection under the law. Dr. Harvey said essentially yes; as long as a description of a variety is in print in a recognized publication it would afford the breeder the opportunity to defend himself if necessary. Dr. Hammons, as Chairman of the CSSA Subcommittee for Peanut Variety Registration reported that 12 peanut varieties have been registered in Crop Science in 1969/70 and strongly urged breeders to register other varieties and germ plasm. A list of the registered varieties follows this discussion.

The discussion on the need to broaden the genetic base of peanut breeding programs was introduced by Dr. Ray Hammons, who is preparing a report on the "Genetic Vulnerability of the Peanut" for the National Academy of Sciences, National Research Council.

Dr. Hammons illustrated the narrow genetic base of the present peanut acreage, not only in the USA but almost worldwide, by pointing out the close relationship in percentage among the most widely grown varieties. Four recently released Spanish varieties are all related to two widely grown varieties, Starr and Argentine. Five related varieties of the Virginia type are grown on a large percentage of the U. S. acreage, two of them alone cover 17%. Many varieties grown in other countries are also related to U. S. varieties and breeding lines. The obvious danger of such a situation has been brought home by the sudden spread of the Southern corn blight disease in the USA in the past year.

Several factors were cited in the discussion as having contributed to this, the main one possibly being the strong pressure on the breeders from processors and other users for a constant, uniform quality peanut. As a result exotic types have not been widely used. The large germ plasm collections available have never been brought together and uniformly evaluated and screened. There is a lack of scientific knowledge in peanuts on the genetics of many characteristics and specific breeding methodology and manipulation of characters and breeding stocks has not been widely practiced.

At a follow-up discussion session the group of Federal and State peanut breeders unanimously agreed to recommend that a coordinated effort should be made to insure the preservation and maintenance of the present germ plasm collection of wild *Arachis* species and that steps should be taken to add to this collection. They also recommended that coordination in this work be provided by the Agricultural Research Service USDA.

Further efforts should also be made to look into the situation of the several scattered germ plasm collections of cultivated peanuts, *Arachis hypogaea*, and to organize a sustained program for uniform classification, evaluation, cataloging, and maintenance.

PEANUT VARIETIES REGISTERED 1969-1971

Variety	<u>Registration</u> No. Year		<u>Originating</u> institutions, agencies, or organizations	<u>Author(s)</u> of registration articles	<u>Crop Science</u> <u>Reference</u>
Florigiant	1	1969	Florida AES	W. A. Carver	9(5):849-850
Florunner	2	1969	Florida AES	A.J. Norden, R.W. Lipscomb, W. A. Carver	9(5): 850
Spancross	3	1970	Georgia Coastal Plain & Oklahoma AES & ARS, USDA	R. O. Hammons	10(4): 459
Tifspan	4	1970	Georgia Coastal Plain & Okla. ARS & ARS, USDA	R. O. Hammons	10(4): 459
NC 2	5	1970	North Carolina ARS	W. C. Gregory	10(4): 455-460
NC 5	6	1970	North Carolina ARS	D.A. Emery, W.C.Gregory	10(4): 460
NC 17	7	1970	North Carolina AES	D. A. Emery	10(4). 460
Virginia Bunch 67	8	1970	Georgia AES & ARS, USDA	R. O. Hammons	10(4):460-461
Southeastern Runner 56-15	9	1970	Georgia AES & ARS, USDA	R. O. Hammons	10(5): 757
Virginia 56R	10	1970	Tidewater Res. Station VPI, Holland, Va	M. W. Alexander A. H. Allison	10(6): 727
Virginia 61R	11	1970	Tidewater Res. Station VPI, Holland, Va.	M. W. Alexander A. H. Allison	10(6): 728
Georgia 119-20	12	1971	Georgia AES & ARS, USDA	R. O. Hammons	11(2): 313

List prepared by R. O. Hammons, Chairman Subcommittee for Peanut Variety Registration.

REPORT ON SHELLING PLANT OPERATION DISCUSSION GROUP

by

**W. M. Birdsong, Jr., Discussion Leader
Birdsong Storage Co., Inc., Pretlow Peanut Division,
P. O. Box 88, Franklin, Virginia 23851**

Invited Guests: Mr. W. S. Conway, Wilco Peanut Company; Mr. Robert Pender, Pender Peanut Company; Mr. James I. Davidson, Peanut Research Laboratory.

About 22 people were present and entered into the discussion. Discussion included information from the Peanut Research Laboratory over the 12 variables that effect commercial shelling of seed peanuts. Best cold storage conditions seemed to be with the peanut having about 7½% moisture content. A rule of thumb is for the total of the temperature and relative humidity not to exceed 100 points. Most commercial cold storages carry temperature of about 38°F and relative humidity of about 62%. Research work should be done to find out if these conditions are the best for storing commercial peanuts and seed peanuts. Rewetting peanuts is a help for better shelling but decreases quality causing skin shippage. This practice is prohibited by the Peanut Administrative Committee.

Presizing of the peanuts prior to shelling causes less splitting. There seemed to have been no excessive pest infestation problems during the 1970 crop. Continuing research efforts are helping greatly in this field.

The labor force needs to be motivated. Supervisors and management must do this and methods must be obtained.

DISEASE & INSECT CONTROL IN PEANUTS DISCUSSION GROUP

by

**J. C. Wells, Discussion Group Leader
Extension Professor, Plant Pathology,
N. C. State University, Raleigh, N. C.**

Discussion Group Panel. Diseases (Wendell Horne, Texas A & M; Wyatt Osborne, V. P. I.; Roy Sturgeon, Oklahoma State University; Insects (John Smith, Tidewater Research Station, Holland, Va.; J. W. Smith, Texas A & M University; Loy Morgan, Georgia Coastal Plains Experiment Station, Tifton, Georgia.

The discussion panelist gave a 1 minute presentation concerning specific research underway in the control of soil and foliar insects and soil and foliar diseases affecting peanuts. Approximately 10 minutes were allotted for discussion after each paper. Sixty persons attended and participated in this discussion session.

SEED STANDARDS PANEL DISCUSSION GROUP

by

W. G. Conway, Discussion Leader

President, Wilco Peanut Company, San Antonio, Texas

The panel members were:

1. Dr. Lewis E. Clark, Texas A & M University, College Station, Texas.
2. Dr. Gene Sullivan, N. C. State University, Raleigh, N. C.
3. Mr. James Keel, Keel Peanut Company, Greenville, N. C.
4. Mr. Robert R. Pender, Pender Peanut Company, Greenwood, Florida.
5. Dr. Leland Tripp, Oklahoma State University, Stillwater, Oklahoma.
6. Mr. W. M. Birdsong, Birdsong Storage Company, Franklin, Virginia.

First discussed was the wide range of germination results it is possible to obtain by sending parts of the same sample to different state seed testing laboratories. It was decided to recommend that steps be taken to try to get all state official seed testing labs to use the same methods of determining seed germination. Also, it was suggested that all states adopt common seed standards for each type.

Sullivan, Keel, Birdsong and others report no seed sizing in Virginia-Carolina area but there is feeling that there should be some sizing done. The question was raised that since the development of planters that handle one seed at a time, is seed sizing necessary for smaller type kernels? Tripp and Clark reported 4 sizes are a part of Texas and Oklahoma seed certification standards.

Best types of environment for storage of farmers stock and shelled goods was touched on. Commercial cold storage generally 35° and 65% relative humidity is considered best for shelled seed while storage of farmers stock in bags has many advantages to help the peanuts cure and equalize moisture.

HARVESTING AND CURING DISCUSSION GROUP

by

Nat K. Person, Jr., Discussion Leader

Agricultural Engineering Dept.

Texas A & M University, College Station, Texas

The discussion group on peanut harvesting and curing was attended by approximately 75 individuals representing all segments of the industry. Such subjects as digging, field curing, harvesting and mechanical drying were discussed.

After a thorough discussion of the inverter type digger, it was concluded that this method of harvesting peanuts has many advantages over the conventional method now in use. It was stated that peanuts cured in inverted windrows have more uniform moisture at the end of the field curing period than peanuts in the conventional windrow. Also, under adverse drying conditions, inverted peanuts are less subject to quality loss due to molds.

The group briefly discussed the direct harvest method of harvesting peanuts which would eliminate the need for any field exposure. It was felt that this harvesting method was of importance and that research should be continued in this direction.

The discussion group ended their session with a discussion of the combining and mechanical drying operations. This included comments on the need for recovering peanuts lost during the digging operation.

MYCOTOXINS DISCUSSION GROUP

by

A. C. Mixon, Discussion Leader

Research Agronomist, USDA, Auburn, Alabama

Mr. Frank G. Dollear presented an informal discussion on the topic "Current Status and Relative Significance and Trends in Mycotoxin Research." He pointed out that ARS Administrator, George W. Irwing, Jr., has recently authored ARS 20-17, May, 1971 entitled "Aflatoxin Research, A Review of Agricultural Research Service Studies." Copies were made available.

Dr. Dollear's discussion was presented under five headings: Occurrence, Prevention, Detection and Analysis, Biological Activity, and Inactivation and Removal.

Occurrence - There are now at least 12 toxic compounds which are structurally similar to aflatoxin. Other mycotoxins which are metabolites of microorganisms other than *Aspergillus Flavus* or *A. Parasiticus* include zearalenone, ochratoxins A and B, patulin, and sterigmatocystin.

Prevention - Numerous methods of preventing mold growth and aflatoxins out of food and feeds were discussed.

Detection and Analysis - Dr. Dollear emphasized that good detection and analysis methods are available for aflatoxins, and other mycotoxins (see S. Stoloff "Report on Mycotoxins," J. A. O. C. 54, 305-309, February, 1971).

Biological Activity - In order to answer questions on the effects of aflatoxins on farm as well as laboratory animals, studies have been conducted by ARS and other research institutions. At high dose levels some of the effects noted were growth inhibition, decreased efficiency in feed utilization and increased size of internal organs. It has been shown that aflatoxin fed to livestock may be detected in meat or eggs. Small amounts have been found in milk from cows.

Attention was called to a recently published paper entitled "Cirrhosis in Children from Peanut Meal Contaminated by Aflatoxin" by Indira Amala, C. S. Kamala, G. S. Gopkrishna, Paul Jayaraj, V. Sreenivasamurthy, and H. A. B. Parpia, the American J. Y. Clinical Nutrition, 24, 609-614 (June, 1971).

Inactivation and Removal - Physical separation, chemical treatment, and extraction with aqueous polar solvents such as acetone or isopropyl alcohol were mentioned as methods of possibly reducing aflatoxin content of contaminated peanut meal.

Dr. R. J. Cole discussed recent findings of new mycotoxins. He related information on a new aflatoxin metabolite in monkeys, Aflatoxin P1. It is a new phenolic derivative of aflatoxin B1, and has been identified as the principal urinary metabolite of aflatoxin B1 in rhesus monkeys. Its identification in human urine might facilitate estimation of aflatoxin in human populations.

Several scientists discussed their findings on various phases of mycotoxin research they have underway.

**PEANUT AROMA AND FLAVOR, QUALITY
MEASUREMENTS, AND ENVIRONMENTAL CONTROL IN PROCESSING -
PARLORS A & B**

by

**Clyde T. Young, Discussion Leader
Associate Professor, Georgia Experiment Station
Experiment, Georgia 30212**

Increased knowledge of raw and roasted volatiles primarily due to use of gas-chromatography and mass spectrometer.

Outline of recent developments:

Bob Johnson identified some 47 components.

Discussed method of isolation of Aroma:

Pressed hot roasted peanuts

Isolated under vacuum

Fractionation

Identification by GC-MS

Basic fraction was mostly alhylypyrazines

Neutral fraction - carbonyls, etc., a large variety of compounds

International flavors and fragrances found a total 187 steam volatile components

What good is this information? . . . For example, can be used to study - Shu and Waller; Powers, et al; Pattee

Discussion:

How do you extract flavor from the peanuts? Is this a normal procedure? The pressing and stripping of the oil was found to remove more of the aroma and the condensate gives a typical aroma.

The residue does not contain much flavor. It is quite possible that some components are not oil soluble. Avoided steam distillation because of possible artifacts.

Why not use a water slurry distillation system?

How much carryover of raw volatiles into the roasted profile may be expected? Most of the raw volatiles are expected to be volatilized during roasting, but need to do additional research in this area.

Need to adjust P H to about 5 to remove pyrazines.

What effect does ageing of peanuts have on the profile? Ageing of peanuts does produce an increase in the carbonyls but not yet tested on the above discussed approach.

What causes the increase in carbonyls? Probably mostly due to antioxidation.

How would you compare these aroma profiles? Discussed work of Powers, et al and Pattee, et al - probably a computer system is needed. Probably need to examine several or many peaks.

What is the main objective of this type of study? It will provide an overall improvement of peanut quality. For example, a better consumer product.

Is this a long range study or does it have immediate application for the peanut industry?

Is a longer shelf-life more important or is the loss of flavor more important to the processor?

The addition of chemicals has a bad connotation but we should not let this impede research. May be better to prevent than to add something to the peanut product.

Environmental Control in Processing

Environment - the aggregate of all external and internal conditions.

The effect of peanut moisture on oil roasting of peanuts.

Moisture can affect end point of roasting.

The effect of peanut temperature on processing.

Is oxygen necessary for the roasting process or should it be excluded during roasting?

Nitrogen flushing and vacuum packing can extend shelf-life.

Length of time in cold storage is important on flavor of processed peanuts.

Peanuts stored in the shell have a longer shelf-life than those shelled and stored at the same temperature.

Peanuts stored under warehouse conditions produce more volatiles than those in cold-storage. The raw volatile evolution increases to a maximum and then declines.

Should we store in the shell and shell when ready for processing?

There is very little change in the raw volatile profile of peanuts during the first sixty days.

Must have sealed storage facilities for control of insects by carbon dioxide.

Quality Measurements: Charles Holaday and Frank Dollear

Quality - a degree of excellence

MATURITY

Farmer must dig peanuts at proper time to obtain peak flavor

OD method is tentatively adopted although method still has errors. There is a decrease in yellow pigments during maturation.

A new method - extraction of peanuts (pods) with aqueous alcohol, filtered and red color (which is mainly due to extraction of interior color from the shell).

A moisture distribution method is being tested at the Dawson Peanut Laboratory.

We may need to measure the stability of the intact kernel instead of just the extracted oil. A fast (40-50 minutes) method is being examined for oil stability. It is based on light transmittance at a wave length of 315.

Also there is a need to examine quality of seed peanuts, and relation to germination.

We need to examine or determine the milling quality of peanuts. New equipment must be developed to measure these milling parameters for small lots of peanuts.

Should peanuts be conditioned before shelling? One can improve milling quality by wetting just before shelling.

A new simple gas-chromatography for measuring peanut quality by passing the carrier gas through a raw peanut sample inserted in the injection part of the GC was described. It is to be published as a research note in the JAOCS. Partial identification of some of the peaks was made.

What is the relationship of fatty acid composition and flavor of peanuts? Would industry prefer a peanut with a high iodine value and good flavor or a longer shelf-life and less flavor.

Should the level of natural antioxidants in peanuts be ignored? They are mostly destroyed in roasting.

What degree of unsaturation will give the best balance between shelf-life and consumer health, i.e. 25 percent linoleic???

What is the effect of variety of volatile profile of peanuts? The qualification measurements thus far are the same, but concentrations do vary. May need to examine the peak ratios for the best estimates.

AGRONOMIC PRACTICES, IRRIGATION AND WEED CONTROL DISCUSSION GROUP

by

Preston H. Reid, Discussion Leader

Director, Tiedwater Research Station, Holland, Va.

• Three general problem areas were discussed; namely, weed control, calcium sources and irrigation.

Dr. Leland Tripp, Extension Specialist on peanuts at Oklahoma State University discussed the problems which he considered most prevalent. These problems are:

1. Herbicide injury as influenced by temperature and moisture relationships. Several herbicides caused injury this year, which had not done so previously.
2. The need for a good broadleaf control.
3. Materials are needed for resistant species.
4. More specific control measures need to be followed. Shotgun approaches which attempt to control all weeds are expensive and frequently disappointing. Farmers need to get to know their specific weed problems and treat for the weeds which they have.

Weed control is a continuing operation. Control of weeds throughout the rotational sequence aids in control of weeds in the peanut crop. More effective control can be obtained by treating for specific weeds which are present in the crop. There does not seem to be a good broadleaf, post emergence chemical available.

Mr. Allan Allison reviewed briefly the role of calcium in peanut nutrition and in disease control. Some of the important points he made are:

1. Calcium levels must be high in the fruiting medium as calcium does not translocate to the fruit.
2. Foliar applications of calcium materials frequently result in increased yields but will not supply calcium for fruit fill.
3. The placement and rate of calcium are more important for fruit fill than is the source. High levels of soil calcium will provide but will not cure them.

Additional points brought out in the discussion are:

1. Although there are probably varietal differences in calcium requirements, all varieties need calcium in the zone of fruit formation.
2. If new materials replace gypsum as the principal source of calcium, great care must be taken that sulfur deficiency does not become severe.
3. Soil tests in Alabama have proven effective in determining the calcium requirements of peanuts.
4. There is need for re-evaluation of the calcium nutrition of peanuts.

Irrigation was discussed by Dr. Lawton Samples from the Southeast area, Dr. Simson from the Southwest and by Dr. Snead from the Virginia-Carolina area. Pertinent points brought out are:

1. Irrigation may create as many problems as it solves unless it is carefully controlled.

2. Periods of moderate moisture stress in the early part of the growth cycle of peanuts may do little damage, except that preliminary Texas research showed stress periods at 30 - 45 days of age to be detrimental.

3. Irrigation is profitable in the southwest, where rainfall is severely limited. In the southeast and Virginia-Carolina areas results are not as consistent. The use of irrigation equipment for other crops will help defray the cost.

4. Preliminary trials with the application of fungicides through the irrigation system have met with some success but further trials are needed.

**MINUTES OF THE REGULAR BUSINESS MEETING OF THE
AMERICAN PEANUT RESEARCH AND EDUCATION ASSOCIATION
Hilton Inn, Raleigh, North Carolina, July 20, 1971**

President Bill Dickens called the meeting to order at 8:30 A. M.

It was moved by Jim Butler and seconded by Ed Sexton to dispense with the reading of the minutes of the last year's meeting since each member present had a copy and no changes were indicated. Passed.

President Dickens recognized the assistance of Mrs. Ruth Sturgeon and Mrs. Bernie Tripp for their part in helping with the registration.

President Dickens then gave special recognition to Syd Reagan for his many hours of work in helping the Association secure a tax status of 501(C):(6).

President Dickens then asked for old business; there was none.

New business--there was none.

He then asked for committee reports.

Finance--Dan Hallock--see Appendix I

It was moved by Charles Holaday and seconded by Astor Perry that we accept this report. Passed.

Publication and Editorial--Frank McGill--See Appendix II

Peanut Quality--Charles Holaday--See Appendix III

Program--Bill Mills--See Appendix IV

Public Relations--Jim Butler--See Appendix V

Nomination--Bill Conway--See Appendix VI

Jim Butler moved and Ed Sexton seconded that we elect the group by acclamation. Passed.

It was then announced the next annual meeting of APREA would be held at Albany, Georgia, July 16-19, 1972.

President Dickens pointed out that since the position of Executive Secretary, USDA Oilseed and Peanut Research Advisory Committee no longer existed, a change in the by-laws of the Association would be voted upon at the next meeting. He stated further that there was a possibility that the office of Administrative Advisor from the Southern States Research Division should possibly be discontinued.

President Dickens then turned the meeting over to incoming President Bill Mills.

President Mills expressed his appreciation for the excellent job that Bill Dickens had done as the Association's President for 1970-71.

The meeting was adjourned at 9:25 A. M.

REPORT OF THE FINANCE COMMITTEE

Daniel L. Hallock, Chairman

This Committee is charged with the responsibility "for preparation of the financial budget of this Association" and "for promoting sound fiscal policies within the Association." It also "directs the audit of all financial records of the Association and makes such recommendations as they deem necessary or as requested or directed by the Board of Directors." A limited audit of the financial records of this Association was made by this Committee. The records were found to be in agreement with financial statements concerning APREA from the First National Bank and Trust Company of Stillwater, Oklahoma. Also, this Committee reviewed the procedures employed by our executive secretary-treasurer concerning financial matters of APREA and found them efficient and entirely adequate.

Your Finance Committee feels that this Association is presently quite strong financially, especially in view of its youth. However, it would seem timely that APREA expand its programs. Implementation of such activities, of course, will require additional finances. This Committee recommends that additional income for the near future be obtained primarily from increased registration fees at meetings. Also, skyrocketing publication costs may be offset partially by certain publication charges. These avenues for new moneys seem more plausible than increased membership dues.

APREA needs to establish a formal "Reserve Fund" to insure stability during future financial crises, should they occur. We recommend that the 1971-72 Finance Committee consider this request and present a proposal to the Board of Directors for adoption when feasible. It will be necessary that limitations imposed by the Internal Revenue Service be investigated thoroughly in order that APREA's tax-free status not be jeopardized. In this regard special thanks are due Mr. Sid Reagan, Leland Tripp, and others.

Your Finance Committee feels that the overall program of APREA has "jelled" sufficiently now so that all committees can estimate with reasonable accuracy their future financial needs. Therefore, we recommend that these committees henceforth plan to present their monetary requests to the Finance Committee. This will certainly help promote sound and realistic financial planning within APREA.

In presenting the new budget proposal for your consideration, a review of the past budget estimate and actual transactions seems warranted. An accounting of these transactions accompanies this report. Special note should be made of the low cost of secretarial services which was due to the bookkeeping and other activities of Mrs. Tripp who did not accept remuneration and to the nominal cost of services rendered by the Agronomy Department of Okla. State University. Certainly all APREA members are most grateful to Mrs. Tripp, especially, and to the University and hereby express our deep appreciation for their services.

As its final act of this year, your Finance Committee presents for your consideration the 1971 budget for APREA. These budget estimates were adopted by the Board of Directors at their recent meeting.

AMERICAN PEANUT RESEARCH AND EDUCATION ASSOCIATION

1970 Budget Report
Assets & Income

	<u>Budgeted</u>	<u>Transacted</u>
Reserve - January 1, 1970	\$1,760.00	\$1,767.81
Membership & Registration (Annual Meeting)	4,750.00	4,258.00
Proceedings Sales	350.00	539.92
Special Contributions	<u>1,650.00</u>	<u>1,443.50</u>
TOTAL	\$8,510.00	\$8,009.23

Liabilities and Expenditures
January 1, 1970 - December 31, 1970

<u>Item</u>	<u>Budgeted</u>	<u>Expended</u>
1 Proceedings - Printing	\$2,000.00	\$2,266.00
2 Annual Meeting - Printing - Catering - Miscellaneous	1,850.00	1,465.96
3 Secretarial Services	500.00	288.00
4 Postage	150.00	252.01
5 Office Supplies	300.00	187.17
6 Position Bond for \$5,000 (Exec. Secretary-Treasurer)	15.00	13.00
7 Travel - President	300.00	350.48
8 Travel - Executive Secretary-Treasurer	200.00	90.00
9 Registration - State of Georgia	5.00	5.00
10 Miscellaneous	<u>190.00</u>	<u>197.50</u>
SUB-TOTAL	\$5,510.00	\$5,115.12
 Reserve - December 31, 1970	 <u>\$3,000.00</u>	 <u>\$2,894.11</u>
TOTAL	\$8,510.00	\$8,009.23

AMERICAN PEANUT RESEARCH AND EDUCATION ASSOCIATION

1971 Budget

<u>Item</u>	<u>Budget</u>
<u>Assets and Income</u>	
Balance - December 31, 1970	\$2,895.00
Membership & Registration (Annual Meeting)	5,000.00
Proceedings & Reprint Sales	600.00
Special Contributions	<u>250.00</u>
TOTAL	\$8,745.00

Liabilities and Expenditures

Proceedings - Printing	\$2,500.00
Annual Meeting - Printing, Catering - Miscellaneous	750.00
Secretarial Services	350.00
Postage	300.00
Office Supplies	250.00
Position Bond for \$5,000 (Executive Secretary-Treasurer)	15.00
Travel - President	300.00
Travel - Executive Secretary-Treasurer	250.00
Registration - State of Georgia	5.00
Miscellaneous	<u>250.00</u>
SUB-TOTAL	\$4,970.00
 Reserve - December 31, 1971	 <u>\$3,775.00</u>
TOTAL	\$8,745.00

PUBLICATIONS AND EDITORIAL COMMITTEE REPORT

J. Frank McGill, Chairman

During the past year, each committee member has had the following primary responsibility in carrying out the major objectives of this committee as outlined in the by-laws.

Mr. Wallace K. Bailey has continued to serve during the year in a highly efficient manner as Editor of "Peanut Research", APREA's official newsletter. At this point we wish to publicly commend Mr. Bailey for his untiring efforts in the regard and also to express appreciation to the National Peanut Council for their assistance in printing and mailing "Peanut Research" to all those who have requested that their names be placed on the Council's mailing list.

Committee member, Joe S. Sugg, has had primary responsibility for getting the annual proceedings of our annual peanut research conference published and distributed. Concrete evidence of his efficiency during the past year can be attested to by the fact that last year's proceedings were published and mailed to those concerned within eight (8) weeks following the close of last year's session, and he plans to have them out within four (4) weeks this year.

Dr. Coyt Wilson, a member of this committee and a sub-committee Chairman, continued to have primary responsibility for the very difficult task of getting chapters written and revised for updating the textbook entitled "The Peanut - The Unpredictable Legume." It is my happy privilege to report to you since Dr. Wilson could not be present today that a final deadline for chapter authors has been set and approved by the Board of Directors which will permit, according to Dr. Wilson, publishing and release of this textbook prior to the next annual meeting of the American Peanut Research and Educational Association.

During the past year, the Publications and Editorial Committee lists the following achievements as a matter of information to APREA's membership.

1. A Presidents News column has been carried bi-monthly in Peanut Journal and Nut World as a means of keeping APREA's membership informed.
2. Image building articles on APREA's organizational make-up, purposes and future goals have been carried in the following publications whose cooperation in this connection we deeply appreciate.
 - (a) Farm Technology
 - (b) Peanut Farmer
 - (c) Virginia-Carolina Peanut News
 - (d) Southeastern Peanut Farmer
 - (e) Southwestern Peanut Association News
3. The format heading for "Peanut Research" has been revised and approved by the Board of Directors. This new heading will be updated to include APREA's insignia, color scheme, etc., as that is currently being used on the organization's official stationary, letter-head and copies of proceedings.

And now in conclusion to those things which this Committee in collaboration with the Board of Directors seeks to do during the coming year - -

1. By unanimous vote of the recently held Board of Directors Meeting, next year's chairman of the Publication and Editorial Committee work with the National Peanut Council in up-dating their mailing list

of those who receive "Peanut Research." Furthermore, that such list shall include the names and addresses of all APREA members, those registering attendance at Research Conferences plus all University Libraries who presently receive complimentary copies of Conference proceedings. This up-dating of mailing lists will insure that all of the above named shall automatically receive copies of "Peanut Research" without having to make a written request to receive this official news organ of the association.

2. Publications and Editorial Committee has been asked by the Board of Directors to submit to them at their next meeting standard suggested format which could be sent to all authors of papers to be presented at the next peanut Research Conference. This committee was further instructed to develop a suggested standard format including limitations on lengths and requests other recommendations concerning the publishing of annual proceedings.

APPENDIX III

REPORT OF THE PEANUT QUALITY COMMITTEE

Charles E. Holaday, Chairman

The 1969-70 Quality Committee recommended four specific areas of endeavor for this year's Quality Committee. They are as follows:

1. Run collaborative studies on the iodine number of peanut oil by the refractive index method; blanchability method; and optical density measurement of the oil as a means of estimating maturity.

Collaborative studies were completed on the refractive index and optical density methods and although the results indicated that neither was as accurate as had been hoped by the Committee. Recommended that they be tentatively accepted provided further work be done to improve the accuracy of both methods. No collaborative study was made on the blanchability method because not enough collaborators could be located.

The Board of Directors recommended that both the optical density and refractive index methods be published in the proceedings for 1971.

2. Develop equipment and methodology for measuring milling quality. The Committee was unable to locate suitable equipment for making this measurement.
3. Further investigate the causes of off-flavor in certain lots of peanuts blanched before roasting. A contract was let by the Southern Marketing and Nutrition Division of ARS to Oklahoma State University to look into this problem. The incoming Quality Committee was advised of this work.
4. Further discuss quality standards and ways and means of maintaining and improving quality for the good of industry. The Quality Committee recommended to the Board of Directors that the responsibility of the Committee be broadened to encompass work on peanut seed quality. The Committee was brought up to date on two new maturity methods and a new stability method being worked on at the National Peanut Research Laboratory.

Dr. Tom Whitaker, Chairman of the Subcommittee on sampling, reported on the new sampling method for aflatoxin which will become effective this year.

This year's Quality Committee recommends the following action for the incoming Committee:

1. Further improve the accuracy of the optical density and refractive index methods.
2. Develop equipment and methodology for measuring milling quality.
3. Develop appropriate methodology for measuring seed quality.
4. Further discuss quality standards and work on the new maturity and stability methods.

The numbering system for APREA quality methods and Method A-1, B-1, B-2 and B-3, are part of this report.

NUMBERING SYSTEM FOR APREA QUALITY METHODS

A. Subject Methods (Edible Peanuts)

1. Cler Method
2.
etc.

B. Objective Methods (Edible Peanuts)

- 1.
2.
etc.

C. Subjective Methods (Seed Peanuts)

- 1.
2.
etc.

D. Objective Methods (Seed Peanuts)

- 1.
2.
etc.

APPROVED BY THE PEANUT QUALITY COMMITTEE, 1970 Method A-1

Method: Orgnaoleptic quality perception (Cler score).

DEFINITION

This method will indicate the relative organoleptic quality level of a given sample, both qualitatively and quantitatively.

SCOPE

Applicable to roasted peanuts. Recommended as an "in-house" flavor evaluation method suitable for exploratory tests and for preliminary screening of samples scheduled for more sophisticated evaluation. Std. deviation (a) = 14.37; Coefficient of variation = 24.23% based on collaborative study involving 7 collaborators and 10 samples.

(A) Apparatus:

1. Electric Rotisserie (Modified, see notes).

(B) Reagents:

None.

(C) Procedure:

1. Roast in the rotisserie approximately 300 grams of peanuts to peak roast.
2. Remove the peanuts when they have reached peak roast and place them on a suitable tray. Cool the peanuts immediately either by placing them in a refrigerator or in front of an electric fan.
3. When the peanuts are at room temperature, remove crosswise from the tray 20 peanuts and taste them one by one as they are removed (see diagram).
4. Score each peanut, as it is tasted, selecting one of these categories:
 - a. Badly off flavor.
 - b. Low level off flavor.
 - c. Low peanut flavor.
 - d. Good peanut flavor.

(D) Calculations:

1. Multiply the number of peanuts in each category by 5 and the result is the percentage of peanuts in each category, relative to the total sample. This is a quantitative measurement, but caution must be observed in extrapolation to a large shipment, because of the small sample size.
2. Multiply the number of peanuts in the "Badly off flavor" category by 5, the number of peanuts in the "Low level off flavor" category by 4, the number of peanuts in the "Low peanut flavor" category by 2. (For this calculation, ignore the number of peanuts in the "Good peanut flavor" category.) Add the individual results and deduct them from 100.

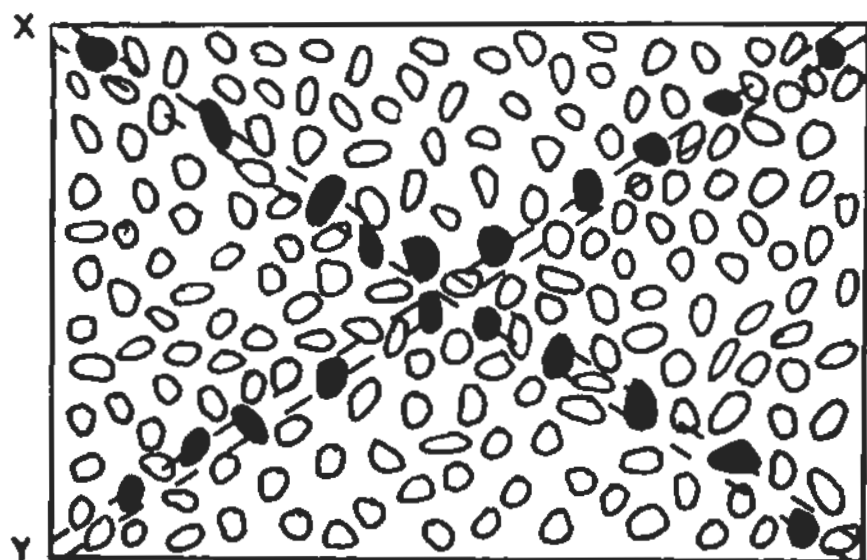
$$100 - (5a + 4b + 2c) = \text{Cler Score.}$$

Cler score is a numerical value of the relative organoleptic quality level of a given sample of roasted peanuts, within the sample limitations of the test.

(E) Notes:

1. A cylindrical wire basket is used to contain the peanuts while roasting. It measures 8" x 3 1/2" and is made of 1/4" mesh.
2. If an obviously damaged peanut is picked at random for tasting, automatically place it in the "Badly off flavored" category. It is not necessary to taste it.
3. It is recognized that a Cler score may be changed by upgrading peanuts by picking. It may be desirable to approach plant practices (which include a picking operation) more closely by making the Cler score test after such picking.

TRAY OF PEANUT HALVES



SELECT 10 HALVES RANDOMLY ALONG X AXIS
AND 10 HALVES RANDOMLY ALONG Y AXIS.

TENTATIVELY APPROVED BY PEANUT QUALITY COMMITTEE, 1971
Method B-1

**Expressing Oil From Ground Raw Peanut Kernels For
Various Quality Measurements**

- A. Introduction: Oil may be "cold-pressed" from whole peanut kernels or from ground kernels. Rather limited tests at the National Peanut Research Laboratory indicate that grinding the peanuts before pressing can approximately double the oil yield, increase the optical density reading about 18%, and slightly improve the precision of the optical density measurement.
- B. Environment: All peanut samples to be compared should be handled similarly, especially in regard to curing and storage (except intentional experimental variation), and should be dried to the same moisture level before grinding and pressing; 5% is recommended. The room temperature, the material to be pressed, and the oil, during filtering, should be maintained as near 74-76° as practicable.
- C. Equipment:
1. Motomco Moisture Meter (or equivalent) and Calibration Charts for Spanish, Runner, and/or Virginia peanuts.
 2. Hammermill, fitted with approximately 3 mm or 1/8 in. sieve. (Roughly 50% by wt of ground kernels should pass through a 20 mesh screen and ride a 35 mesh screen.)
 3. Carver Laboratory Press (hydraulic) with nickel-plated-steel cage equipment and stainless-steel drain pan.
 4. Bleached, unsized cheesecloth.
 5. Apparatus required to vacuum-filter oil samples (vacuum equivalent to ca 19-24 in mercury).
 6. Reeve-Angel, glass-fiber, flat filter discs.
 7. For each oil sample, a 25 ml glass-stoppered Erlenmeyer flask.
- D. Procedure: Obtain a representative sample of the lot of peanuts to be characterized. Dry down to 5% moisture with forced air (75-95°F and 10-20 cfm/cu ft). When the moisture level reads 5% (± 0.25), grind the 250 g sample used to obtain the moisture reading. Mix the ground sample thoroughly, weigh out 100 g, wrap it in a single layer of cheesecloth, and place it in the clean, dry press cage. Pump the press to 5,000 psi dial reading and hold for about 1 minute. (This will allow initial consolidation of the ground peanuts, allow the oil to begin to flow, and greatly reduce the chance of peanut meal bursting through the cheesecloth and escaping from the press cage.) Increase the pressure to 20,000 psi and hold for about 14 more minutes, or a total of 15 minutes. Vacuum filter the oil into clean dry flash through two Reeve-Angel filter discs, replace with clean discs and refilter the oil into another clean, dry flask. Make quality measurement(s) on filtered oil or store in stoppered flask at 35-40°F for later evaluation.

MATURITY

Spectrophotometric Method 1

Definition:

This is an abridged spectrophotometric method, whereby the density of yellow pigmentation in freshly pressed and filtered raw peanut oil is measured at 450 mu wavelength and corrected for incidence of haze by formula application of densities measured at 380 mu and 520 mu wavelength.

Scope:

The relationship of this method to the average maturity level of a sample of peanuts is based upon observations of the progressive dilution or disappearance of oil-soluble yellow pigments, including various carotenoids, during the process of maturation. Values of 0.1 or greater for corrected net optical density at 450 mu wavelength are considered to be "indicators of undesirable average immaturity."¹) The validity of the method may be modified by the presence of other influences upon color intensity. Some such reported influences are: variety of peanut, speed and temperature of curing or drying, and cultural and environmental effects upon total oil production.

A. Apparatus:

1. Bausch & Lomb Spectronic 20 Colorimeter/Spectrophotometer with good line-voltage regulation.
2. Set of optically-matched sample tubes, scrupulously cleaned and dried.

B. Reagent:

1. Distilled water.

C. Procedures:

1. Use freshly pressed and filtered oil from representative samples of raw peanuts. (See "Expressing Oil from Ground Raw Peanut Kernels.") If oil has been cold stored, allow to come to room temperature before testing.
2. Be sure spectrophotometer is properly calibrated according to its instruction manual.
3. Turn instrument on and allow to warm up about 30 minutes before using.
4. Thoroughly clean a greater number of spectrophotometer test tubes or cuvettes than there are oil samples in the series to be tested. Fill tubes about half-full of room-temperature (as near 74°-76°F as practicable) distilled water. Read transmittance values (according to instruction manual) at 450 mu wavelength, select and number tubes showing greatest agreement, and use the one nearest the selected-group average as the reference tube. Position tubes in instrument the same way for each reading.
5. Standardize instrument and tubes as follows:
 - a. Turn Wavelength Selector to 380 mu setting.
 - b. With instrument sample holder covered and empty, adjust meter reading to "0" with Zero Control.

- c. Place reference tube of distilled water in instrument sample holder, close cover, and turn Light Control until meter reads slightly below "100%" transmittance. Record chosen reference value. (95% should easily allow all suitable tubes to fall on-scale.) Caution - Check temperature of water in reference tube frequently, since prolonged or quickly repeated placement of tube in instrument could cause significant temperature increase.
- d. Place the first sample tube of distilled water in instrument sample holder, close cover, and read and record percent transmittance. Calculate the percentage difference between sample-tube and reference-tube values. Record as "+" or "-" correction percentage of and for the sample tube.
- e. Repeat steps "b" through "d" for each of the sample tubes to be used.
- f. Repeat the above standardization procedures for 450 mu wavelength and for 520 mu wavelength.
6. Empty distilled water from sample tubes, dry them thoroughly, and fill about half-full with oil samples (ca. 74°-76°F) to be tested.
7. Test oil samples as follows:
 - a. Turn Wavelength Selector to 380 mu setting.
 - b. "Zero" instrument as in standardizing.
 - c. Insert reference tube of distilled water into instrument and adjust Light Control until meter reads "100%" transmittance.
 - d. Replace with oil-sample-tube "1"; read and record percent transmittance.
 - e. Repeat steps "b" through "d" using oil-sample-tube "2," "3," . . . in step "d."
8. Repeat entire test procedure (step "7") at 450 mu setting and again at 520 mu setting.
9. Make necessary percent-transmittance corrections for all samples at all wavelengths, as illustrated in "D-1" below.
10. Duplicate the test procedure by repeating steps "7" through "9" for each sample.
11. Average the two corrected transmittance values for each sample at each wavelength.
12. Convert average percent-transmittance values to optical density values.
13. Calculate the corrected net optical density at 450 mu (corrected for haze) for each sample, as illustrated in "D-2" below.
- D. Calculations:
 1. Standardization of instrument and tubes:
 $A - B = C \text{ then } C \div B = D \text{ or } A = B + [(A - B) \div B]$
 Example $95 - 94 = 1$ then $1 \div 94 = 1.064$
 where A = % transmittance of reference tube with
 B = % transmittance of sample tube measured
 at reference setting of light intensity
 C = difference between A and B
 D = % of B required to be applied to B to
 make B = A.

2. Correction for haze: 1

$$\text{Corrected Net O. D. at 450 mu} = \frac{(A - C) - (B - C)}{2}$$

where A = O. D. at 450 mu

B = O.D. at 380 mu

C = O. D. at 520 mu

1)Sexton, E. L., D. A. Emery, Astor Perry, and Calvin Golumbic. 1966. Report of PIWG committee on methods for the determination of quality factors in peanuts. Proceedings Fourth National Peanut Research Conference, 98.

2)Kramer, Amihud and Bernard A. Twigg. 1966. Fundamentals of Quality Control for the Food Industry, Second Edition. The AVI Publishing Co., Inc., Westport, Conn.

Optical Density

(Outliers Omitted [if significant at 5% level by Dixon's Criteria])

Pair No.	Mean Value	Precision S_p^2	Systematic S_b^2	Degrees of Freedom	F Value	Standard Deviation S_d	Coefficient of Variability C.V.
I	.0640	.000024	.000153	7	13.71** (0.5%)	.018134	28.3%
II	.1586	.000037	.000573	6	31.95*** (0.1%)	.034380	21.68%
III	.2292	.000015	.000150	5	21.47** (0.5%)	.017944	7.8%

1)Table of values for collaborative study on "Maturity, Spectrophotometric Method," run in 1971 according to principles and procedures recommended by Youden, W. J. 1967. Statistical Techniques for collaborative Tests. The Association of Official Analytical Chemists, Washington, D. C.

TENTATIVELY APPROVED BY THE PEANUT QUALITY COMMITTEE, 1971 Method B-3

IODINE VALUE

Refractometric Method

Definition:

This is a rapid method for determining the iodine value of peanut oils. It is based upon several hundred refractive index determinations, correlated (1) with Wijs Method (2,3) determinations.

Scope:

Iodine Value is primarily a measure of the unsaturation of fats and oils (3, 4) and is widely used in the peanut industry as an indicator of relative storage life (before onset of oxidation and rancidity) of peanuts and products from different varieties, production areas, seasons, lots, etc. It should also be useful, in the reverse, for estimating the relative value of oils for "low cholesterol" diets.

A. Apparatus:

1. Bausch & Lomb Precision Oil Refractometer with sodium vapor lamp, refractive index range of 1.33 to 1.64, Lab-Arc Transformer, and tables for converting instrument scale readings to refractive indexes.
2. Precision Temperature Controller properly adjusted and connected to refractometer with shortest practicable hose lengths. Even with short hose connections room temperature fluctuation can cause error.

B. Reagents:

1. Small quantity of Cargille Index of Refraction Liquid, Master Calibration Series, $n_D^{25} = 1.45760$
2. Supply of hexane, methanol, and soft lint-free wipes for cleaning prisms.

C. Procedure:

1. Turn on refractometer and temperature controller and allow to warm up until the illumination is bright and uniform and the desired temperature has been achieved and stabilized to within $\pm 0.1^\circ\text{C}$.
2. Place about 3 drops of the calibration liquid in the refractometer, wait 5 minutes for temperature adjustment, and standardize the instrument to the scale value which converts most closely to the stated refractive index when using another temperature. (To correct n_D for the temperature being used, determine the difference between that temperature and 25°C . Then for each degree [up to 10] above 25°C , subtract 0.00037; for each degree [up to 10] below 25°C , add 0.00038.)

Note: If the refractometer is to be used mainly for Iodine Value determination, it may be desirable to minimize computations by standardizing the instrument to read the computed n_D^{40} value (ca 1.45210 or refractometer scale reading of 20.30) of the calibration liquid since the conversion from refractive index to iodine value is based upon peanut oils evaluated at 40°C .⁵ Actually making the refractive index readings as near 40°C as equipment will allow (while maintaining highly precise and accurate temperature control) should minimize error from differences in refractive index-temperature relationships between the calibration liquid and the peanut oils being evaluated.

3. After standardizing the refractometer, remove calibration oil with a soft wipe, followed by a hexane-saturated wipe then by a methanol-saturated wipe. Allow methanol to evaporate, leaving clean dry prism surfaces.
4. Place in the refractometer about 3 drops of filtered peanut oil from the test sample. (See "Expressing Oil from Ground Raw Peanut Kernels." Allow to stand 5 minutes and carefully read and record the correct scale value to the third decimal (estimated 0 to 5). Clean sample from instrument as described above and proceed with the remaining samples, in like manner.
5. Re-check the standardization of the refractometer, make adjustment, if necessary, and proceed as above for a duplicate set of readings.

6. Average the two refractometer scale readings for each sample and convert the averages to refractive indexes to iodine values according to the following regression equation⁵:

$$I.V. = -12,781.228 + 8798.1836 R.I.$$

$$\text{Example -- } I.V. = -12,781.228 + 8798.1836 \times 1.46345$$

$$I.V. = 12875.70178942 - 12,781.228$$

$$I.V. = 94.47$$

1)Avera, F. L., E. L. Sexton, S. A. Watson, and D. Melnick. 1966. Correlation between refractive index and iodine number of oil from peanuts (Abstract). Proceedings Fourth National Peanut Research Conference. 86.

2)Oral communication with S. A. Watson, Corn Products Company (now CPC International).

3)A.O.C.S. Official Method Cd 1-25. Iodine Value, Wijs Method, Revised April 1956. Official and Tentative Methods, The American Oil Chemists' Society, Volume 1.

4)A.O.C.S. Official Method Cc 7-25. Refractive Index. Corrected 1951. Official and Tentative Methods, The American Oil Chemists' Society, Volume 1.

5)Written communication from S. A. Watson, Corn Products Company, November 22, 1966.

Iodine Value

(Data from Four-Decimal Refractometer Omitted)

Pair No.	Mean Value	Precision Sr^2	Systematic St^2	Degrees of Freedom	P Value	Standard Deviation Sd	Coefficient of Variation C.V.
I	92.98	.0155	.6019	2	83.83*(2.5%)	1.1392	1.23%
II	93.24	.0376	.4598	2	25.46*(5%)	.9784	1.05%
III	94.96	.0000	.8848	2	<>>	1.3303	1.40%

1) Table of values for collaborative study on "Iodine Value, Refractometric Method," run in 1971 according to principles and procedures recommended by Youden, W. J. 1967. Statistical Techniques for Collaborative Tests. The Association of Official Analytical Chemists, Washington, D. C.

APPENDIX IV

PROGRAM COMMITTEE REPORT

William T. Mills, Chairman

In February, 1971 the entire membership was asked to submit paper titles and abstracts. Fifty-four (54) were submitted. Eight (8) were later withdrawn and two (2) were screened out as being too limited in scope for a national meeting. Forty-four (44) were programmed for this meeting.

This was an increase of 14 papers over the 1970 meeting. The balance of papers, geographically and among disciplines were good, although we would like to have more papers from industry.

In March, 1971 the Program Committee met in Raleigh and subcommittees were appointed and charged with specific responsibilities. These men, who are listed on your program, have done a good job and I want to extend my personal thanks.

APPENDIX V

REPORT OF THE PUBLIC RELATIONS COMMITTEE

J. L. Butler, Chairman

One of the primary responsibilities of the Public Relations Committee is the development of membership. In this regard, the committee has written several letters. The contribution of all members in the enlisting of members is recognized and encouraged.

As of today, July 20, 1971, the following comparison is given:

Category	1970	1971
Sustaining members	15	17
Organizational members	53	58
Individual members	211	207
Student members	5	13

One year ago today, one of our members, Dr. William Earl Cooper died. The following resolution is offered:

"RESOLUTION"

Be it resolved that the American Peanut Research and Education Association (APREA) does recognize that the death of Dr. William Earl Cooper will be keenly felt by the peanut industry. Dr. Cooper, who served most of his professional career as a research plant pathologist with the North Carolina Experiment Station, made many important contributions to the industry. Some of the more notable were:

The close work with plant breeders in developing a southern stem rot and leaf spot resistant variety (N. C.-2),

The development of a seed treatment program for North Carolina,

The development of a leaf spot control program, and,

Rotations which reduced idseasc and nemotode problems.

We do hereby recommend that this resolution be included in the official minutes of the 1971 Annual Meeting of the APREA and that a copy of it be forwarded to his survivors.

APPENDIX VI

NOMINATIONS COMMITTEE REPDRT

W. G. Conway, Chairman

President Elect - Olin Smith

Sheller Representative - Robert Pender

End-User Representative - George McClees

Executive Secretary-Treasurer - Leland Tripp

These individuals have been contacted and expressed a willingness to serve in the positions to which they have been nominated.

MEMBERSHIP LIST
AMERICAN PEANUT RESEARCH AND EDUCATION ASSOCIATION

July, 1971

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Vice-President

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Reeves Peanut Co.
Eufaula, Ala. 36027
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Vice-President

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Virginia Peanut Growers Assn.
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