AEC Peanut

February 27, 1953

Memorandum to P. H. Harvey
From W. C. Gregory
AEC Peanuts

Response to your request for proposed (1953) action under contract A T 265 follows:

The publicity given this research project has had the effect of considerably exaggerating the relative emphasis given it in our peanut breeding research program. As a matter of actual fact it will form only a small part of our total effort in 1953. For this reason it will be necessary here to provide additional background for your benefit since an inspection of allocated funds in 1952 and immediately preceding years would have the effect of misinforming you considerably.

Therefore, below you will find not only our proposed action program for AT 265 1953 but also Spnl 1953, the latter appearing first.

4 BJ 5 H 10

PROVISIONAL Spn I 1953:	REPLICATED EXPERIMENT	NO. ENTRIES	NO. LOCATIONS
1. F_4	plant progeny trials	600	2
2. F_4	(F_3 plot bulked)	150	3
3. F_9	(F_4 ind. plant bulked in F_5)		
	(ind. plant F_7 bulked in F_8)	350	2
	Total	1,100	
	BREEDING NURSERY	600	1

The locations referred to in the table are: (1) Upper Coastal Plain Station, (2) peanut Test Farm, and (3) Holland Station.

PROVISIONAL: A T 265:	REPLICATED EXPERIMENT	ENTRIES	LOCATIONS
1.	O^2_g Selection Exp. & bulk X_4 YT	40	2
2.	X_5 YT X_4 Bulked Mutant from X_4 nursery	31	2
3.	X_4 YT X_4 ind. plant progeny	80-120	1-2
	Total	151-171	

Plant Path Plans Unknown: Attention Cooper & Jensen

X_5	NURSERY ROWS	5,000	1

A short Resume of pertinent factors affecting our work follows:

The summary and analysis of data, collected 1949 - 1952, stopped August 1, 1952 and has not been resumed.

Reasons: Field work, departmental shift of personnel - Resulting increased load.

(1) Field notes - August and early September.

(2) Harvest Sept. Oct. Nov. Dec.

(3) The loss of Smith in toto Oct. 1952 till Feb. 1953 -----

(4) The loss of Poole Feb. 1952 ----

(5) The loss of Johannsen (Lancaster) April 1952

(6) The loss of Hammons Nov. 1952 (100% time Ph.D.).

With the absolute loss of three of my ablest people the additional work for the rest of the group has taken up more and more time. In evaluting items 1 - 6 above however it should be noted that Perry and Bernard, graduate students, have been added to the program.

With these things in mind it should be noted that even with the currently proposed restitution of the laboratory assistant (in the form of one who can type) it will not be possible for us to assume anything like the proportions we have had in the last 4 years.

We have committed ourselves to completing a final report (including mss. for publication) to the Division of Biology and Medicine of the Atomic Energy Commission as of April 1, 1953. This is obviously impossible, so we are going to ask for another extension of time. Under present circumstances we will be fortunate to get out such a report by April 1, 1954. Therefore I suggest:

(1) (a) That field activities under this project be limited to the yield trials necessary to establishing the superiority or its absence of certain selected mutants.

(b) Maintainence of a nursery of small plots of the various mutants produced.

(2) That my own activities be free of excessive commitments in the field and concentrated upon the summary and analysis of data in hand.

(3) That an assistant be provided to carry the large breeding program to a successful conclusion in the field.

(4) That a laboratory assistant be provided who can be trained to handle computing machines and if possible already be able to type.

We would therefore be justified in asking the AEC to furnish the following salaries and budgetary items:

(1) The part time field assistant	$2798.00
(2) Assistant mentioned under #3	$4000.00

(3) One graduate assistant	$1800.00
(4) Laboratory assistant mentioned under #4	$2750.00
(5) Contractual	$ 500.00
(6) Travel	$ 500.00
(7) Communication	$ 100.00
(8) Supplies	$ 150.00
(9) Equipment (calculator)	$ 800.00
Total	$13398.00

You will notice that substantial requests for labor, supplies, and travel will have to be made from other sources. If we include these requests in the proposal to AEC they will be quick to observe the discrepancies between fund and function. I would like to point out that if our program develops as anticipated that we would be making relatively large requests of this agency one year from this spring.

I am therefore asking that the proposal presented below for the support of our breeding effort be given serious consideration.

1. The field tests with crossed material indicated on the first page represent a several-fold increase in magnitude over last year.

2. Due to this plus reduction in irradiation project field work, a much smaller proportion than previously of the funds supporting our field work should come from project A T 265.

3. On the other hand, an assistant requested in the proposed A T 265 budget and paid for out of those funds will be employed full-time on this work.

4. Amounts for contractual items, travel, & supplies are included in the A T 265 budget in proportion to requirements of the irradiation project.

The following amounts are proposed for the 1953 Spn I budget:

for BJ5 #10

(1) Labor	$2000.00
(2) Maintenance	1250.00
(3) Equipment	750.00
(4) Travel	1000.00
Total	$5000.00

$1000.00 of the above labor item is designated as salary to J. A. Yarborough for his work on the project for two months during the summer. This work is of a morphological nature supplementing the breeding program and may be summarized as follows:

(1) Completing preparation of slides

(2) Analyzing the slides on the development (ontogeny) of the foliage leaf and cataphyll.

(3) Preparing manuscript on branching patterns and orders and varietal classification - with Gregory.

A total of $1000.00 from the equipment and maintenance items will be designated for use in these morphological studies for obtaining the necessary equipment and supplies to be used in carrying out this work.

C.C. Dr. J. H. Jensen
Dr. W. E. Colwell

Status of AEC - Peanuts Budget as of October 24, 1952

OBJECT	APPROPRIATION	ENCUMBERED AND SPENT TO DATE	UNENCUMBERED BALANCE
Salaries	10,872.00	1,989.97	8,882.03
Wages	3,164.00	1,581.70	1,582.30
Travel	1,800.00	1,333.53	466.47
Transportation	25.00	0.00	25.00
Communication	10.00	.70	9.30
Rents	10.00	0.00	10.00
Printing	150.00	0.00	150.00
Contractual	400.00	65.26	334.74
Supplies	800.00	202.73	597.27
Equipment	300.00	0.00	300.00
Totals	17,531.00	5,173.89	12,357.11

Annual Report
1951-1952

Report to: Atomic Energy Commission

Project No.: AT-(40-1)-264, Department of Agronomy, North Carolina State College, Raleigh, North Carolina.

Title: Study of the Movement of Ions through Soil Systems

Period Covered: July 1, 1951 to June 30, 1952

Presented by: N. S. Hall

Date: April 1, 1952

Contents of Report

A. Experiments involving P32

1. Rate of migration: It had been shown in the previous report that moisture level and amount of phosphorus in the liquid phase were important in the rate of ionic migration of phosphorus. In the previous study it was only possible to express the rate of movement in relative terms. A study was set up to investigate the rate of movement by direct means. This diffusion is accomplished under a diffusion gradient of essentially zero from the standpoint of P but from the standpoint of P32 is quite high. Since these data have not been analyzed mathematically, they are reported in terms of thickness (mgm/cm^2) of aluminum per day (Table I).

Table I. Mean Rate of Movement of the Front of $P32\,O_4$ ions in Cecil (7.8% Fe_2O_3) soil.

	Mean Rate	
Period in Weeks	in terms of mgm/cm^2 of Al per day	in terms of mm. of Al per day
1	62.1	0.23
2	35.1	0.13
3	13.5	0.050
4	3.8	0.014

During the period of four weeks, the total movement of the front of $P32\,O_4$ ions was through a distance equivalent to 3.0 mm. of Al.

It is expected that during the course of Mr. Weed's investigations that he will consider this phenomenon under ideal conditions and with other ions. A mathematical solution of the movement will be attempted. The above results are sufficiently promising to warrant favorable predictions for his success.

2. Movement from high concentrations: It has been shown in previous work that the ionic movement of phosphorus is very slow. It is thought that this movement must precede any movement of large concentrations. This would mean

that the fringe of any added phosphates to a soil would have a very steep gradient. In an experiment designed to study the effect of concentrating the location of phosphorus there was the opportunity to illustrate this by means of radioactive autographs. The experiment has three treatments: (1) 18 gms. of 20 per cent monocalciumphosphate plus 6 gms. of $(NH_4)_2SO_4$ mixed with 9.05×10^3 cm^3 (0.32 ft^3) of soil, (2) this same amount of material placed in small pile in the center of this volume of soil and (3) a brickett made by pressing this amount of material into a volume of 12.3 cm^3 (0.75 in^3; 4.3×10^{-4} ft^3) and place in the center of this volume. Radio-autographs were made after twelve weeks and are presented in figure 1. There are two items of interest. First, that as predicted, the boundry of phosphorus movement is very sharp. There is seldom more than 1/4 of an inch that shows much change in concentration. Secondly, that the bricketts show a large amount of movement due to the downward movement of applied water. Only one replication out of three of the hill (treatment 2) application showed this same effect. It is thought that this is due to the presence of $(NH_4)_2SO_4$. The interaction between this and the monocalciumphosphate would be much greater in the pressed samples. These radiographs contribute to the understanding of why phosphorus is "fixed" or held tightly, only at low concentrations. Chemical analysis of area indicated by the presence of P32 yield approximately 10-1500 ppm phosphorus soluble in .002 NH_2SO_4. The darkened areas contain about 70 ppm of phosphorus of this solubility. Calculations on the above data show that approximately one third of the phosphorus in this concentrated area has moved into the area about the source.

3. Isotopic exchange in static systems: In recent experiments designed to locate the activity absorbing roots of the plant, it was noted that the specific activity of the plant fell off more rapidly than could be accounted for by increased growth. Since only a small fraction of the roots were outside volume covered by the test P32, it meant that the test sites were changing in specific activity. There are

two possibilities; first that the test site is undergoing isotopic exchange at a rate much slower than that noted in laboratory examinations. These showed that greater than 95 per cent of the reaction is completed in 5 to 10 days. Secondly, it may be that the plant is withdrawing phosphorus of a certain solubility and then a redistribution, through isotopic exchange, is made of the remaining P32.

Moist soils were injected with P32 and allowed to stand at that moisture over a period of 50 days. The specific activity of the phosphorus soluble in dilute acid was checked on individual samples over this period and no change was discernable. This means the second explanation is probably valid. The implications with respect to disposal are evident. If there is no water movement or plant growth, one may expect that the change in specific activity due to isotopic exchange will take place during the first 5 to 10 days and most of that reaction will be over after the first 1 to 2 days. It means further, that laboratory experiments on isotopic exchange and diffusion may be readily transposed to field conditions.

4. Isotopic exchange in air-dry systems: It has been shown that the specific activity of a carbonate labeled with C14 will change through isotopic exchange with atmospheric CO_2. This depends upon the relative humidity of the atmosphere. A small experiment was designed to test whether isotopic exchange of PO_4 would take place under relatively dry conditions. A sample of monocalciumphosphate was stored in a relative humidity of 50 per cent. The material had been pressed sufficiently to hold its shape. After a period of one week had elapsed to assure the absorption of moisture was at equilibrium, one drop of labeled H_3PO_4 was added. Examination of these tests showed no appreciable movement of the P32 from the H_3PO_4. This means that the moisture films are not of sufficient thickness to provide direct contact.

5. Organic-inorganic phosphrous relation: A small part of our efforts were devoted to studying some of the conditions under which there is an exchange between the organic and inorganic forms of phosphorus. The purpose of this study is to see if this would have any effect on the movement of phosphorus in soils of high organic matter content. In any soil profile, organic matter is not evenly distributed, usually a higher level is found in the surface layers. Ions which leach through the soil pass from a zone of higher organic matter to one of lower.

While the full analysis of this is not available, it can be stated that the type of microbial population seems very important in this phenomenon. Under conditions in which the population is mainly filamentous organisms (pH about 5) there is very little interchange between these two sources. However, at a higher pH (6 - 6.5), the exchange is quite marked and one can expect the movement of phosphorus released from organic sources.

B. Experiments involving Ca^{45}.

1. The effect of the amount of clay on movement: It was indicated in the 1951 report that the movement of Ca^{45} through soil systems was affected by the type of material utilized. It also indicated that the amount of exchange material present would change this movement. An experiment was designed to indicate the effect of amount of clay (exchange material) on the movement of Ca^{45}. These data are plotted in Figure 2a. The diffusion medium was an Agar gel containing varying amounts of clay. Since it was not possible to use a uniform source, the data are expressed as relative to the source at the time measurements were taken. An amount of Ca^{45} greater than the source would indicate an inhibiting effect while less than the source would be expected for normal movement through a free space. Figure 2a shows that increasing the amount of exchange material inhibits the movement of the Ca^{45}.

2. Effect of associated cation: The above trials were later expanded to include the effect of hydrogen and calcium on the exchange complex. These results are

in figure 2b. The data are in good agreement with those reported earlier.

The combination of these results indicate that the movement of Ca^{45} is markedly influenced by the opportunities to enter into an exchange with its surroundings. In effect this means that as the opportunity for exchange is increased, (by increasing the amount of exchange material or presence of a common cation) the effective cross-sectional area through which it is moving is increased and the rate decreased. The presence of hydrogen lessens the chances of exchange since this cation is held more tightlyto the exchange material than calcium.

3. Field study: A field study utilizing Ca^{45} in the form of sulfate, carbonate and monocalciumphosphate was designated to study the utilization of these materials by the tobacco plant. It provided an excellent opportunity to determine movement under field conditions.

The materials were distributed in narrow bands in the row. An analysis of the soil 2-4 inches under these bands and 1-2 inches on each side indicated that no Ca^{45} had moved into these areas. The total rainfall during this season was about 11 inches. This is about 5 inches less than would normally be expected.

The fact that little movement of Ca^{45} was detected under field conditions tends to confirm the often made observation that most of the leaching from soils occurs during periods in which plants are absent or not actively growing. This means that it would be a good recommendation for disposal sites to be kept vegetated whenever feasable.

C. Experiment with $Fe^{55, 59}$.

The conflicting results of phosphorus and calcium movement required that another ion be studied. Since a source of $Fe^{55, 59}$ was available, a simple experiment was designed that would not conflict with our safety factor. The technique to study movement was the same as that described for phosphorus in last year's report. Essentially this consists of placing a source next to the medium through which movement is to be studied and sealing the system. Both sides of the system are measured for appearing and disappearing activity. The results are plotted in Figure 3. The soil used had 7.8 per cent free Fe_2O_3. It is of considerable interest that when treated with substances that decrease the solubility of iron, the rate of movement was decreased. Also it must be noted that the rate of movement is much slower than that found for phosphorus and calcium. It is believed this can be accounted for by the difference in solubility between the phosphate from its complex and the mechanism of exchange in the case of calcium.

It indicates that the conditions under which an ion moves in a soil depends on whether the ion enters preferentially into an exchange reaction (calcium) or a chemical precipitation - solution reaction (phosphate and iron). One can see that the difference in hexndling the disposal of an ion would be exactly opposite in these cases. This phase of the problem appears so promising that emphasis is being given it in Mr. S. B. Weed's program.

D. Summary of results

A brief summary of the past year's results indicates the following points:

1. The rate of ionic movement of PO_4 decreases exponentially with time. The initial rate is in excess of 0.23 mm (Al equivalent) per day. In this particular study the relation is:

Rate (in mm Al equivalent per week) = $e^{-0.42t} + 33$ where t is in weeks.

2. Radioautographs confirm the observation that phosphate fixation takes place at low concentrations. When a critical level of phosphorus is reached mass movement takes place rapidly. A very high concentration gradient is required to initiate much movement.

3. The rates of isotopic exchange noted in laboratory experiments closely approximate the rate encountered under moist field conditions. That is, the specific activity of a system should not change more than a few per cent after the first

few days unless some portion of the total is removed by leaching or biotic growth.

4. Isotopic exchange of P32 in the form of PO_4 will not exchange with solid mono-calciumphosphate under relatively humid (50 per cent) conditions.

5. The interaction of organic and inorganic phosphates is dependent upon the microbial makeup. The filamentous organisms are not as active in this interchange as the bacterial organisms. This may be due to the similarity between the phosphorus compounds in the former and the organic forms originally present.

6. The amount and rate of movement of Calcium 45 in porous systems decreases as the chances for exchange reactions to occur increase. Thus the conditions for its movement are markedly different from those of phosphorus and iron.

7. The movement due to leaching of Ca45 in a field study was much less than a comparable laboratory study by J. M. Blume. The movement in a field when subjected to 11 inches precipitation was less than 2 inches downward and less than 1 inch laterally. This was probably due to the protective action of plants on leaching.

8. The conditions under which Fe 55, 59 move in a porous medium are more similar to those of P32 ~~and~~ than Ca45. Thus it is expected in these cases two phenomena are operative. In the case of Fe 55, 59 the solubility of the complex increases movement while Ca45 enters into an isotopic exchange reaction to reduce its rate of movement.

E. Proposal for the fiscal year 1952-1953

1. General remarks: The outlook for expanded use of isotopes with long half-life is more encouraging that it has ever been before. In 1947 the facilities of this laboratory were designed to handle only short-lived isotopes. This was because new accomodations were expected within the ensuing four-year period. This means, that while we have utilized the isotopes Ca45 and Fe 55, 59 in addition to P32, the extreme caution and care required to use these under existing facilities has markedly reduced the amount of work. It has not been possible to have a large number of

treatments underway at any one time. It also means that we have not attempted to use the several isotopes as was planned. It is felt that while the shift has delayed the obtaining of the information planned, the additional information aids in a clearer understanding of the ionic movement of P32, Ca45 and introduces consideration of Fe in soil systems.

There appears to be no reason for predicting that adequate facilities will not be available after June 1, 1952. Thus it will be possible to utilize the more haxardous isotopes with an adequate safety factor.

2. Program for mathematical solution of ionic movement. The part-time Research Assistant now associated with this project comes to us from Brigham Young University. He has a very excellent background in physical chemistry and we expect him to make a big contribution to these studies. His program will be to attempt a mathematical solution to the movement of ions under ideal porous systems. This will also entail an attempt to separate the effects of charged particles in the system (exchange materials), the solubility product of the compounds associated with the ion studied and the proximity of the charged particle or compound (size of pore through which movement occurs). Such a mathematical solution will enable one to predict the rate and extent of movement of any ion once the conditions of its movement are known.

3. Program for general solution of ionic movement. Theobjective of this portion of the program of the laboratory will be to establish the conditions under which the movement of several ions will take place. This means that the ions that were originally scheduled to be studied this year will be investigated in light of this year's results. It will be the purpose of this phase of the program to inquire as to whether these ions are affected by the solubility of the compounds they form (as is P32 and Fe 55,59) or if they are preferentially affected by the amount and character of charged particles (refer to Ca45).

By knowing the conditions that affect the movement of ions, it will be possible to utilize the information from the previous section to estimate the rate and extent. Also by careful consideration of the nature of the ions studied, it should be possible to predict the conditions for the movement of general groups of ions.

F. Budget Request - Fiscal Year 1952-53.

AEC - Soils

Proposed Budget 1952-53

Salaries	
Two (2) laboratory technicians at $2880	
One (1) part-time research assistant at $1500	
	$7260
Labor	400
Tavel	125
Transportation	20
Communications	20
Contractual	200
Sypplies	570
Equipment	300
	$8,895

Figure 1. Prints from radioautographs of monocalciumphosphate containing P32, 12 weeks after application.

a. 18 grams plus 6 grams $(NH_4)_2SO_4$ mixed with 0.32 ft^3 of soil.

b. Same amount placed in a small volume as the powder.

c. Same amount pressed at 1400 lbs. per in^2 into a brickett.

(the ink line indicates outline of original material)

Figure 2. Movement of calcium 45

a. Influence of amount of exchange material (% caly)

b. Influence of associated cation (Ca or H)

Figure 3. Movement of iron in soil

STATEMENT OF EXPENDITURES THROUGH MAY 1, 1952, AND ANTICIPATED UNEXPENDED

BALANCE OF JUNE 30, 1952

Balance covering A.E.C. Contract #AT40-1-264

Item	Budget 1951-1952	Expenditures Encumbered April 30, '52	Unencumbered Balance May 30, '52	Anticipated Needs Through May and June	Unexpended Balance June 30, '52
Salaries	5552.	4,541.30	1,010.70	1010.	.70
Labor	1575.	1,257.98	317.02	300.	17.02
Travel	43.	42.42	.58	0	.58
Transportation	20.	19.52	.48	0	.48
Communication	20.	19.26	.74	0	.74
Rents	0	0	0	0	0
Printing	0	0	0	0	0
Contractual	175.	172.51	2.49	2.40	.09
Supplies	1868.	1829.01	38.99	38.00	.99
Equipment	345.	344.24	.76	0	.76
TOTAL	9598.*	8226.24	1371.76	1350.40	21.36

* The total amount budgeted (9598) is an increase of $703. over the amount stipulated in the contract for the current fiscal year. This increase was a carry-over from the fiscal year 1950-51. The specific amounts in the various objects are different from those originally budgeted as a result of transfers within the budget which had the approval of Mr. Kenneth Kasschau before they were made.

UNITED STATES
ATOMIC ENERGY COMMISSION

Oak Ridge, Tennessee
March 13, 1952

Mr. Joseph W. Smith, Administrative Assistant
School of Agriculture and Forestry
N. C. State College of Agriculture and Engineering
Raleigh, North Carolina

Subject: TRANSFERS OF FUNDS WITHIN THE BUDGET OF N.C. STATE COLLEGE LUMP-SUM CONTRACT NO. AT-(40-1)-264.

Dear Mr. Smith:

We are in receipt of your letter dated February 26, 1952, and wish to reply to your inquiry regarding transfer of funds within the budget of the above contract.

We have examined your request of funds, and note that the exchange will be principally from travel, instrument maintenance, and transportation, as you suggest, plus the smaller amounts from communications, rents, and equipment, so there is a transfer of the sum $995.00 within the budgeted amount of $8,895.00. It is understood this eliminates the transfer of $350.00 from Supplies to Labor as authorized by our letter of Nov. 20, 1951. We are very willing to approve these changes.

Although considerable leeway is permitted within the terms of the contract for transfer of funds within the budgeted amount, these transfers are of sizable sums and we appreciate your cooperation in keeping us informed as to the requirements in these transfers and the budget sources of the amounts involved.

Sincerely yours,

Kenneth Kasschau

Kenneth Kasschau
Acting Director
Office of Research & Medicine

CC: Dr. Paul B. Pearson, Wash.

Shoup:ec

Contract No. AT-(40-1)-264

Object	Budgeted	Spent to Feb. 1, 1952	Balance Jan. 31, 1952	Estimated Needs Feb. 1 - June 30 1952	Needs Over or (Under) Jan. 31 Balance
Salaries*	5,191.00	3,026.30	2,164.70	2,525.70	361.00
Labor	659.00	1,292.78	(633.78)	.22	634.00
Travel	300.00	88.05	211.95	26.95	(185.00)
Transportation	20.00	14.76	5.24	5.24	-
Communication	50.00	6.95	43.05	13.05	(30.00)
Rents	30.00	0	30.00	0	(30.00)
Printing	5.00	0	5.00	5.00	-
Contractual	395.00	155.06	239.94	19.94	(220.00)
Supplies	1,750.00	1,135.19	609.81	109.81	(500.00)
Equipment	500.00	326.24	175.76	145.76	(30.00)
Total	8,895.00	6,055.33	2,849.67	2,849.67	0

*This item reflects the approved transfer as per your letter dated November 20, 1951 transferring $250.00 from Salaries to Labor. The letter just mentioned also approved a transfer of $350.00 from Supplies to Labor but this transfer has never been officially made on our records and we request that it not be made but superseded by the transfer request outlined below.

From:		To:	
Travel	$185.00	Salaries	$361.00
Communications	30.00	Labor	634.00
Rents	30.00		
Contractual	220.00		
Supplies	500.00		
Equipment	30.00		
	$995.00		$995.00

Comments on requests for transfers:

To salaries $361.00. The need for an increase in salaries is due to an oversight when the previous request was made transferring funds from salaries to wages. There was a $180.00 cost of living adjustment for all salary personnel effective July 1, 1952. Since two of our salary employees under this contract were included in this cost of living pay adjustment, we are requesting the $361.00 transferred back to salaries to meet this need.

To labor $634.00. As you will note, this merely removes the $633.78 deficit in the labor account. This deficit is the result of the temporary help that was hired at the beginning of the current fiscal year being carried on the payroll longer than originally anticipated due to additional laboratory requirements on the projects. There was no increase in wage rates. All additional labor required during the remainder of the year will be paid from other funds.

The reductions of sizable amounts can be made from the indicated objects for the following reasons.

From supplies $500.00. The need for chemicals were not as great as anticipated due to the type of investigation carried on. A reduction in the breakage of glassware also contributed to the unused balance.

From contractual $200.00. The Geiger Counter scaling circuits did not require as much maintenance as was anticipated.

From Transportation $185.00. The amount of travel anticipated at the beginning of the fiscal year has been curtailed somewhat by the pressure of project work. Some of the travel expenses that were incurred have been reimbursed by other sources of funds. For example, the expenses of a trip to Oak Ridge, Tennessee, and a trip to Washington, D. C., were reimbursed by the Phosphate Industry.

UNITED STATES
ATOMIC ENERGY COMMISSION

Oak Ridge, Tennessee
March 13, 1952

Mr. Joseph W. Smith, Administrative Assistant
School of Agriculture and Forestry
N. C. State College of Agriculture & Engineering
Raleigh, North Carolina

Subject: TRANSFERS OF FUNDS WITHIN THE BUDGET OF NORTH CAROLINA STATE COLLEGE LUMP-SUM CONTRACT NO. AT-(40-1)-265.

Dear Mr. Smith:

We are in receipt of your letter of February 26, 1952, together with the statement of expenditures and estimate of obligations for Contract No. AT-(40-1)-264 and 265. A reply is being prepared for each contract since we maintain separate records by individual contracts.

We have examined your request for transfer of funds within the budget of the subject contract, and note the changes involved are mainly the change in wage designation combined with the wage increase plus the contract with International Business Machines. We note that the total transfer of $1,560.00 is by adjustment within the contract budget, and we extend our approval of your making this change in allottment of funds.

Although considerable leeway is permitted within the terms of the contract for transfer of funds within the budgeted amount, these redesignations involve sizable sums, and we appreciate your cooperating in keeping us informed as to the desirability of making these adjustments.

Sincerely yours,

Kenneth Kasschau

Kenneth Kasschau
Acting Director
Office of Research and Medicine

CC: Dr. Paul B. Pearson, Wash.

Shoup:ec

North Carolina State College of Agriculture and Engineering
of the
University of North Carolina
Raleigh

SCHOOL OF
AGRICULTURE AND FORESTRY
RESEARCH EXTENSION
RESIDENT TEACHING

DEPARTMENT OF AGRONOMY

February 26, 1952

Mr. Kenneth Kasschau
Acting Director
Office of Research and Medicine
P.O. Box E
Oak Ridge, Tennessee

Dear Mr. Kasschau:

I am in receipt of a copy of your letter to Chancellor J. W. Harrelson regarding the renewal of contracts No. AT-(40-1)-264 and No. AT-(40-1)-265. After consulting with project leaders Dr. N. S. Hall (AT-(40-1)-264) and Dr. W. C. Gregory (AT-(40-1)-265) and Dr. W. E. Colwell, Head of the Department of Agronomy, the following schedule was agreed upon.

(1) Submission at once of current statement of expenditures incurred to date and an estimate of the obligations to be incurred during the remainder of the contract period.

(2) Along with the above report, a request for transfers between the objects now under contract.

(3) Between March 15 and April 1 to submit the annual reports due under each contract along with the proposed program for the fiscal year beginning July 1, 1952 and ending June 30, 1953.

I trust that the above schedule meets your approval and that in no way will our responsibilities under these contracts cause you any delay in your execution of these contracts.

You will find enclosed the statements of expenditures, estimated obligations and suggested transfers for contracts AT-(40-1)-264 and AT-(40-1)-265 with comments about the transfers enclosed. Should there be any further information desired or any suggestions regarding the presentation of this information, I shall be most happy to cooperate in every way possible.

Very truly yours,

Joseph W. Smith
Administrative Assistant

JWS:c

Contract AT-(40-1)-265

Object	Budgeted	Spent to Feb. 1, 1952	Balance Jan. 31, 1952	Estimated Needs Feb. 1 - June 30 1952	Needs Over or (Under) Jan. 31 Bal.
Salaries	9,780.00	5,270.93	4,509.07	3,769.07	(740.00)
Labor	4,000.00	3,648.15	351.85	1,511.85	1,160.00
Travel	2,910.00	2,668.77	241.23	241.23	0
Transportation	25.00	5.04	19.96	19.96	0
Communication	10.00	9.50	.50	.50	0
Rents	10.00	-	10.00	10.00	0
Printing	150.00	-	150.00	0	(150.00)
Contractual	790.00	711.97	78.03	478.03	400.00
Supplies	1,790.00	1,033.92	756.08	206.08	(550.00)
Equipment	1,500.00	1,379.14	120.86	.86	(120.00)
Totals	20,965.00	14,727.42	6,237.58	6,237.58	0

On the basis of the above information, it is suggested that the following transfers be made;

From;		To;	
Salaries	$740.00	Labor	$1,160.00
Printing	150.00	Contractual	400.00
Supplies	550.00		
Equipment	120.00		
	$1,560.00		$1,560.00

Comments on requests for transfers;

Increase in wages of $1,160.00. This transfer of $740.00 is due to the resignation of a laboratory assistant who was replaced and the replacement was paid on the labor payroll instead of on salary. The additional $420.00 requested from Printing, Supplies and Equipment to be transferred to Labor is needed to cover unforseen additional labor for shelling, processing, and planting peanuts.

It should be noted that the additional need for labor money does not reflect any increase in wage rates nor do we anticipate any increase in wage rates.

The major item requiring additional funds ($400.00) in the contractual category is a contract already entered into with International Business Machines to punch 100 thousand mark sensed cards, the rate being quoted by International Business Machines at $3.75 per 1,000, total cost $375.00.

April 30, 1951

Atomic Energy Commission
Division of Biology and Medicine
Washington, D. C.

Subject: One report pertaining to Contract No. AT-(40-1)-264 in the Agronomy Department at North Carolina State College to request the renewal of this contract for the fiscal year 1952.

Gentlemen:

I am submitting in this report two theses that were sponsored by this contract. The thesis by Mr. Preston H. Reid has been shortened by the omission of the "Review of Literature". Only one copy of these theses is being submitted. However, if additional copies are desired, they can be obtained.

A summary of these theses is included. This summary indicates the importance of these studies and contains our reasons for desiring to continue this study. We feel that such a study extended to other elements will contribute greatly to the general isotope program of the Commission.

Pertaining to the request for renewal of this contract, we are submitting a budget for the fiscal year of 1952. This budget contains our best estimate of the requirements to continue the project in the manner in which we would like to see it.

We are also submitting at this time the unexpended balance and the commitments of this balance to the end of this fiscal year.

If there are any questions pertaining to the report or to the request for renewal, we would appreciate hearing from you.

Very truly yours,

N. S. Hall
Professor of Agronomy

NSH:c

Enclosure

May 15, 1951

Dr. Paul B. Pearson
Chief, Biology Branch
Division of Biology and Medicine
United States Atomic Energy Commission
Washington 25, D. C.

Subject: Additional information regarding request for renewal of contract, AT-(40-1)-264.

Dear Dr. Pearson:

Our plans for next year on the project covered by this contract are as follows:

(1) Phosphorus: We believe that the knowledge pertaining to movement of phosphorus has progressed to the extent where we should attempt to duplicate laboratory findings to field conditions. In order to accomplish this, established phosphorus conditions will be utilized to determine the extent to which the phosphorus can be mobilized by the addition of cationic complexing reagents. This has proved very feasible in the laboratory and should work out under field conditions. Additional work is contemplated on adding quantities of phsophorus to a system with a low content of phosphate complexing compounds (iron and alluminum complexes) and trying to prevent the movement of phosphorus through the addition of phosphorus complexing compounds.

(2) Calcium: The studies indicated in the thesis of Preston H. Reid, submitted as partial report, demonstrated the effectiveness of anions in increasing the mobility of calcium. It is believed that a study of the effect of these anions at very low concentrations must be conducted. This is very pertinent because of the low concentration of anions normally occurring in soil systems. Additional work is necessary on calcium movement with respect to the hydrogen ion concentration of the medium. There were indications in the work by Mr. Reid that changing the hydrogen ion concentration increased the mobility of the calcium.

3. Zinc: The project is to be expanded to include zinc. Laboratory investigations of the mobility of zinc will be conducted along the lines outlined in the theses by Reid and Satchell. This consists of noting the mobility of zinc ions in the presence and absence of associated zinc.

4. Sulphur: The isotopic techniques employed in the movement of phosphorus should be applicable to studies on the movement of sulphur. It is anticipated that the portion of the project pertaining to this element will develop along similar lines to that explored in connection with phosphorus.

The techniques used to study isotope movement in the laboratory briefly consists of placing the radioactive element to be studied in contact with the medium through which it is to move. The concentration of the tracer element is such that the overall concentration gradient is away from the medium. There is of course a positive concentration gradient of the tagged element per se. This means that one can study the diffusion and mobility of this ion under essentially no concentration gradient. Such a study indicates the contact and the distance over which this contact is maintained in a given time. To my knowledge this is the best technique for studying the mobility of ions in a porous medium and to predict the extent to which the ion will move under various conditions.

It must be remembered that under field conditions the movement of ions due to water leaching through the soil occurs during a small portion of the total time. This means that a study of ionic movement under conditions of no water movement is very important in understanding the behavior of these ions. We feel that the technique that we have developed to study this movement is very good and provides an excellent insight into this problem.

I hope this has provided the additional information requested in your letter of May 8.

Sincerely yours,

N. S. Hall
Professor of Agronomy

NSH:c

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

IN REPLY REFER TO:
BMB:PBP

8 May 1951

Dr. N. S. Hall
Department of Agronomy
North Carolina State College
Raleigh, North Carolina

Dear Doctor Hall:

We have received the progress report and request for renewal on your contract, AT-(40-1)-264.

It would materially assist us in evaluating the relative importance of this project if you could expand on the plans for work next year. While we recognize that this is important work and that movement in soil of other isotopes may well be studied, it would be helpful to know what other ions are to be studied next year. Provided the techniques and approach differ from those in the past, would you please indicate this. One might expect that some new approach to the problem may be indicated on the basis of work during the past two years.

It is doubtful that we can provide funds for two laboratory technicians since this does represent a substantial increase in the expansion in your program over last year.

Sincerely yours,

Paul B Pearson

Paul B. Pearson
Chief, Biology Branch
Division of Biology and Medicine

2388 -> out

BUDGET PROPOSAL FOR CONTRACT AT-(40-1)-265 — Peanuts

Fiscal Year 1952 — april 1957

SALARIES $9,780.00
575
10,355

Apportioned as Follows:

march 26, 1952

Assistant (Genetics and Cytogenetics, entire salary)	$3,800.00 + 180 + 120
Field Assistant (Pathology, entire salary)	2,400.00 + 180 -> 1500
Laboratory Technician (Cytogenetics, half salary the other half to be paid by the N. C. Agr. Exp. Sta.)	1,200.00 + 90 -> 2780 1200 1980
Field Assistant (Breeding, four fifths salary, the other fifth to be paid by the N. C. Agr. Exp. Sta.	2,380.00 + 125 + 96
Total	$9,780.00

575

LABOR $4,000.00

This item includes the hand shelling of individual mutant plants; sorting, classification, counting, and weighing of seeds; preparation and packaging seeds for planting; and routine temporary laboratory labor in excess of that capable of being accomplished by the permanent technical staff.

See list of 9 person included

TRAVEL $2,000.00

The peanuts will be planted at three locations, 60, 90, and 120 miles from the Raleigh Station, respectively. This item includes the operation of the motor vehicle and food and lodging for the technical staff while working on these plant locations.

TRANSPORTATION . . . . $ 25.00

COMMUNICATION . . . . $ 10.00

PRINTING . . . . $ 150.00

CONTRACTUAL . . . . $ 800.00

Cost of planting, cultivating and harvesting the 20 acres of peanuts. The N. C. Agr. Exp. Sta. will furnish the same for the 30 additional acres.

SUPPLIES $2,700.00

Mainly to be used for stakes, bags, and plant tags.
Chemicals, Records, etc.

EQUIPMENT $1,500.00

To be used for seeding, cultivating, and harvesting equipment.

TOTAL $20,965.00

COPY

1956
Contract No. At-(40-1)-1747
North Carolina State College
Mod. No. 2

SUPPLEMENTAL AGREEMENT

THIS SUPPLEMENTAL AGREEMENT, entered into this 21st day of June, 1956, by and between the UNITED STATES OF AMERICA (hereinafter called the "Government"), represented herein by the UNITED STATES ATOMIC ENERGY COMMISSION (hereinafter called the "Commission"), and NORTH CAROLINA STATE COLLEGE (hereinafter called the "Contractor"):

WITNESSETH THAT:

WHEREAS, the Government and the Contractor entered into Contract No. At-(40-1)-1747, dated June 17, 1954, providing for a study of the comparative effect of irradiation on mutation frequency, total genetic variance, and progress from selection in different genotypes of peanuts and their hybrids; and

WHEREAS, the Contract has been amended heretofore by Modification No. 1; and

WHEREAS, the parties hereto desire to extend the term of the contract in order to continue the research activities previously undertaken, as such extended program is described in TITLE III of Appensix "A:, and to effect certain other changes as are hereinafter more particularly described; and

WHEREAS, this Supplemental Agreement is authorized by and executed under the Atomic Energy Act of 1954:

NOW, THEREFORE, the parties hereto do mutually agree that said contract is hereby modified in the following particulars, but in no others:

1. The following new section "3" os added tp Article II:

"3. The third period of performance for the research project covered by this contract will commence on July 1, 1956, and will end on October 31, 1956."

2. a. The following new subsection "1. c." is added in Article III:

"c. In consideration of the performance of the research activities described in TITLE III of Appendix "A", and the Contractor's agreement to support that work in the estimated amount of Fourteen Thousand, Seven Hundred Thirty-seven Dollars ($14,737.00), the Government will pay to the Contractor for the third period of performance the sum of Eight Thousand, Fourteen Dollars ($8,014.00)."

b. Section 2. of Article III shall not be in effect during the third period of performance, but shall be in effect thereafter in the event this contract is renewed. During the third period of performance only, the following section 2. of Article III shall be in effect:

"2. <u>Payment</u>

"a. On or before the date of commencement of the work on the project described in Appendix "A", the Government shall pay to the Contractor upon submission by the Contractor of a properly certified voucher, the agreed consideration; provided, however, that this payment shall be reduced by the amount of the balance, if any, agreed to be remaining unexpended from the previous period of performance."

3. "ARTICLE VI - PURCHASE OF RADIOISOTOPES" is deleted in its entirety and the following new Article "VI is inserted in lieu thereof:

"ARTICLE VI - PROCUREMENT OF MATERIAL AND SERVICES FROM COMMISSION FACILITIES: COMPLIANCE WITH COMMISSION REGULATIONS

"The Contractor shall comply with all licensing and other requirements of the Commission with respect to possession and use of byproduct material, source material, and special nuclear material (as these terms are defined in the Atomic Energy Act of 1954), and may purchase or acquire such materials, irradiation services, other radioactive material, cyclotron time, etc. from the Commission or Commission facilities in accordance with applicable procedures."

4. The following new Article "VI-A" is added immediately following Article VI:

"ARTICLE VI-A - PURCHASE OF RADIOISOTOPES UNDER AN AEC DISCOUNT CERTIFICATE

"If any radioisotopes are budgeted in the outline of cost estimates at the full amount of the price as established by the Commission, but are purchased at less than such established prices under an AEC Discount Certificate issued to the Contractor (See: Title 10 C.F.R., Part 37), then any difference between the established price and the price so paid shall be paid by the Contractor to the Government or otherwise credited to the Government's account as the Contracting Officer may direct or approve. The requirement for a report to be submitted to the Commission indicating the purchases under the discount program is outlined in Appendix "C".

5. In subsections a. and b. of section 1. Patents of Appendix "B", the words "in the course of any of the work under this contract" are deleted, and the words "In the course of, in connection with, or under the terms of this contract" are inserted in lieu thereof in both subsections.

6. In Appendix "B:, section 7. Nondiscrimination in Employment is deleted in its entirety and the following new section "7." is inserted in lieu thereof:

"7. Nondiscrimination in Employment

"a. In connection with the performance of work under this contract, the Contractor agrees not to discriminate against any employee or applicant for employment because of race, religion, color or national origin. The aforesaid provision shall include but not be limited to, the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post hereafter in conspicuous places, available for employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of the nondiscrimination clause.

"b. The Contractor further agrees to insert the foregoing provision in all subcontracts hereunder, except (i) subcontracts for standard commercial supplies or raw materials, (ii) subcontracts to be performed outside the United States where no recruitment of workers within the limits of the United States is involved, (iii) purchase orders on pocket-size forms similar to U. S. Standard Form 44, and (iv) subcontracts to meet other special requirements or emergencies, if recommended by the Committee on Government Contracts. In the case of purchase orders hereunder which do not exceed $5,000, the last sentence of paragraph a. above may be omitted."

7. In Appendix "B", the following new section "15. <u>Buy American Act</u>" is added immediately following section 14. <u>Foreign Travel</u>:

"15. <u>Buy American Act</u>

"In the event this contract provides for the acquisition of articles, materials, or supplies by the Government, the following provision shall apply with respect to such items: The Contractor agrees that there will be delivered under this contract only such unmanufactured articles, materials and supplies (which term 'articles, materials and supplies' is hereinafter referred to in this clause as 'supplies') as have been mined or produced in the United States, and only such manufactured supplies as have been manufactured in the United States substantially all from supplies mined, produced, or manufactured, as the case may be, in the United States. The foregoing provisions shall not apply (i) with respect to supplies exempted by the Commission from the application of the Buy American Act (41 U.S.C. 10a-d), (ii) with respect to supplies for use outside the United States, or (iii) with respect to the supplies to be delivered under this contract which are of a class or kind determined by the Commission not to be mined, produced, or manufactured, as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, or (iv) with respect to such supplies, from which the supplies to be delivered under this contract are manufactured, as are of a class or kind determined by the Commission not to be mined, produced, or manufactured as the case may be, in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality, provided that this exception (iv) shall not permit delivery of supplies manufactured outside the United States if such supplies are manufactured in the United States in sufficient and reasonably available commercial quantities and of a satisfactory quality."

8. In the list of reports on the first page of Appendix "C", the designation "5." is revised to read "6.", and the following new report is provided for as "5." of the list:

"Radioisotope Purchase Report	With renewal proposal if proposal is submitted, otherwise on contract termination	Three"

9. In Appendix "C", the following new paragraph is added immediately following the provision on page 3 entitled "13. Residual funds.":

> "The radioisotopes purchase report shall list all radioisotopes included in the budget for the current period at the regular price established by the Commission, but which are purchased, or will be purchased during the current period, at a price less than the established price by utilizing the discount authorized by an AEC Discount Certificate issued to the Contractor. For each such purchase, the report shall state the price as established by the Commission, the price paid or to be paid using the discount, and the savings realized or to be realized. The report due on contract termination shall cover all such purchases actually made during the final period."

10. In Appendix "C", delete the words "Research and Medicine Division", and insert the words "Research and Development Division" in lieu thereof.

11. The following new "TITLE III" is added in Appendix "A":

"TITLE III

"July 1, 1956 - October 31, 1956

"This TITLE III describes the research program and cost estimates agreed upon between the Commission and the Contractor for the third period of performance.

"1. <u>PROGRAM</u>

"a. <u>Scope and Plan of Approach</u>"

The Contractor shall continue work on (1) the comparative effect of irradiation upon mutation frequency, total genetic variance and progress from selection in different genotypes of peanuts and their hybrids, and (2) the genetic characteristics of radiation injury resistance in peanuts.

The work will test for comparative genetical variability among hybrids vs. inbreds under the action of radiation compared to that of their non-irradiated counterparts.

Tests will be made to determine if radiation treatment will effect a larger total genetic variance in hybrids through increased recombination from the effects of broken linkages, through increased mutation rate, or both.

In addition, selected F_2 lines irradiated with X-rays and neutrons will be studied for (1) Percent germination, (2) Percent surviving, (3) Degree of radiation injury as represented by (a) X_1 injury score and (b) the number of days from planting to first flower.

"2. BUDGET

"a. Outline of Cost Estimates for the Third Period:

(1)	Salaries and Wages:		$10,960.00
	Dr. W. C. Gregory	$2,720.00	
	Research Assistants, Tech. etc.	8,240.00	
(2)	Rents:		4,357.00
(3)	Supplies:		540.00
(4)	Communication, Transportation, etc.:		341.00
(5)	Travel:		1,360.00
(6)	Indirect Cost		5,193.00
		TOTAL	$22,751.00

"b. Items of property to be procured or manufactured by the Contractor during this period, title to which will vest in the Government (see Article V):

12. In Appendix "C" delete the date "April 1" wherever it appears, and insert the date"August 1" in lieu thereof in each instance.

13. Upon written notice by the Contracting Officer before October 31, 1956, this contract shall be automatically renewed and modified in the following particulars, but in no others:

a. The following new section "4." will be added in Article II:

"4. The fourth period of performance for the research project covered by this contract will commence on November 1, 1956, and will end on October 31, 1957."

b. The following new subsection "1.d." will be added in Article III.

"d. In consideration of the performance of the research activities described in TITLE IV of Appendix "A", and the Contractor's agreement to support that work in the estimated amount of Forty-two Thousand, Five Hundred Fifty-four Dollars ($42,554.00), the Government will pay to the Contractor for the fourth period of performance the sum of Seventeen Thousand, Three Hundred Seventy-nine Dollars ($17,379.00). Notwithstanding anything else in this contract, any balance remaining unexpended from the third period of performance shall be carried forward and considered as an unexpended balance for the fourth period of performance."

c. The following new "TITLE IV" will be added in Appendix "A":

"TITLE IV

"November 1, 1956 - October 31, 1957

"This Title IV describes the research program and cost estimates agreed upon between the Commission and the Contractor for the four period of performance.

"1. PROGRAM

"a. Scope and Plan of Approach:

"The Contractor shall continue the research program outlined in TITLE III.

"2. BUDGET

"a. Outline of Cost Estimates for the Fourth Period"

(1)	Salaries and Wages		$27,715.00
	Dr. W. C. Gregory (full time)	$ 8,175.00	
	Research Associates, Assistants, Technicians, etc.	19,540.00	
(2)	Supplies		1,500.00
(3)	Equipment		200.00
(4)	Rents		12,960.00
(5)	Communications, Transportation, Printing, etc.		900.00
(6)	Travel		2,000.00
(7)	Indirect Cost		14,658.00
		TOTAL	$59,933.00

"b. Items of property to be procured or manufactured by the Contractor during this period, title to which will vest in the Government (see Article V): None."

IN WITNESS WHEREOF, the parties hereto have executed this Supplemental Agreement the day and year first above written.

UNITED STATES OF AMERICA

BY: UNITED STATES ATOMIC ENERGY COMMISSION

BY : Herman M. Roth
Director
Research and Development Division

____
(Contracting Officer)

CONTRACTOR

BY: ______________________________

TITLE: ______________________________

WITNESSES:

____

____
(Address)

____

____
(Address)

ACCEPTANCE BY SENIOR INVESTIGATOR

I have read the foregoing Supplemental Agreement and agree to be bound by the provisions of this document.

____
Senior Investigator

AEC Contract AT - (40-1) - 1747

April 1, 1956

Statement of Contracted, Allocations, Allocations after Transfers,

Expenditures, Balances and Estimated Needs

North Carolina State College Contribution

Objects	Contract	Allocated	Allocations after Transfer	Expended 4-1-56	Balance 4-1-56	Needed 5-30-56
Salaries	14,334	14,334*	14,334	10,750	3,584	3,584
Wages	1,300	1,300	1,223	852	371	371
Travel and Communication						
Travel						
Communication			49	49		
Transportation						
Contractual			150	159		
Total						
Rents	(13,070**)					
Supplies	500	500	350	8	340	340
Equipment						
Printing			28	28		
Total	16,134	16,134	16,134	11,864	4,295	4,295

* This includes $1500 as an estimated share of Dr. W. E. Cooper's salary in the Department of Plant Pathology. The total shown on the Agronomy Department Books is therefore $12,834.

** The Land Rent shown in outline of costs for second period in the contract Supplement Appendix A in the amount of $13,070 is cost of operating Experimental field plots. This is incurred by the Test Farm Division, N. C. State Department of Agriculture and is not budgeted through the Department of Agronomy (Field Crops).

AEC Contract AT - (40-1) - 1747

April 1, 1956

Statement of Contracted, Allocations, Allocations after Transfers,

Expenditures, Balances and Estimated Needs

AEC Contribution

Objects	Contract	Allocated	Allocations after Transfer*	Expended 4-1-56	Balance 4-1-56	Needed 6-30-56
Salaries	12,981	11,700	11,700	8,775	2,925	2,925
Wages	2,963	2,867	2,867	2,497	370	370
Travel and Comm.						
Travel		2,000	2,000	1,360	640	640
Communication		100	75	42	33	33
Transportation		50	30	14	16	16
Contractual		860	1,645	1,170	466	466
	3,010					
Rents		110	135	135		
Supplies	2,000	2,000	1,235	1,007	230	230
Equipment	400	400	400	400		
Printing						
Total	21,354**	20,087**	20,087	15,400	4,680	4,680

* Transfers: Most of the transfers were occasioned by the unexpected demand for contract labor in the preparation of special planting facilities, plant benches, soil and sand, for the running of an auxillary control experiment on the effects of fast neutrons on peanut seeds. This experiment became necessary as a result of discussions concerning the efficiency ratio of rep/r in fast neutrons and X-rays.

** Unallocated $1,267.00 Administered by the Director's Office.

AEC Contract AT - (40-1) - 1747

April 1, 1956

Statement of Contracted, Allocations, Allocations after Transfers,

Expenditures, Balances and Estimated Needs

North Carolina State College Contribution and AEC Combined

Objects	Contract	Allocated	Allocations after Transfer	Expended 4-1-56	Balance 4-1-56	Needed 6-30-56
Salaries	27,315	26,034	26,034	19,525	6,509	6,509
Wages	4,263	4,167*	4,090	3,349	741	741
Travel and Communication						
Travel		2,000	2,000	1,360	640	640
Communication		100	124	91	33	33
Transportation		50	30	14	16	16
Contractual		860	1,795	1,329	466	466
Total	3,010	3,010				
Rents		110	135	135		
Supplies	2,500	2,500	1,585	1,015	570	570
Equipment	400	400	400	400		
Printing			28	28		
Total	37,488	36,221	36,221	27,246	8,975	8,975

* $110 Transferred to rents.

Contract AT - (40-1) 1747

Renewal Proposal

Period July 1, 1956 - October 31, 1956
November 1, 1956 - October 31, 1957

1. Title: I. The Comparative Effect of Irradiation upon Mutation Frequency, Total Genetic Variance and Progress from Selection in Different Genotypes of Peanuts and their Hybrids.

   II. The Genetic Characteristics of Radiation Injury Resistance in Peanuts.

2. Institution: The North Carolina State College, Department of Field Crops.

3. Scientific Background: Provided in the Original Proposal.

4. Scientific Scope of the Proposed Research: The general scope of the work proposed was provided in the original proposals of 1954 and 1955.

   (A) Scope of Work for the Next Contract Period:

   Title I: The growing season of 1956 is the critical year for this experiment, the preparation for which was begun in 1953. In 1955 a subsample of 5 F_1 5 F_1X_1, 5 P_1, 5 P_1X_1, 5 P_2 and 5 P_2X_1 plants each of 6 crosses was used to obtain estimates of phenotypic stability under conditions of radiation and no radiation treatment. Preliminary results indicate that radiation per se does not render peanuts subject to greater environmental fluctuations or larger experimental errors. Therefore, the tests for comparative genetical variability among hybrids vs inbreds under the action of radiation compared to that of their non-irradiated counterparts may be successfully made.

   The critical test to be made here is whether or not radiation treatment will effect a larger total genetic variance in hybrids through increased recombination from the effects of broken linkages, through increased mutation rate, or both. This can be done in the F_3 and F_3X_3 generations where the effects of F_2 segregation are shown in the differences in plant progeny means.

This will require a large population of progenies from as many crosses as testing facilities permit. For this purpose 10 plants from each of 5 F_1 and 5 F_1X_1 progenies from each of 14 of the 15 crosses available*, and 10 plants from each of 25 P_1, P_2, P_1 X_1, and P_2 X_1 progenies were selected at random for testing in 1956.

A minimum of 5 plant progenies from each of these sources will be compared in randomly arranged field trials in a minimum of 2 replications at 2 locations in 1956. The field design and the analysis of variance will be constructed in a manner to maximize the accuracy of the estimate of the total genetic variance. The number of mutant plants will be determined and the results correlated with the variance estimates.

The total number of experimental units in the experiments will be 8,400 and the minimum area of land required will be 10 acres.

Title II: Circumstances within the AEC installations prevented the comparison of X_1 and N_1 effects of X-rays and fast neutrons on peanuts during 1955. Therefore when the appropriate treatments were obtained, the seeds were placed at subfreezing temperatures and have remained there awaiting the 1956 season.

The following procedure for 1956 is abstracted from the procedure suggested for 1955. Two inbred lines of peanuts susceptible to the direct effects of X-rays and two lines resistant to the direct effects of X-rays and their F_2 populations were chosen for study. The F_2 thus represented the following combinations with respect to susceptibility to injury by X-rays: Susceptible by susceptible, susceptible by resistant, and resistant by resistant. Twenty plants for each of the two radiation treatments were selected from each line and each hybrid such that each had produced a total of 50 seeds. Each of these seeds in the hybrids is an F_2 plant so that when the observations are made they will show directly the F_2 segregation for resistance and/or susceptibility to primary injury by the two sources of radiation.

The following observations, all indices of primary effects of radiation on peanuts, will be made: (1) Percent germination, (2) Percent surviving, (3) Degree of radiation injury as represented by (a) X_1 injury score and (b) the number of days from planting to first flower.

* Six parental lines were used to make all possible (15) F_1 hybrids between the in 1953. One cross was lost through radiation injury.

The experiment will thus consist of three treatments:

(a) 15,000 r X-rays
(b) 5,490 rep fast neutrons
(c) Control

With 20 plants per genotype and 2 replications of 25 seeds each at one location the experiment will contain 1,200 plots.

5. Scientific Personnel:

Walton C. Gregory	Professor
John A. Yarbrough	Professor (Meredith College)
Joseph Peter Loesch	Instructor
Assistant to be appointed	Instructor
William Earl Cooper	Assistant Professor

6. Other Personnel:

J. M. Eason
Dahlia Rembert
Laboratory technician to be appointed (now Eunice Carpenter who is to retire)

7. Other Financial Assistance: None other than from North Carolina State College

8. Materials, Equipment and Facilities: All facilities necessary to the successful prosecution of the research are in existence at the present time, These include farms, greenhouses, laboratories and the specialized items of equipment such as planters, harvesters, calculators etc.

9. Travel: This item consists almost exclusively of the maintenance of field crews during May through November in the planting, the gathering of the data and the harvest of the seeds in the various experiments.

Schedule of Estimated Expenditures

July 1, 1956 - October 31, 1956

Department of Field Crops	NCSC	AEC	Total
Salaries	4,778	4.327	9,105
Wages	876	988	1,855
Travel and Communication			
Travel		1,360	1,360
Communication	16	24	40
Transportation		16	16
Contractual		285	285
Rents*	4,357		4,357
Supplies	120	420	540
Equipment			
Printing			
Total Direct Costs	10,138	7,420	17,558
Indirect Costs**	4,599	594	5,193
Total	14,737	8,014	22,751

* The cost of conducting field experiments on a per acre basis, includes land, farm labor, etc. and estimatedfor peanuts at about $500.00 per acre. Since an estimated return of $140.00 per acre may be expected from experimental peanuts the figure here is $360.00 per acre for 36 acres on a yearly basis.

** Estimated by the Business Office to be 45.36 percent of direct.costs. The AEC portion is derived 8 of the 45.36 percent and was calculated as follows: (7.420 x 45.36) - (7,420 x 37.36) = $594.00.

Schedule of Estimated Expenditures
November 1, 1956 - October 31, 1957

	NCSC	AEC	Total
Salaries			
Department of Field Crops			
Walton C. Gregory	8,175		8,175
Joseph Peter Loesch		3,200	3,200
Assistant to be appointed		3,200	3,200
J. M. Eason	900	2,900	3,800
Dahlia Rembert (3/4 time)	1,870	9,300	1,870
Assistant to be appointed	1,870		1,870
Department of Plant Pathology			
William Earl Cooper	1,500		1,500
Wages			
John A. Yarbrough (Summer)	1,300	2,800	4,100
Total Salaries and Wages	15,615	12,100	27,715
Rents*	12,960		12,960
Supplies	500	1,000	1,500
Contractual		700	700
Equipment	200		200
Travel, Communications etc.			
Travel		2,000	2,000
Communication		125	125
Transportation		30	30
Printing		45	45
Total Direct Costs	29,275	16,000	45,275
Indirect Costs**	13,279	1,379	14,658
Total	42,554	17,379	59,933

* The cost of conducting field experiments on a per acre basis, includes land, farm labor, etc and estimated for peanuts at about \$500.00 per acre. Since an estimated return of \$140.00 per acre may be expected from experimental peanuts the figure here is \$360.00 per acre for 36 acres on a yearly basis.

** Estimated as 45.36 percent direct costs. The AEC portion is derived as 8 of the 45.36 percent and was calculated as follows:
(16,000 x 45.36) - (16,000 x 37.36) = \$1379.00

Progress Report - Contract AT (40-1) - 1747

Period July 1, 1955 - March 30, 1956

1. Title: II. The Comparative Effect of Irradiation upon Mutation Frequency, Total Genetic Variance, and Progress from Selection in Different Genotypes of Peanuts and their Hybrids.

II. The Genetic Characteristics of Radiation Injury Resistance in Peanuts.

2. Scope of Investigation and Significant Results.

(A) Scope of Investigation 1955:

Objectives:

I (1) To obtain estimates of progeny to progeny variability in yield of the following classes of material: (a) Parent line plant progenies and (b) F_1 plant progenies (i. e. F_2 generation) of crosses and parent lines where both parents and crosses were compared unirradiated and irradiated with X-rays.

(2) To enumerate the mutant plants in plant progenies in the material referred to above.

II (1) To obtain comparative X-ray and fast neutron treatments for lines of peanuts and their F_1 progeny which showed apparent genetic differences in primary injury by X-rays.

Procedure:

I In 1954 each of six self-pollinating lines of peanuts and the 15 F_1 hybrids between them were irradiated with a dose of 15,000 r X-rays and planted with the same lots untreated. Individual plants of each of the irradiated stocks and a comparable number of untreated plants from the same genotypes were planted in 1955. The purpose of the progeny yield trials was twofold: (1) To establish the relative stability of hybrids vs inbred parents under normal as well as under conditions of irradiation treatment. (2) To obtain a measure of hybrid vigor in the F_2. For this work six hybrids and their parents were selected and arranged in a field design such as to make the progeny to progeny measurements comparable in all genotypes, irradiated and non-irradiated. The remaining plant progenies were planted in nursery rows where each plant was classified as to phenotype late in the season.

II The fast neutron treatments were difficult to obtain prior to planting season in 1955 and were finally arranged with the University of California research laboratory at Los Alamos. Two sets of treatments were made. (1) The parents and hybrids utilized in the X-ray work described above. (2) The "control" variety used in the initial study of irradiation effects in peanuts conducted under Contract AT (40-1) - 265. A single dose of 5,490 was provided for the parents and hybrids while 8 doses from 3,712 - 74,375 were obtained for the "control" variety.

(B) Significant Results Obtained:

I Progeny tests run in duplicate at each of two locations provided the essential information on the between-progenies mean squares. These mean squares are measures of stability of genotype under enviromental stress, since genetical differences between progenies were not expected within parents or within F_2 generation. The differences among progenies were significant for the irradiated hybrids. The non-irradiated hybrids, the irradiated parents and one set of non-irradiated parents showed no such significance. (See Table I A.). However in one set of non-irradiated parents the mean square for within progeny differences was significant. The study of these analyses is incomplete and the meaning of the behavior of this group of parents has not been evaluated. The variability of the progeny mean squares in the two trials is shown in Table I, B and C, where the estimated variance is given for each genotype and location separately.

Table I. Mean Squares for Progenies in Parents and F_2 Hybrids Irradiated (X) Non-irradiated (XO). Yield of Fruits.

(A) Combined Location Analysis - Progenies d.f = 4

Error	Treatment	P_1	P_2	$F_2^{(1)}$	$F_2^{(2)}$
d.f. = 63					
140,279	XO	103,592	496,643	137,080	99,790
"	X	173,439	181,874	483,814	843,465

Table I. Continued

Mean Squares for Progenies in Parents and F_2 Hybrids Irradiated (X) Non-irradiated (XO). Yield of Fruits.

(B) Location (1) Lewiston - Progenies d.f = 4

Error	Treatment		P_1		P_2		$F_2^{(1)}$		$F_2^{(2)}$
df = 32	XO	YT32	50,216	YT24	14,239	$F_2^{(1)}$	18,614	$F_2^{(2)}$	13,129
18,176	X	YT32	23,217	YT24	25,080	$F_2^{(1)}$	48,558	$F_2^{(2)}$	26,498
	XO	YT32	56,926	YT13	9,453	$F_2^{(1)}$	16,461	$F_2^{(2)}$	25,408
15,617	X	YT32	22,407	YT13	10,004	$F_2^{(1)}$	5,701	$F_2^{(2)}$	8,593
	XO	C12	35,698	YT24	6,866	$F_2^{(1)}$	9,770	$F_2^{(2)}$	31,247
16,036	X	C12	47,464	YT24	23,836	$F_2^{(1)}$	21,083	$F_2^{(2)}$	98,040
	XO	C12	21,274	YT13	6,181	$F_2^{(1)}$	33,271	$F_2^{(2)}$	5,584
14,750	X	C12	56,858	YT13	12,985	$F_2^{(1)}$	55,936	$F_2^{(2)}$	34,493
	XO	C12	21,388	YT32	61,722	$F_2^{(1)}$	25,125	$F_2^{(2)}$	12,558
19,318	X	C12	30,683	YT32	30,683	$F_2^{(1)}$	26,187	$F_2^{(2)}$	12,153
	XO	C12	18,424	A18	10,894	$F_2^{(1)}$	69,393	$F_2^{(2)}$	9,711
18,967	X	C12	12,394	A18	6,899	$F_2^{(1)}$	2,918	$F_2^{(2)}$	22,677

Table I. Continued

Mean Squares for Progenies in Parents and F_2 Hybrids Irradiated (X) Non-irradiated (XO). Yield of Fruits.

(C) Location (2) Rocky Mount - Progenies d.f = 4

Error	Treatment	P_1		P_2		$F_2^{(1)}$		$F_2^{(2)}$	
d.f = 32	XO	YT32	21,676	YT24	44,935	$F_2^{(1)}$	34,651	$F_2^{(2)}$	38,896
40,521	X	YT32	58,992	YT24	6,625	$F_2^{(1)}$	32,659	$F_2^{(2)}$	25,684
	XO	YT32	21,106	YT13	24,334	$F_2^{(1)}$	39,303	$F_2^{(2)}$	25,938
25,410	X	YT32	10,764	YT13	19,136	$F_2^{(1)}$	59,136	$F_2^{(2)}$	39,344
	XO	C12	4,959	YT24	41,026	$F_2^{(1)}$	16,626	$F_2^{(2)}$	61,200
31,244	X	C12	110,734	YT24	14,916	$F_2^{(1)}$	33,618	$F_2^{(2)}$	58,492
	XO	C12	16,690	YT13	27,209	$F_2^{(1)}$	618	$F_2^{(2)}$	23,936
27,151	X	C12	87,116	YT13	112,054	$F_2^{(1)}$	63,698	$F_2^{(2)}$	22,075
	XO	C12	28,317	YT32	39,377	$F_2^{(1)}$	20,953	$F_2^{(2)}$	19,149
29,574	X	C12	90,151	YT32	7,946	$F_2^{(1)}$	30,515	$F_2^{(2)}$	47,491
	XO	C12	56,090	A18	41,290	$F_2^{(1)}$	62,566	$F_2^{(2)}$	82,194
32,823	X	C12	67,908	A18	24,789	$F_2^{(1)}$	20,268	$F_2^{(2)}$	151,566

Despite the possibility, from the combined analysis, that the F_1 progenies were more susceptible to increased variability, under the action of X-rays, than their parents the distribution of the individual P_1, P_2, and F_1 progeny variances in the different crosses shown in Table I, B and C gives little support to this conclusion.

In addition, and as expected, the F_2 was highly significantly superior to the mean of the parents both in non-irradiated and in irradiated progenies. Also, as expected, the non-irradiated progenies were highly significantly superior to the irradiated. These facts are brought out in Table II. The interesting feature of Table II is the virtual absence of any interaction of radiation treatment and source of genotype as shown by the very low mean square obtained for (F_2 vs P)(XO vs X).

Table II. Mean Percent Increase in Grams of Dry Fruits of F_2 over the Mean of the Parents and of the Non-irradiated Progenies over the Irradiated.

Treatment	$P_1 + P_2$ Grams	$F_2^{(1)} + F_2^{(2)}$ Grams	% Difference
XO	356,251	383,628	7.68 %
X	316,383	342,063	8.12 %
% Diff.	12.60 %	12.15 %	

F_2 vs P Differences highly significant. Mean square 17,594,033

XO vs X Differences highly significant. Mean square 41,445,834

(F_2 vs P)(XO vs X) Non-significant 17,999

A comparison of interest in connection with the action of radiation in the production of superior genotypes lies in the relative amounts of heterosis exhibited in the hybrids of superior sister mutants of the same pure line variety. In the present study the superiority of the F_2 over the parents is a measure of heterosis. The parental lines used in this study were derived such that sister X_5 mutants occurred in hybrid combination with one another as well as with non-irradiated lines. Table III shows the yield in grams and percent superiority of F_2 over P_1 and P_2 in hybrids of mutants, hybrids of mutants and non-irradiated lines, and one hybrid of non-irradiated lines.

Table III. Yield in Grams and Percent Superiority of $F_2^{(1)} + F_2^{(2)}$ over $P_1 + P_2$

Type of Hybrid	No. of Hybrids	$P_1 + P_2$	$F_2^{(1)} + F_2^{(2)}$	Percent Difference
X_5 by X_5	2	25,812	28,112	8.9
X_5 by F_9	3	46,964	50,436	7.4
F_9 by F_9	1	16,285	17,357	6.6

It appears reasonably safe to assume that the enviromental stability of pure lines of peanuts and their hybrids is much the same and that strict comparisons in selection experiments may be made in irradiated and non-irradiated progenies of the same initial genotype.

Whether or not the genetical stability of hybrids is less than that of their parents under conditions of radiation cannot be answered from the experiments conducted in 1955. The relatively high mean squares for plant progeny differences in the F_2 X_2 compared to F_2 is counteracted to some extent by the erratic behavior of these mean squares for individual crosses within locations and by the fact that one set of non-irradiated parents showed a mean square of similar magnitude.

In the F_3 X_3 generation genetical differences between F_2 and F_2 X_2 individual plants can be measured. The results of such measurements should contribute strongly to answer the question concerning relative genetic stability of hybrids vs inbreds under irradiation.

The summaries of the X_2 mutations have not been completed. The classifications of the plants were made and the data recorded on I B M cards. When these are obtained, a further contribution can be made to the problem of genetic stability.

II Results on the fast neutron and X-ray treatment of different lines of peanuts and their hybrids will not be available until the end of the 1956 growing season.

List of Publications and Abstracts:

1. X-Ray Breeding of Peanuts (*Arachis hypogaea* L.) Agronomy Journal 47: 396 - 399. 1955.

2. The Comparative Effects of Radiation and Hybridization in Plant Breeding. Proceedings of the Geneva Conference.

AEC Contract AT - (40-1) - 1747

April 1, 1956

Statement of Contracted, Allocations, Allocations after Transfers, Expenditures, Balances and Estimated Needs

Objects	Contract	Allocated	Allocations after Transfer*	Expended 4-1-56	Balance 4-1-56	Needed 6-30-56
Salaries	12,981	11,700	11,700	8,775	2,925	2,925
Wages	2,963	2,867	2,867	2,497	370	370
Travel and Comm.						
Travel		2,000	2,000	1,360	640	640
Communication		100	75	42	33	33
Transportation		50	30	14	16	16
Contractual		860	1,645	1,170	466	466
	3,010					
Rents		110	135	135		
Supplies	2,000	2,000	1,235	1,007	230	230
Equipment	400	400	400	400		
Printing						
Total	21,354**	20,087**	20,087	15,400	4,680	4,680

* Transfers: Most of the transfers were occasioned by the unexpected demand for contract labor in the preparation of special planting facilities, plant benches, soil and sand, for the running of an auxillary control experiment on the effects of fast neutrons on peanut seeds, This experiment became necessary as a result of discussions concerning the efficiency ratio of rep/r in fast neutrons and X-rays.

** Unallocated $1,267.00 Administered by the Director's Office.

THE COMPARATIVE EFFECTS OF RADIATION AND HYBRIDIZATION IN PLANT BREEDING*

By

Walton C. Gregory - North Carolina State College

INTRODUCTION

The value of irradiation in the field of plant breeding depends upon the extent to which induced genetic variation either supplements or replaces the natural resources in genetic variability.

Gustafsson (1947), Shebeski and Lawrence (1953), Mac Key (1954), and Humphrey (1954) have demonstrated that certain useful mutations of special character may be of value to the breeder. Freisleben und Lein (1942), Konzak (1954), Frey (1954) and Cooper and Gregory (unpublished) have demonstrated that disease resistant mutant plants can be produced by irradiation. Gregory et al. (unpublished) have shown that a continuous spectrum of mutation expressed in numerous ways, exists in advanced generation populations of plants following irradiation with X-rays. Gregory (in press) has shown that samples of irradiated populations which included only the normal types of intra-varietal variation of a self-pollinating species showed highly significantly greater polygenic variation in yield of fruits than untreated controls. In this study progress from selection resulted in yields much exceeding the mean of the population. When sampling was restricted to plants of only "normal" character, progress from selection did not exceed the non-irradiated controls in yield comparisons. The genetic variance estimates were not made upon samples of irradiated plants which included the full range of phenotypic variation since many of the mutants did not lend themselves to such experiments. When mutant plants of extraordinary vegetative vigor were tested, lines significantly superior in yield to the non-irradiated controls were discovered.

The justification for "mutation breeding" has been made chiefly upon (a) the production of new mutations of economic value, such as for example, stiffness of straw in barley and (b) the creation of variation in highly adapted but uniform agricultural varieties. In the high latitudes and specialized conditions of Sweden where highly adapted varieties had already been produced the necessary conditions for the successful use of "mutation breeding" were recognized by Swedish plant breeders. It has been under these specialized environments that the most successful and voluminous mutation work has been done.

* Proceedings of the Geneva Conference on the peaceful uses of Atomic Energy.

The question arises as to whether the general problems of breeding under the much more general conditions of the warm temperate and tropical zones of the world will lend themselves readily to solution by mutation breeding.

Most of the world's agriculture and most of the world's crops do not meet highly specialized conditions. This is especially true for tropical and subtropical cross-fertilizing species. The value of ionizing radiations as a consistent part of established breeding procedure under these conditions or under any conditions where natural resources in genetic variability are great and therefore relatively unexploited depends almost wholly upon the following conditions:

(1) If new characteristics are desired but do not exist in natural populations.

(2) If variation in established characters will be increased by orders of magnitude sufficient to much increase the efficacy of selection beyond the levels expected in the naturally variable populations.

The first case always has a chance of success in that new changes do occur and in that breeders can visualize desirable characteristics which do not exist in their populations. The probability of success however is lowered by the fact that the types of changes desired cannot as yet be specified by the treatment and the chance of a random change being desirable is distinctly low.

In the latter case, that is, increased variation in established characters, and this includes all polygenically controlled variation, success will depend almost wholly upon the magnitude and upon the distribution of the variation induced. The relative magnitudes of quantitative genetic variability expected from hybridization among varieties and from mutations following radiation are at present unknown.

In order to evaluate the usefulness of atomic energy or of mutagenic agents generally, in the field of plant breeding the following elementary questions must be answered.

(1) Can new as well as useful mutations be produced with sufficient frequency to justify adoption of "mutation breeding" generally among crops?

(2) Do the relative magnitudes and distributions of quantitative variation induced by radiation and hybridization justify adding the radiation induced variability to the populations under selection?

(3) Will the additional variability induced by mutation add simply to that recovered by hybridization or will irradiation of the hybrids themselves produce greater or less variability than the sum of the variance of the irradiated parents and of the non-irradiated hybrids?

(4) Will the hybrids among induced non-useful mutations produce populations of complex variability and manifold usefulness to the breeder, or will simple monogenic distribution of the mutant forms only be recovered?

NEW USEFUL MUTATIONS

New and useful mutations have been produced by radiations in self-pollinating species of higher plants (Gustafsson (1947), Mac Key (1954) and in rapidly reproducing micro-organisms (Hollaender 1945; Hollaender et al. 1945). An instance of a useful induced mutation has been described in cross fertilizing white mustard by Andersson and Olsson (1954). In a discussion of the potential uses of mutagens in the "rationally directed" evolution of organisms Muller (1954) suggests that where inbreeding may be practiced in cross-pollinating species of plants the effects of radiation might be equaled and possibly surpassed by expoloiting the accumulated natural mutations which already have some chance of possessing adaptive value. He points out however that if an organism possesses a complex of desired characteristics which might be lost by outcrossing radiation might be usefully employed. This is especially true of certain inbred lines of corn which have failed to respond to outcrossing as a means of improving the line itself while retaining the combining properties with other lines for the production of known adapted hybrids which have been established at great cost. Disease resistant mutants, already established in normally self-pollinating species [Freisleben und Lein (1942), Konzak (1954), and Gregory and Cooper (unpublished)] should just as readily be established in cross-pollinating species where selection is carried out under epidemic conditions.

Where populations may be large and the radiation problem simple as in the case of cross-pollinating species the effectiveness of radiation in the development of improved varieties should almost equal that to be expected in normally self-pollinated organisms. Certainly experience has deviated sufficiently from the expected in the past in the field of mutation breeding to justify a more extended effort in the case of normally cross-pollinated species of economic plants.

HYBRIDIZATION VS. RADIATION

The true role of radiation in the field of plant breeding will not be felt by its specialized uses until its more general applicability in plant breeding procedure has been investigated. Success in selection for change in any character in any sexually reproducing organism is intimately associated with the genetic variance of the character and the intensity of selection. In general genetic variance, latent in individual members of a self-pollinating species, may be made most completely labile by hybridization. Once this is done the genetic variance may be estimated in F_2 and subsequent generations during the passage of which the variance rapidly becomes latent again by the laws of progression. Selection opportunity exists at all levels of this process but diminishes at the same rate as the variance is lost. Therefore any procedure which will significantly increase the genetic variance, or retard its return to latency will be of value to the breeder.

Comparable estimates of total genetic variance of polygenically controlled characters such as yield of fruits have been made in peanuts, (*Arachis hypogaea* L.) (Gregory, in press). When the same species, the same fields, similar means, similar experimental designs, and similar population sizes are used, comparable error variances in a quantitative measurement should be obtained.

Under such conditions estimates of genetic variance should also be comparable. By using such data it has been possible to make comparisons of the quantitative variation induced in peanuts by X-rays with that released from latency by hybridization. The error and treatment (variety) variances in yield of fruits (See table I) for four different classes of peanuts: (a) F_3 generation progenies of four different hybrids involving eight different parents; (b) "Normal" X_2 plant progenies (X_3) of X-irradiated plants of the uniform variety (c) Mutant X_3 plant progenies (X_4) from the same population as (b); (These mutants were of essentially normal appearance except for their excessive size and increased vegetative vigor.) (d) Individual plant progenies of a pure breeding uniform variety; (Peanuts are naturally self-pollinated.) were developed.

Table I The comparison of quantitative genetic variation of hybrids with that produced by X-rays in peanuts (*Arachis hypogaea* L.)

Code Letter	Source of Plants	Date	Plot size (feet)	Plot means grms.	Treatment Variances	Error Variances	Variance Ratios
(a)	F_3 hybrids A	1947	15'4"	850	112914	21561	5.24
"	" B	1947	"	931	159256	25901	6.15
"	" C	1947	"	790	113853	21041	5.41
"	" D	1947	15'4"	852	143076	19284	7.42
(b)	X_3 of uniform variety	1951	18'0"	747	57717	18909	3.05
(c)	X_4 of " "	1952	18'0"	1478	266265	43279	6.15
(d)	Uniform Variety	1951	18'0"	834	28493	20090	1.42

Except for class (c) the mean of which very much exceeded all other means, the error variances were essentially the same in all classes, and the treatment variances of the hybrids were twice as great as the treatment variance of the X_3 "normals".

There is little evidence in table I to demonstrate that the treatment variances given in the two classes of X-ray progenies arose from numerous small mutations of polygenic character since the variance measured was estimated from differences between individual X_2 and X_3 plants each of which traced back to a separate X_1 seed. That this variation was polygenic is suggested however by the very large assortment of visible mutant sibs of the tested normals in the X_2 and X_3 generations. In addition Gregory et al. (unpublished) have shown that the observable variation in each mutant of the population from which the normal and vigorous samples were drawn, formed a continuous spectrum of expression from the extreme mutant type to normal.

RADIATION OF THE HYBRIDS THEMSELVES

In order to compare the relative magnitude of and the character of the genetic variation in irradiated organisms with hybrid populations hybridizations among irradiated mutants themselves are required.

In 1953 an experiment was designed to make these estimates and at the same time to compare the sum of the variances of non-irradiated hybrids and their irradiated parents with the sum of the variances of the irradiated hybrids and their non-irradiated parents.

The expected relation of the above variables in advanced generations following hybridization and irradiation would be:

$$\sigma^2 g\ F_2X_2 = \sigma^2 g\ \frac{P1X_2 + \sigma^2 g\ P2X_2}{2} + \sigma^2 g\ F_2$$

Where $\sigma^2 g$ is the genetic variance of the character measured; F_2X_2 is a hybrid population in the F_2 generation treated with radiation in the F_1 generation; $P1X_2$ and $P2X_2$ are the parents of the hybrid in the second generation following irradiation. However there is no experimental evidence to contradict the hypothesis that the radiation treatments might destroy some of the latent variance in the F_1 generation thereby rendering

$$\sigma^2 g\ F_2X_2 < \sigma^2 g\ \frac{P1X_2 + \sigma^2 g\ P2X_2}{2} + \sigma^2 g\ F_2$$

Gustafsson (1954) presented evidence that hybrids are naturally more mutable than pure breeding lines. Assuming this to be so then the greater mutability of hybrids should be accentuated by the radiation of the F_1 generation and

$$\sigma^2 g\ F_2X_2 > \sigma^2 g\ \frac{P1X_2 + \sigma^2 g\ P2X_2}{2} + \sigma^2 g\ F_2$$

It is likewise probable that somatic recombinations and translocations produced in irradiated F_1 hybrid plants would give rise to a wider range of genetic recombinations in subsequent generations. Such additional variance as occurred from this source would be added to that produced by new gene mutations and would therefore be expected to swell the variances of the irradiated hybrids beyond that resulting from mutation alone.

AN EXPERIMENT IN RADIATION BREEDING

Three X-ray induced mutants in the X_5 generation selected because of their superior vigor and yield of fruits were chosen to measure the total genetic variance (yield of fruits) of their hybrids. Each of these mutants arose from a different X_1 plant and each differed distinctly from the other. One produced a remarkably tall vegetatively vigorous plant; one was a bright golden green color and the third was intermediate in vegetative vigor. Three superior varieties of widely different and of non-irradiated origins were likewise chosen for estimating the genetic variances arising among their hybrids.

These six lines were hybridized in all possible ways in 1953 to produce fifteen F_1 hybrids. A minimum of one hundred seeds of each cross were obtained. Fifty seeds of each cross and each parent were treated with 15000 r of hard X-rays. The remaining fifty seeds of each cross and parent were not irradiated. Each parent and hybrid, irradiated and non-irradiated was planted in single row plots in 1954. Represented then were the following classes of hybrids, both treated with X-rays and not treated:

1. X-ray mutant by X-ray mutant
2. X-ray mutant by non-irradiated variety
3. Non-irradiated variety by non-irradiated variety

Because of primary X-irradiation injury appropriate comparisons of the above three kinds of hybrids could not be made in the treated samples in the F_1X_1 generation. The untreated samples however could be used to estimate differences in heterotic yield response of hybrids in the different classes in the F_1 generation.

In these comparisons of the yields, evidence of heterosis would suggest genic differences in the parents even though the absence of heterosis would not suggest the lack of genic difference. Furthermore the more distantly related any two lines were the greater the heterotic expression should be. In order to see more clearly the order of relationship among the parent lines their pedigrees and origins are presented in table II.

Table II The pedigrees and origins of three X-ray mutants and three non-irradiated peanut varieties for the purpose of visualizing their degree of genetic relationship.

Symbol	Pedigree	1953 Generation
YT24	Single plant selection NC4[1]	X_5
X_4YT13	" " " "	X_5
X_4YT32	" " " "	X_5
A18	NC4 x Sp. 2B ("Spanish" Selection from S. C.)	F_9
B35	(Ga. variety x African) x (N.C. Whites Runner)	F_9
C12	A. hypogaea macrocarpa (Argentina) x N. C. Bunch	F_9

[1]Irradiated with 18,500 r in 1949.

From table II it can be seen that the three X-ray mutants should be the most closely related among themselves and to A18. The next most closely related line to this group of lines is B35 while the most distantly related line to all others is the subspecies cross C12. The average yield in grams of each parent and hybrid in the three classes of material are given in table III.

Table III Differences in yields in grams of seeds among F_1 hybrids and their parents of 3 different classes of hybrids arranged in order of presumed relationship.

Class of Hybrid	Order of Relationship	Lower Parent	Higher Parent	F_1 Hybrids	% Increase
X-ray mutant by X-ray mutant	1	53.9	54.5	58.5	7.9
		54.5	56.1	62.4	12.8
		53.9	56.1	69.3	26.0
X-ray mutant by non-irradiated variety	2	54.5	58.3	69.6	23.4
		53.9	58.3	72.3	28.9
		56.1	58.3	76.3	33.4
	3	54.5	55.0	83.1	51.9
		53.9	55.0	68.5	26.4
		55.0	56.1	72.4	30.4
	4	54.5	55.9	85.8	55.4
		53.9	55.9	89.5	63.0
		55.9	56.1	82.5	47.3
Non-irradiated variety by non-irradiated variety	--	55.0	58.3	85.0	50.2
		55.9	58.3	83.4	46.1
		55.0	55.9	90.0	62.5

ESTIMATING THE TOTAL GENETIC VARIANCE

In order to determine with certainty the relative magnitudes of quantitative variation in the various classes of hybrids discussed above, it will be necessary to study the results of plant progeny tests in the F_2X_2 and the F_3X_3 generations. When these tests are made in conjunction with similar tests of the F_2 and F_3, appropriate analyses of variance will disclose: (a) the comparative contribution of irradiation and hybridization to the total variance; (b) the latent variances of ordinary varieties and of X-ray mutants can be compared; and (c) the relative magnitude of the effects of radiation of the same dose can be shown for a hybrid and its two parents.

SUMMARY

The amounts of latent variation in hybrids of X-ray mutants, hybrids of varieties, and hybrids of X-ray mutants and varieties have been discussed and the expression of the F_1 generations compared. An experiment in re-irradiation of the X-ray mutants and their F_1 hybrids, and of the different varieties and their hybrids, and of hybrids between these has been presented. It has been shown how appropriate analyses of the variances of these parents and hybrids and their re-irradiated counterparts will provide information leading to a more rational interpretation of the part to be played by atomic energy in the future of plants through breeding.

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C-O-P-Y

AEC-Peanuts

United States
Atomic Energy Commission

Oak Ridge, Tennessee
May 12, 1955

Dr. W. C. Gregory
Department of Agronomy
North Carolina State College
Raleigh, North Carolina

Subject: CONTRACT NO. AT-(40-1)-1747

Dear Dr. Gregory:

We have received approval for preparation of a modification of Contract No. AT-(40-1)-1747 to extend the period to June 30, 1956. The Commission's contribution, however, was approved at a level not to exceed $20,000 in new funds instead of the $26,147 requested in the proposal. This $20,000 was approved for the continuation of the present work under the contract plus the addition of new work on "The Genetic Characteristics of Radiation Injury Resistance in Peanuts."

We shall appreciate your advising us whether or not North Carolina State College would be willing to accept the $20,000 contribution to the total cost of $73,715. If the College is not able to increase its support to permit you to conduct the research at the level indicated in your proposal, we shall appreciate receiving a revised budget indicating the reduced total cost keeping in mind that the $20,000 is for both of your projects. In computing the budget, you may consider the $20,000 over and above the $1,825 unexpended balance.

Your cooperation in submitting this information as soon as possible will be appreciated.

Very truly yours,

C. S. Shoup
Chief, Biology Branch
Research and Medicine Division

cc: J. G. Vann, North Carolina

Rounsaville:lr

North Carolina State College of Agriculture and Engineering
of the
University of North Carolina
Raleigh

SCHOOL OF
AGRICULTURE AND FORESTRY
RESEARCH EXTENSION
RESIDENT TEACHING

DEPARTMENT OF AGRONOMY

May 16, 1955

Dr. C. S. Shoup
Chief, Biology Branch
Research and Medicine
U.S. Atomic Energy Commission
Oak Ridge, Tennessee

Subject: CONTRACT NO. AT-(40-1)-1747 Reference to: GR:JER

Dear Dr. Shoup:

I am unhappy to report that the North Carolina State College budgets have already been firmed. Therefore, my only choice is to attempt to perform the research proposed with the reduction indicated in the enclosed revision of the proposed schedule of expenditures.

I have considered the consequences of the necessary reductions in effort from the standpoint of the reliability of our experiments. It is my considered opinion that with these reductions we will have certainly weakened our effort but will not have reached the threshold where it would be unwise to continue. Therefore, I propose that the contract be drawn according to the revision enclosed.

Sincerely yours,

Walton C. Gregory

WCG:plb

cc: Dr. Earl Green
Dr. E. T. York
Dr. P. H. Harvey
Dr. R. L. Lovvorn
Mr. J. G. Vann

2 Copies
of this letter please -

UNITED STATES
ATOMIC ENERGY COMMISSION

In Reply Refer To:
ADC:JN

Oak Ridge, Tennessee
June 17, 1954

North Carolina State College
Department of Agronomy
Raleigh, North Carolina

Attention: Dr. W. C. Gregory

Subject: CONTRACT NO. AT-(40-1)-1747

Gentlemen:

Your research project which was submitted to the Commission's Division of Biology and Medicine, Washington, D. C., has been approved by that office in the amount of $18,819.00 and has been forwarded to this office for preparation of an appropriate contract covering the Commission's support of your project.

Enclosed in triplicate, duly signed on behalf of the Commission, is a contract numbered as shown in the subject line above which incorporates in Appendix "A" a description of your project and the budget for the first period which you are to follow as a general guide.

It is requested that you sign each copy of the contract in the space provided for the Senior Investigator and have the copies signed by the proper official of the College, returning one signed copy to this office. The two remaining copies are for your retention.

It will be noted that the contract provides for payment in Article III of a lump sum in consideration of your performance of the research activities described in Appendix "A". The first payment, representing 45 per cent of the amount of the agreed compensation, will be paid to you upon your submission of a properly certified voucher on or before the first date established in Article II of the contract. Another 45 per cent of the agreed compensation will be paid to you within six months from the date of the first payment. The remaining 10 per cent of the agreed compensation will be paid to you upon receipt and acceptance of a satisfactory progress report or the final report as the case may be.

In order to assist you in preparing an appropriate voucher there is enclosed an instruction sheet containing numbered instructions corresponding with numbers appearing on a specimen copy of the voucher form. Vouchers should be submitted to the Office of Research & Medicine, Oak Ridge Operations Office, U. S. Atomic Energy Commission, Post Office Box E, Oak Ridge, Tennessee in one original (white) and four copies (yellow). It is assumed that you will give your business office the benefit of these instructions.

Your attention is called to the reporting requirements outlined in Appendix "C" to the contract, especially to Item No. 3 requiring the immediate submission of a 200 word summary statement describing the purpose and scope of your project.

For your information and guidance in purchasing isotopes through the Commission, in accordance with the provisions of Article VI, there is enclosed a copy of the latest Procurement Procedures for Radioisotopes together with a set of application forms, which you will use in making purchases of isotopes.

Your particular attention is invited to Appendix "B", Section 12 - Fellowships.

It is believed that the remaining portions of the contract are self explanatory, however, if you have any questions concerning the application or interpretation of any of the contract provisions I will be glad to furnish you with additional information.

Very truly yours,

R. G. Humphries

R. G. Humphries
Acting Director
Contract Division
Oak Ridge Operations

Enclosures:
Contract (in trip.)
Vouchers & Instr. Sheets
Procurement Procedures
for Radioisotopes

Nicholson:jm

Revised Summary of Proposed
Schedule of Expenditures
as of May 16, 1955

	N.C.S.C.	5-16-55 Revision of AEC CONTRACT AT(40-1)-1747	Use of Estimated Unexpended Balance ($1825)	Total
I DIRECT COSTS				
1. Salaries and Wages				
(a) Salaries	15,615	11,700	----	27,315
(b) Wages	1,300	2,220	743	4,263
Total Salaries and Wages	$16,915	$13,920	$743	$31,578
2. Supplies	500	1,718	282	2,500
3. Equipment	----	400	----	400
4. Communication, Travel, Contractual	----	2,370	640 (160)*	3,010
5. Land Rent	12,960	110	----	13,070
Total Direct Costs	$30,375	$18,518	$1,665	$50,558
II INDIRECT COSTS	17,193	1,482	----	18,675
Total Costs	$47,568	$20,000	$1,665	$69,233

* To Medical College of Virginia for X-radiation services May 5-6, 1955.