EFFECTS OF APPLICATION METHODS OF INOCULUM AND SEED FUNGICIDES ON STAND AND YIELD OF SPANISH PEANUTS

By

DOUGLAS EUGENE FREEMAN

Bachelor of Science

Oklahoma State University

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Thesis Approved:

Ralph S. Matlock
Thesis Adviser

James S. Kirby

Lester W. Reed

Robert D Morrison

D. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Inoculation of the seed with appropriate cultures of *Rhizobia* suited to the plant is unnecessary in many areas where legumes are grown regularly and soil conditions are favorable. However, in places where legumes of the desired inoculum group have not been grown before, or where soil conditions are unfavorable for the survival of these microorganisms, inoculation of legume seeds with a suitable *Rhizobium* species to insure an adequate nitrogen supply to the plant is necessary. Moreover, it is sometimes possible to introduce strains that are more effective than those naturally present in the soil.

Seed inoculation is a widely used method of applying the bacteria. Since inoculation of legumes is so widely practiced, it is desirable to know the best inoculant to use as well as the most efficient and economical method of application.

The effect of longevity of nitrogen fixing bacteria upon the legume seedcoats is an important practical problem. Often a grower inoculates seed and, because of rain or other reasons, cannot plant the seed at once. The question immediately arises, "How long can enough bacteria survive on these seeds to produce good inoculation of the plants?" Obviously, the time varies with climatic conditions, methods of applying the bacteria to the seeds, and the species of legume.

Treatment of peanut seed with a fungicide is a recommended practice for the prevention of seed rot and other seedling diseases that reduce stands.

The idea was conceived that if the bacteria were compatible with seed protectants and could survive on the seedcoats for a sufficient length of time, then the seed dealers could attend to the inoculation and treatment of seed when processing. This would save the grower time and result in a more uniform coating of the seed. Seed dealers generally sell legume cultures and seed fungicides. They should be able to do the work on a volume basis at considerably less expense.

These studies were conducted to examine the results of preplant application of inoculum and seed fungicides and application of fresh inoculum and fungicide separately and in combination.

CHAPTER II

LITERATURE REVIEW

The inoculation process consists of treating legume seeds with a suitable strain of nitrogen-fixing bacteria before the seeds are planted. When the young plant begins to grow, the bacteria invade the root hairs and multiply in large numbers. Growths called nodules then begin to form on the roots. The bacteria live in these nodules and through a symbiotic process known as nitrogen fixation, enable the plant to convert atmospheric nitrogen into amino types of compounds of use to the plant (10).

Fred, Whiting, and Hastings (16) relate the nitrogen fixing process to the amounts of carbohydrates produced by the host plant. The greater the amount of carbohydrate in relation to the amino acids that are produced, the larger the amounts of nitrogen that will be fixed.

Erdman (11) published a complete cross inoculation grouping for legumes common in the United States. Allen and Baldwin (3) made a complete study of strains within several groups. They reported that there was a marked difference between strains in their ability to fix nitrogen. There was a change in the amount of nitrogen fixed by pure strains after successive passage through plant generations.

Helz, Baldwin, and Fred (19) found that some strains of Rhizobium produced nodules, but did not increase the nitrogen content of the plant. Large nodules on the upper roots or taproots of the plant were beneficial to the host. Nodules produced by bacterial cultures not so beneficial were usually scattered over the lateral roots.

In pot cultures and plot experiments it was shown by Newton and Wyatt (25) that more effective strains of legume bacteria than those already present in the soil can be isolated.

Roberts and Olson (26) reported that certain strains of peanut _Rhizobia_ were adapted better than others to fix nitrogen in poorly nourished plants, while among well nourished plants these strains were less marked in their effect.

Fred, Baldwin, and McCoy (15) discussed the findings of numerous workers with respect to the factors affecting growth and survival of _Rhizobia_. In general, these are aerobic organisms, non-spore formers, with elemental requirements similar to those of other living organisms. Their growth was inhibited by antagonistic substances produced by numerous other microorganisms. However, it is significant that various bacterial agents that have been found in the soil have much less effect on the _Rhizobia_.

Walker and Brown (30) have shown that the conditions of the soil with reference to organic matter, lime, and phosphate, have a much larger influence on the number of nitrogen fixing organisms in the soil than the frequency of growth of the host plant.

Thornton (28) found that the survival of _Rhizobium_ organisms in a Florida soil depended upon the availability of calcium, phosphate, and potassium, and upon aeration, moisture, and pH.

Wilson (32) observed that the most suitable strain of legume bacteria may not come in contact with legume root hairs when the population is low in the soil. When the available carbohydrate content of the plant was curtailed, nodules suffered and disappeared. Giobel (17) showed that nitrogen fixation was best in plants well-supplied with nitrate and ammonia nitrogen during the early stages of growth.

Walker and Brown (30) stated that recommendations for soil or seed inoculation should be based not only upon a knowledge of the cropping system to which the soil has been subjected, but also upon a knowledge of the soil management practices that have been followed.

According to Albrecht (1) some benefit due to inoculation of Spanish peanut seed on unfertilized plots was obtained since inoculated plots outyielded the uninoculated plots. Furthermore, the application of fertilizer in the absence of inoculation led to increased hay production. The highest yields were harvested, however, from plots on which both fertilizer and inoculation were used. Nodulation of plants growing on plots fertilized and inoculated was considerably more abundant than in the case of plants from plots inoculated but unfertilized. Duggar (9) showed that the mean number of nodules on Spanish peanuts was found under most conditions to be significantly and positively related to the mean yield of peanuts per plant. The artificial inoculation of peanuts resulted in large increases in the numbers of both total and large nodules and in mean increases of approximately 30 per cent in yield of nuts per plant (9).

Investigations have shown that desiccation of inoculated crimson clover seed in a dry soil is detrimental to the Rhizobium organisms (8). Burton (8) observed that effective strains of red clover nodule bacteria stored in sterile soils for several months undergo desiccation into less efficient strains. Alexander and Chamblee (4) showed that exposure of inoculated seed to sunlight resulted in less effective inoculation.

Alexander and Chamblee (4) stated that in many instances stand failure and poor legume vigor are known to be the result of inadequate inoculation even where standard inoculation procedures are followed. Fellers (13) studied the viability of soybean and alfalfa organisms on seed. Most of the organisms died during the first 24 hours, but a few persisted 6 to 9 months. Albrecht (2) showed that dry inoculated alfalfa seed stored 10 days before being planted gave nodule production no greater than uninoculated seed. From preliminary tests, Albrecht (2) concluded that the use of dry inoculants and preplant application of dry inoculants provides ease of manipulation at the cost of efficiency in nodule production.

Means and Erdman (22) showed that after 7 years of storage under oil, 190 out of 620 strains were viable but they varied markedly by cross-inoculation groups in survival and nitrogen fixing ability. The effectiveness of preservation of cultures under paraffin oil has been shown by several investigators. Gordon and Smith (18) tested strains from 43 genera, including Rhizobium, and found the method satisfactory during a 6-month period for all but 8 genera studied. Hartsell (20) tested 456 strains representing 25 genera. Their survival time ranged from 1 month for 3 genera of Mycobacterium to 11 years for Escherichia coli. Unfortunately, no Rhizobia were included in this study. Fellers (13) made a comparative study of agar, liquid, and soil and muck cultures, using plate counts as a test of nodulation. This study showed clearly the superiority of humus cultures.

Poor stands of peanuts may be caused by one of several conditions. Seed rot, however, is one of the most common causes of poor stands (31). Much of the seed rot can be prevented by treating seed with the proper chemical disinfectant. According to Wilson (31), seed treatment serves two purposes. The disinfectant kills the organisms present on the seed surface that cause seed rotting and seedling disease. It also protects the seed against similar organisms that are present in the soil. This latter protection is especially important on machine-shelled seed because seedcoats are broken frequently by the machine. Unless the seed are covered by a disinfectant, broken testae provide ideal places for entrance of seed rotting organisms. This protection during germination gives the young seedling a better chance to become established before disease organisms attack and produce stem and root rot.

In tests conducted by Albrecht (1), several seed disinfectants were tested for their influence upon Spanish peanut production. Arasan proved to be the most effective. Yields of Spergon treated, inoculated plots indicated that this product was not injurious to inoculation. All seed disinfectants tested exerted a protective influence upon stands, but legume inoculation used alone gave a similar protective influence. There is considerable lack of agreement as to the ability of the Rhizobia to tolerate seed protectants when both are applied to the same seed. Results of some workers (5, 6, 23, 29) show that nodulation was not affected as a result of treating the seed with Arasan, Phygon, or Spergon. Other data (21, 24) show that the Rhizobium species were killed by these same chemicals.

Recent work on humus cultures has been concerned largely with the behavior of the bacteria in the presence of chemical seed treatments and with the value of mixed cultures containing two or more *Rhizobium* species. Erdman (12) found Spergon to be the only chemical which was not definitely fatal to the bacteria.

Baur (7) obtained better results by bulking the culture with large amounts of soil, muck, or similar material and sowing it in the drill row through the fertilizer attachment of a drill containing the chemically treated seed. According to Albrecht (1), tests using machine shelled peanuts showed that inoculation of Spergon treated seed produced approximately 14 per cent better stands than uninoculated seed treated with Spergon. Compatibility studies by Ruhloff and Burton (27) using *Rhizobia* with various seed chemicals showed it was necessary to consider each species separately as not all *Rhizobium* species were affected equally.

CHAPTER III

MATERIALS AND METHODS

Fort Cobb and Perkins Field Experiments I and II

The peanut seed used in Experiment I of this study were supplied by the Kalo Inoculum Company. The treatments used are listed in Table I. These treatments were applied to the seed by the Kalo Inoculum Company.

Seed of certified Starr used in Experiment II were obtained from Oklahoma Foundation Seed, Inc. The treatments listed in Table I were applied immediately prior to planting. The inoculum and fungicide were combined on the seed to ensure good distribution.

Experiments I and II were conducted at the Agronomy Research Station near Perkins, Oklahoma, and at the Caddo Peanut Research Station near Fort Cobb, Oklahoma.

The soil type in the plot area near Perkins was a Norge loam. The soil type in the plot area near Fort Cobb was a Cobb fine sandy loam. Peanuts were not grown on the plots near Perkins the previous year.

Two hundred pounds per acre of 12-29-0 fertilizer was broadcast and worked into the soil prior to seeding at the Perkins Station. At the Fort Cobb Station 200 pounds per acre of 8-32-16 fertilizer was applied prior to planting.

TABLE I

VARIETY, INOCULUM, AND FUNGICIDE TREATMENTS USED IN EXPERIMENTS ON THE AGRONOMY RESEARCH STATION NEAR PERKINS AND THE CADDO PEANUT RESEARCH STATION NEAR FORT COBB

EXPERIMENT I		
Variety	Treatment	Code
Starr	Bacteria + Oil	B + O
Starr	Bacteria + Thiram + Oil	T + B + O
Starr	Thiram + Oil	T + O
Starr	Oil	O
Starr	Check	CK
Argentine	Bacteria + Oil	B + O
Argentine	Bacteria + Thiram + Oil	B + T + O
Argentine	Thiram + Oil	T + O
Argentine	Oil	O
Argentine	Check	CK
Spantex	Bacteria + Oil	B + O
Spantex	Bacteria + Thiram + Oil	B + T + O
Spantex	Thiram + Oil	T + O
Spantex	Oil	O
Spantex	Check	CK

EXPERIMENT II		
Variety	Treatment	Code
Starr	Nitragin + Untreated	N + U
Starr	Nitragin + Thiram	N + T
Starr	Nitragin + Botran-Captan	N + BC
Starr	Kalo + Untreated	K + U
Starr	Kalo + Thiram	K + T

A randomized complete block design with three replications was used at both locations. Plantings were made at the rate of 5 seed per foot of row and 1 1/2 inches to 2 inches deep. The row spacings were 40 inches for tests near Perkins and 36 inches for the test near Fort Cobb. The plots in both tests consisted of 2 rows 20 feet long. The alleys between the ranges were 4 feet wide. Notes recorded during the growing season included emergence, vigor, and nodulation.

Sixteen feet of the 2 row plots were harvested using a mechanical peanut digger. Soil was shaken from the plants by hand, and the peanuts were then allowed to cure in the field. The plants from each plot were threshed with a stationary thresher modified for nursery work. After curing at ambient temperatures the peanuts were cleaned and weighed. The fruit yield per plot was then converted to pounds per acre of clean peanuts.

Emergence counts were determined by actual counts 2 to 3 weeks after planting. Plant vigor was scored at approximately 5 weeks. Vigor scores were rated as 1 - excellent, 2 - good, 3 - fair, 4 - poor, and 5 - dying. Nodulation ratings were made on the tests near Perkins by taking 10 plants at random from each plot after the plots had been dug. They were scored from 1 to 5 according to the amount of nodules with 1 - excellent, 2 - good, 3 - fair, 4 - moderate, and 5 - poor as shown in Figure 1. No nodulation ratings were made on the test near Fort Cobb.

The percentage of nitrogen was determined on forage samples from the tests near Perkins by use of the Micro Kjeldahl procedure.

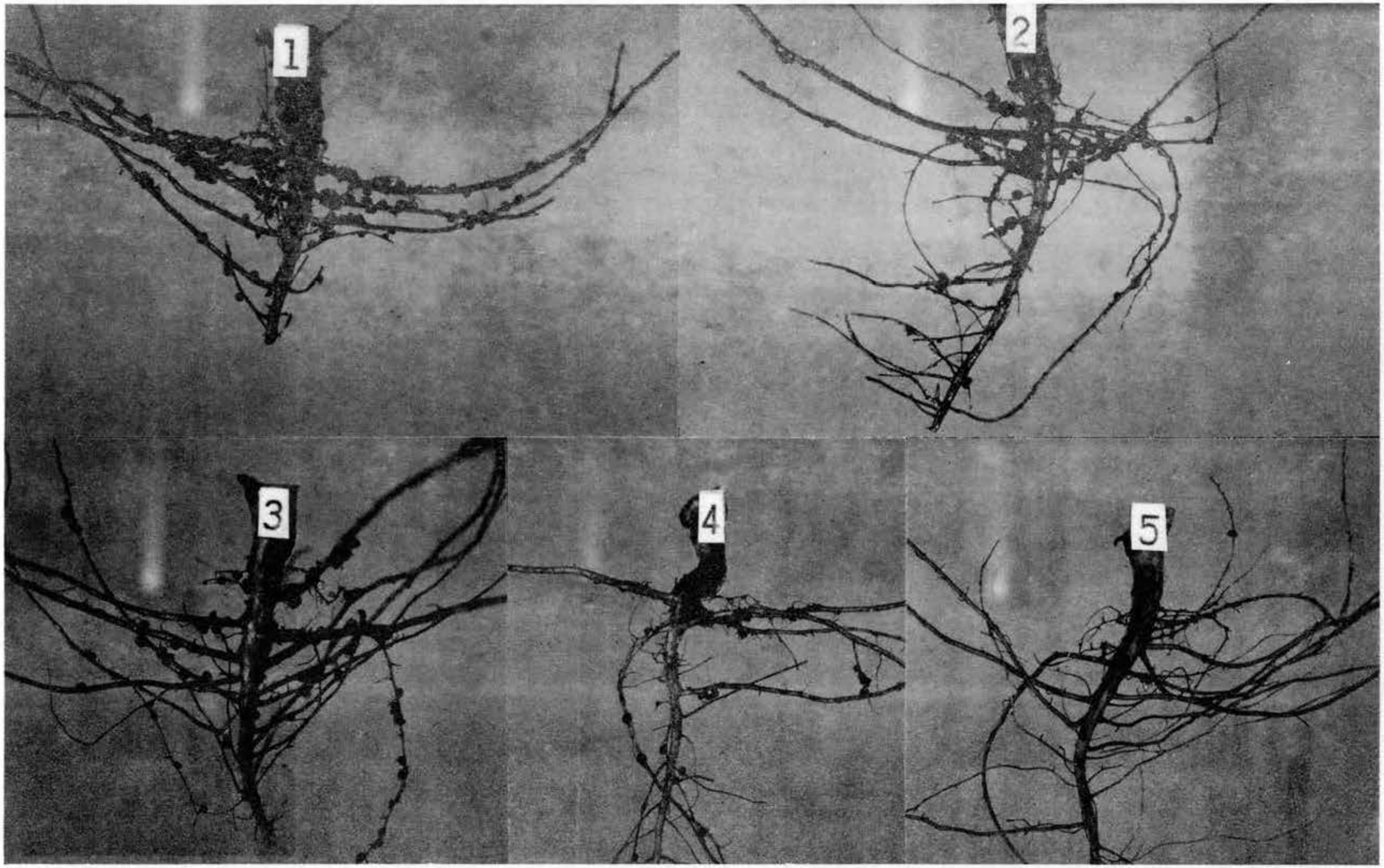

Figure 1. Visual Nodulation Rating Scale Used.

Greenhouse Experiment III

Experiment III was conducted in the greenhouse at Oklahoma State University, Stillwater. The treatments for the greenhouse experiment were the same as the ones used in field Experiment I (Table I).

Six-inch pots were filled with Cobb sandy loam soil from the Caddo Peanut Research Station. Two pots were filled for each of the treatments. One pot of soil for each treatment was placed in a steam autoclave and sterilized at approximately 10 pounds pressure for 2 hours. The other pot of soil was not sterilized. The pots were then transferred to the greenhouse where 5 seed were planted in the soil of each pot.

The plants were thinned to 1 plant per pot after 2 weeks. A completely randomized split-plot design was used in the greenhouse experiment. The 5 inoculum treatments were replicated 3 times by using Starr, Argentine, and Spantex varieties as replications I, II, and III, respectively.

The plants were harvested and separated into various parts, old leaves, new leaves, other mature plant parts (stems, leaves), roots, and fruit. The oven dry weights of each of these parts were recorded.

Levels of calcium, magnesium, potassium, and iron were determined for the plant parts by digesting weighed samples in a 3:1 nitric perchloric acid mixture and the digestates were analyzed by atomic absorption spectroscopy.

The analyses of variance for the data in Experiments I, II, and III were calculated on the IBM computer at the Oklahoma State University Computer Center. The coefficients of variation and the least significant differences were determined using a desk calculator.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of these experiments was to determine the effects of application methods of inoculum and seed fungicides on percentage of emergence and yield of Spanish peanuts. Results were obtained from four field experiments and one greenhouse experiment.

Perkins Field Experiment I

The mean percentages of emergence and detailed analysis of variance (A.O.V.) for peanuts receiving the various treatments in Experiment I at Perkins are summarized in Table II. All means were based on 3 replications of 2-row plots 16 feet long.

In Experiment I at Perkins, the lowest emergence (36 per cent) was obtained from the oil alone treatment. The highest emergence (47 per cent) was obtained from the untreated check. The analysis of variance indicated a significant difference among treatments at the 5 per cent level of probability. The other treatments were not significantly different from the untreated check. The Spantex variety had 6 to 8 per cent higher emergence than Starr and Argentine (Table II).

There was no significant increase in the vigor score due to treatments when compared to the untreated check. However, treatment bacteria + oil (B + O) and oil showed showed a trend for reduced vigor in comparison to the other treatments (Table III).

TABLE II

MEAN PERCENTAGES OF EMERGENCE FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, PERKINS, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	53	37	41	44
T + B + O	40	47	46	44
T + O	43	42	52	46
O	30	34	44	36
Untreated	41	43	56	47
Mean	42	40	48	43

MEAN SQUARE FOR PERCENTAGE EMERGENCE, EXPERIMENT I, PERKINS, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	27.36
Var	2	233.59**
Treat	4	160.69**
VarXTreat	8	162.57**
Error	28	37.37

** Indicates significance at the 1 per cent level of significance.

C.V. = 14.21 per cent

Treatment L.S.D. .05 = 10.3; .01 = 13.8

TABLE III

MEAN VIGOR SCORES FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, PERKINS, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	2.00	2.00	2.00	2.00
T + B + O	1.33	1.33	1.00	1.22
T + O	2.00	1.00	1.33	1.44
Oil	2.00	2.00	2.00	2.00
Untreated	1.67	1.33	1.00	1.33
Mean	1.80	1.53	1.47	1.60

MEAN SQUARE FOR VIGOR SCORES, EXPERIMENT I, PERKINS, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	0.20
Var	2	0.47*
Treat	4	1.26**
VarXTreat	8	0.14
Error	28	0.10

* Indicates significance at the 5 per cent level of significance.

** Indicates significance at the 1 per cent level of significance.

C.V. = 19.76 per cent

Treatment L.S.D. .05 = 0.5288; .01 = 0.7134

Nitrogen determinations for the plant parts are summarized in Table IV. There were no significant differences for percentages of nitrogen.

TABLE IV

MEAN PERCENTAGES OF NITROGEN IN PLANT PARTS FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATION FOR EXPERIMENT I, PERKINS, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	2.07	1.70	1.58	1.78
T + B + O	1.44	1.79	2.02	1.75
T + O	1.58	1.81	1.05	1.48
O	1.49	1.87	1.45	1.60
Untreated	1.76	1.76	1.35	1.62
Mean	1.67	1.79	1.49	1.65

MEAN SQUARE FOR PERCENTAGE OF NITROGEN IN PLANT PARTS, EXPERIMENT I, PERKINS, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	0.12 N.S.
Var	2	0.33 N.S.
Treat	4	0.13 N.S.
VarXTreat	8	0.23 N.S.
Error	28	0.12

N.S. = No statistical difference at the 5 per cent level of significance.

C.V. = 20.99 per cent

The results of nodulation ratings are summarized in Table V. There were no significant differences in the nodulation ratings among the various treatments.

TABLE V

MEAN NODULATION SCORES FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, PERKINS, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	4.20	3.60	3.97	3.92
T + B + O	4.00	4.23	3.80	4.01
T + O	4.23	3.97	4.07	4.09
O	3.63	4.00	3.80	3.81
Untreated	4.36	4.23	4.13	4.24
Mean	4.09	4.01	3.95	4.00

MEAN SQUARE FOR NODULATION SCORES, EXPERIMENT I, PERKINS, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	0.34 N.S.
Var	2	0.36 N.S.
Treat	4	0.24 N.S.
VarXTreat	8	0.06 N.S.
Error	28	0.10

N.S. = No statistical differences at the 5 per cent level of significance.

C.V. = 7.90 per cent

Peanut yields obtained from Experiment I near Perkins are summarized in Table VI. A reliable analysis of these yields was not possible due to damage of some plots between the time of digging and picking. The extent of the damage is shown in Table VII. Plots delayed in harvest due to rain showed a marked reduction in yield compared with those harvested before the rain. The large variance for replications was an indication of its effect.

TABLE VI

MEAN POUNDS PER ACRE OF CLEAN AIR-DRIED PEANUTS FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, PERKINS, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	1499	1240	1131	1290
T + B + O	1458	1512	1281	1417
T + O	1158	1022	1145	1108
O	1281	1635	1226	1381
Untreated	1485	1254	1240	1326
Mean	1376	1333	1204	1304

MEAN SQUARE FOR POUNDS PER ACRE OF CLEAN AIR-DRIED PEANUTS, EXPERIMENT I, PERKINS, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	7330**
Var	2	119464
Treat	4	129819*
VarXTreat	8	63340
Error	28	38749

* Indicates significance at the 5 per cent level of significance.
** Indicates significance at the 1 per cent level of significance.
C.V. = 15.09 per cent   Treatment L.S.D. .05 = 329; .01 = 444

TABLE VII

YIELD IN POUNDS PER ACRE OF CLEAN AIR-DRIED PEANUTS FOR THREE VARIETIES AND FIVE INOCULUM AND SEED FUNGICIDE COMBINATIONS FOR EXPERIMENT I, PERKINS, 1968

Seed Treatment		Variety: Starr	Argentine	Spantex	Total Plots Number Damaged	Treat. Mean
B + O	I	1308.11	1021.96*	940.20*		
	II	1389.87	1062.84*	1185.47*		
	III	1798.65	1635.14	1267.23		
	$\bar{x}$	1498.87	1239.98	1130.96	4	1289.94
T + B + O	I	1021.96*	1348.99*	940.20*		
	II	1716.89	1716.89	1021.96*		
	III	1635.14	1471.62	1880.41		
	$\bar{x}$	1457.99	1512.50	1280.85	4	1417.11
T + O	I	1021.96*	1103.72*	1103.72*		
	II	1021.96*	817.57*	981.08*		
	III	1430.74	1144.60	1348.99		
	$\bar{x}$	1158.22	1021.96	1144.59	6	1108.26
Oil	I	1226.35*	1430.74	1185.47*		
	II	1021.96*	1512.50	899.32*		
	III	1594.26	1962.16	1594.26		
	$\bar{x}$	1280.85	1635.13	1226.35	4	1380.74
Untreated	I	1226.35*	858.45*	1226.35*		
	II	1635.14	1308.11	1144.60*		
	III	1594.26	1594.26	1348.99		
	$\bar{x}$	1485.25	1253.60	1239.98	4	1326.28
Total No. Plots Damaged		6	6	10		
Variety Mean		1376.24	1332.63	1204.55		

* Harvested after rain and crow damage.

Fort Cobb Field Experiment I

Results of Experiment I at Fort Cobb showed that the lowest mean emergence (36 per cent) was obtained from the oil alone treatment. The highest emergence (52 per cent) was obtained from the untreated check. The analysis of variance indicated a significant difference among treatments at the 5 per cent level of probability. The bacteria + oil (B + O) treatment (40 per cent) closely approached significance at the 5 per cent level. Treatments Thiram + bacteria + oil (T + B + O) and Thiram + oil (T + O) were not significantly different from the untreated check. The Spantex variety showed the highest mean percentage emergence of the three varieties. The emergence percentages are summarized in Table VIII.

No vigor scores for the treatments were significantly better than the untreated check. However, treatments of bacteria + oil (B + O) and oil alone showed a significant reduction in vigor when compared to the untreated check. Vigor scores with the analysis of variance are summarized in Table IX. The mean fruit yield at Fort Cobb ranged from 3731 (oil treatment) to 4376 pounds per acre (untreated check). The yields with the analysis of variance are summarized in Table X.

Perkins Field Experiment II

The percentage of emergence for Experiment II at Perkins is summarized in Table XI. The plots receiving inoculum only as a treatment resulted in a significantly lower percentage emergence than the plots receiving inoculum + seed fungicides. Plots receiving inoculum + Thiram (N + T) showed significantly better vigor than the plots receiving inoculum only (N + U and K + U) or inoculum + Botran-Captan

TABEL VIII

MEAN PERCENTAGE EMERGENCE FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, FORT COBB, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	53	37	40	40
T + B + O	45	45	58	49
T + O	49	46	52	49
O	35	28	46	36
Untreated	47	55	54	52
Mean	46	42	50	46

MEAN SQUARE FOR PERCENTAGE EMERGENCE, EXPERIMENT I, FORT COBB, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	24.9
Var	2	228.6*
Treat	4	352.5**
VarXTreat	8	130.7*
Error	28	53.6

* Indicates significance at the 5 per cent level of significance.

** Indicates significance at the 1 per cent level of significance.

C.V. = 15.93 per cent

Treatment L.S.D. .05 = 12.25; .01 = 16.52

TABLE IX

MEAN VIGOR SCORES FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, FORT COBB, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	2.00	2.00	2.00	2.00
T + B + O	1.33	1.33	1.00	1.22
T + O	2.00	1.00	1.33	1.44
O	2.00	2.33	2.00	2.11
Untreated	1.67	1.33	1.00	1.33
Mean	1.80	1.60	1.45	1.62

MEAN SQUARES FOR VIGOR SCORES, EXPERIMENT I, FORT COBB, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	0.16
Var	2	0.42
Treat	4	1.48**
VarXTreat	8	0.23
Error	28	0.13

** Indicates significance at the 1 per cent level of significance.

C.V. = 22.23 per cent

Treatment L.S.D. .05 = 0.603; .01 = 0.813

TABLE X

MEAN POUNDS PER ACRE OF CLEAN AIR-DRIED PEANUTS FOR THREE VARIETIES AND FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR EXPERIMENT I, FORT COBB, 1968

	Variety			
Seed Treatment	Starr	Argentine	Spantex	Mean
B + O	3472	4038	3720	3743
T + B + O	4646	3763	4235	4214
T + O	4946	3887	4219	4350
O	4310	3176	3705	3730
Untreated	4507	4446	4174	4376
Mean	4376	3862	4011	4083

MEAN SQUARE FOR POUNDS PER ACRE OF CLEAN AIR-DRIED PEANUTS, EXPERIMENT I, FORT COBB, 1968

Source	d.f.	M.S.
Total	44	
Rep	2	2301835**
Var	2	1050308*
Treat	4	931804**
VarXTreat	8	429324
Error	28	206310

* Indicates significance at the 5 per cent level of significance.

** Indicates significance at the 1 per cent level of significance.

C.V. = 11.12 per cent

Treatment L.S.D. .05 = 759; .01 = 1024

(N + BC). These results are summarized in Table XI.

TABLE XI

MEANS FOR FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR PERCENTAGE EMERGENCE, SEEDLING VIGOR, PLANT NITROGEN, NODULATION SCORE, AND YIELD OF CLEAN AIR-DRIED PEANUTS PER ACRE FOR EXPERIMENT II, PERKINS, 1968

Seed Treatment		Emergence %	Seedling Vigor Score	Plant Nitrogen %	Nodulation Score	Yield lbs/acre
N + U		29	2.0	1.84	2.97	1199
N + T		53	1.0	1.77	3.03	1144
N + BC		45	1.7	1.85	2.20	1607
K + U		39	1.7	1.77	2.37	1539
K + T		51	1.0	1.67	3.40	1458
Mean		43	1.5	1.78	2.80	1389
C.V. %		10.6	38.73	7.9	24.9	23.0
L.S.D.	.05	8.6	0.729	N.S.	N.S.	N.S.
L.S.D.	.01	12.5	1.790	N.S.	N.S.	N.S.

MEAN SQUARE FOR PERCENTAGE EMERGENCE, SEEDLING VIGOR, PLANT NITROGEN, NODULATION SCORE, AND YIELD OF CLEAN AIR-DRIED PEANUTS PER ACRE, EXPERIMENT II, PERKINS, 1968

Source	d.f.	Emergence %	Seedling Vigor	Plant Nitrogen	Nodulation Score	Yield obs/acre
Total	14					
Rep	2	175.2*	0.07	0.058	2.0200	240965
Treat	4	288.0**	0.60*	0.015	0.7425	128411
Error	8	20.9	0.15	0.020	0.5550	102825

* Indicates significance at the 5 per cent level of significance.
** Indicates significance at the 1 per cent level of significance.

Chemical determinations were made on the vegetative parts for percentage of nitrogen. These results are summarized in Table XI. There were no significant differences in the percentage of nitrogen among the different treatments.

Nodulation ratings were made on the plots in Experiment II using the same procedure as used for Experiment I. These results are summarized in Table XI. The analysis of variance showed no significant difference for nodulation among the treatments in Experiment II. It was noted that all of the plots in Experiment II had more nodulation than the plots in Experiment I. Results of nodulation ratings in Experiment II showed that plots receiving inoculum but no seed fungicide and inoculum + Botran-Captan had slightly better nodulation than plots receiving inoculum + Thiram.

Fort Cobb Field Experiment II

The emergence percentages for Experiment II at Fort Cobb are summarized in Table XII. Plots receiving inoculum only as a treatment resulted in significantly lower percentage germination than the plots receiving inoculum + a seed fungicide.

Plots receiving inoculum + Thiram (N + T and K + T) showed significantly more desirable vigor than plots receiving inoculum only or inoculum + Botran-Captan (N + BC). These results are summarized in Table XII.

Mean yield of peanuts for Experiment II at Fort Cobb in 1968 are summarized in Table XII. There were no significant differences for yield among the treatment combinations.

TABLE XII

MEANS FOR FIVE INOCULUM AND FUNGICIDE COMBINATIONS FOR PERCENTAGE EMERGENCE, SEEDLING VIGOR, AND YIELD OF CLEAN AIR-DRIED PEANUTS PER ACRE FOR EXPERIMENT II, FORT COBB, 1968

Seed Treatment	Emergence %	Seedling Vigor Score	Yield lbs/acre
N + U	33	2.0	4235
N + T	58	1.0	4900
N + BC	56	1.7	4779
K + U	41	2.0	4855
K + T	69	1.0	5369
Mean	52	1.5	4827
C.V. %	10.7	21.1	11.6
L.S.D. .05	10.5	0.491	N.S.
L.S.D. .01	15.3	0.751	N.S.

MEAN SQUARE FOR PERCENTAGE EMERGENCE, SEEDLING VIGOR, AND YIELD OF CLEAN AIR-DRIED PEANUTS PER ACRE, EXPERIMENT II, FORT COBB, 1968

Source	d.f.	Emergence %	Seedling Vigor Score	Yield lbs/acre
Total	14			
Rep	2	236.82**	0.065	614354
Treat	4	604.24**	0.765**	489805
Error	8	31.38	0.068	315798

** Indicates significance at the 1 per cent level of significance.

Greenhouse Experiment III

Plants in Experiment III were harvested November, 1968. They were separated into various plant parts, oven-dried, and weighed. The oven-dry weights for the different plant parts are summarized in Table XIII.

The plants grown in unsterilized soil produced higher total yield than plants grown in sterilized soil. The analysis of variance indicated significance between sterilized and unsterilized soil at the 5 per cent level. Significant differences were not indicated among the inoculum treatments. There was no significant interaction between the treatments.

In an attempt to determine the possible cause of the decreased yield in sterilized pots, chemical analyses of the different plant parts (new leaves, old leaves, and roots) for percentages of calcium, magnesium, potassium, and iron were determined. The results of the chemical analyses with the detailed analyses of variance are shown in Tables XIV, XV, XVI, XVII, and XVIII.

The analysis of variance for percentage of calcium in plant parts from sterilized and unsterilized soil indicated no significant differences among treatments. The percentage of calcium was higher in roots and new leaves from unsterilized than sterilized soil, however, the old leaves from plants in sterilized soil contained more calcium than the unsterilized soil.

The analysis of variance for percentages of magnesium indicated no significant differences for the new leaves between the sterilized and unsterilized soil. The old leaves from the unsterilized soil were

TABLE XIII

MEAN GRAMS OF DRY MATTER FOR EACH OF FIVE INOCULUM AND FUNGICIDE TREATMENTS FOR ROOTS, FRUIT, AND PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSTERILIZED SOIL IN THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

	Roots			Fruit			Total Forage			Total Plant Weight		
Treatment	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$
B + O	1.300	2.067	1.683	5.067	17.100	11.083	5.667	12.133	8.900	12.033	31.300	21.667
T + B + O	1.933	2.867	2.400	5.900	17.267	11.583	5.667	13.567	9.617	13.500	33.667	23.583
T + O	1.600	3.267	2.433	7.767	21.167	14.467	6.133	14.700	10.417	15.500	39.133	27.317
O	1.700	2.467	2.083	8.800	16.600	12.700	8.500	11.567	10.033	19.000	30.767	24.883
Untreated Check	2.367	3.333	2.850	11.200	15.167	13.183	9.300	12.133	10.717	22.933	30.633	26.783
$\bar{x}$	1.780	2.800	2.290	7.747	17.460	12.603	7.053	12.820	9.936	16.593	33.100	24.846

TABLE XIII (continued)

MEAN SQUARES FOR OVEN DRY WEIGHTS OF PEANUT PLANT PARTS FROM GREENHOUSE EXPERIMENT, STILLWATER, 1968

Source	d.f.	Roots	Fruit	Forage	Total Plant Wt.
Total	29	0.0910	26.2523	8.4303	62.1963
Reps	2				
Main Plots					
T_1	1	7.8030	707.6163	249.4083	2043.5253
Error	2	0.0610	21.3563	10.5363	66.8843
Subplots					
T_2	4	1.1355	10.7528	3.0378	32.3420
$T_1 \times T_2$	4	0.2088	21.8972	10.7908	64.4353
Error	16	0.4988	13.6822	5.8858	35.2274
Grand Mean		2.290	12.603	9.936	24.846
L.S.D. .05	Mainplot	0.672	12.58	8.833	22.26
	Subplot	N.S.	N.S.	N.S.	N.S.
C.V. %	Mainplot	10.78	36.67	32.67	32.92
	Subplot	30.84	29.35	24.42	23.89

T_1 = Sterilization

T_2 = Inoculum

TABLE XIV

MEAN PERCENTAGES OF CALCIUM, MAGNESIUM, POTASSIUM, AND IRON FROM NEW LEAVES, OLD LEAVES, AND ROOTS FROM PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSTERILIZED SOIL IN GREENHOUSE EXPERIMENT, STILLWATER, 1968

Concentration in Per cent 1/

	Leaves				Roots 4/	
	Young 2/		Old 3/			
Element	Ster. 5/	Unster.	Ster.	Unster.	Ster.	Unster.
Calcium	2.9199	3.3160	3.0593	2.7971	0.8213	1.0840
Magnesium	0.4220	0.4773	0.4691	0.5566**	0.4173**	0.3319
Potassium	1.4713*	1.0904	1.2276	1.1741	1.0603**	0.5985
Iron	0.0272	0.0149	0.0345	0.0301	0.1107	0.1269

* Indicates significance at the 5 per cent level of significance.
** Indicates significance at the 1 per cent level of significance.

1/ Mean of five treatments.
2/ Leaves taken from apical portion of plant.
3/ Lowest leaves to soil surface.
4/ Root cut at abscission zone.
5/ Sterilized in steam autoclave as described in Materials and Methods.

TABLE XV

MEAN PERCENTAGES OF CALCIUM FOR FIVE INOCULUM AND SEED FUNGICIDE TREATMENTS FOR NEW LEAVES, OLD LEAVES, AND ROOTS FROM PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSTERILIZED SOIL IN THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

	New Leaves			Old Leaves			Roots		
Treatment	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$
B + O	2.8993	3.3933	3.1463	3.3003	2.8790	3.0897	0.7267	1.1800	0.9533
T + B + O	2.5900	3.6133	3.1017	3.1927	2.7767	2.9847	0.9067	1.1200	1.0133
T + O	3.0833	3.2733	3.1783	2.7800	2.6567	2.7183	0.7933	1.2333	1.0133
O	2.6933	3.2400	2.9667	2.9467	2.8800	2.9133	0.8800	0.9600	0.9200
Check	3.3333	3.0600	3.1967	3.0767	2.7933	2.9350	0.8000	0.9267	0.8633
$\bar{x}$	2.9198	3.3160	3.0399	3.0593	2.7971	2.9282	0.8213	1.0840	0.9536

TABLE XV (continued)

A.O.V. WITH MEAN SQUARES FOR PER CENT CALCIUM IN NEW LEAVES, OLD LEAVES, AND ROOTS FROM THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

Source	d.f.	New Leaves	Old Leaves	Roots
Total	29			
Reps	2	0.0262	0.4959	0.0714
Main Plots				
T_1	1	1.1769	0.5153	0.5174
Error	2	0.2565	0.0585	0.0731
Subplots				
T_2	4	0.0507	0.1103	0.0246
$T_1 \times T_2$	4	0.03436	0.0401	0.0457
Error	16	0.1359	0.1101	0.0494
Grand Means		3.0399	2.9282	0.9536
L.S.D. .05	Mainplot	N.S.	N.S.	N.S.
	Subplot	N.S.	N.S.	N.S.
C.V. %	Mainplot	16.66	8.26	28.35
	Subplot	12.13	11.33	23.31

T_1 = Sterilization

T_2 = Inoculum

TABLE XVI

MEAN PERCENTAGES OF MAGNESIUM FOR FIVE INOCULUM AND SEED FUNGICIDE TREATMENTS FOR NEW LEAVES, OLD LEAVES, AND ROOTS FROM PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSTERILIZED SOIL IN GREENHOUSE EXPERIMENT, STILLWATER, 1968

Treatment	New Leaves			Old Leaves			Roots		
	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$
B + O	0.4215	0.5293	0.4754	0.4690	0.6210	0.5450	0.5113	0.3307	0.4210
T + B + O	0.4523	0.4600	0.4562	0.5089	0.5698	0.5394	0.3880	0.3713	0.3797
T + O	0.3659	0.4233	0.3947	0.4396	0.5217	0.4806	0.3807	0.3433	0.3620
O	0.4353	0.4386	0.4370	0.4864	0.5109	0.4986	0.3707	0.3107	0.3407
Check	0.4347	0.5353	0.4850	0.4414	0.5596	0.5005	0.4360	0.3303	0.3697
$\bar{x}$	0.4219	0.4773	0.4496	0.4691	0.5566	0.5128	0.4173	0.3319	0.3746

TABLE XVI (continued)

A.O.V. WITH MEAN SQUARES FOR PER CENT MAGNESIUM IN NEW LEAVES, OLD LEAVES, AND ROOTS FROM THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

Source	d.f.	New Leaves	Old Leaves	Roots
Total	29			
Reps	2	0.0080	0.0119	0.0042
Main Plots				
T_1	1	0.0230	0.0575	0.0548
Error	2	0.0019	0.0009	0.0003
Subplots				
T_2	4	0.0077	0.0047	0.0053
$T_1 \times T_2$	4	0.0037	0.0037	0.0071
Error	16	0.0035	0.0052	0.0047
Grand Mean		0.8792	0.5128	0.3746
L.S.D. .05	Mainplot	N.S.	0.0816	0.0471
	Subplot	N.S.	N.S.	N.S.
C.V. %	Mainplot	4.95	5.85	4.62
	Subplot	6.73	14.06	18.30

T_1 = Sterilization

T_2 = Inoculum

TABLE XVII

MEAN PERCENTAGES OF POTASSIUM FOR FIVE INOCULUM AND SEED FUNGICIDE TREATMENTS FOR NEW LEAVES, OLD LEAVES, AND ROOTS FROM PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSTERILIZED SOIL IN GREENHOUSE EXPERIMENT, STILLWATER, 1968

Treatment	Young Leaves			Old Leaves			Roots		
	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$
B + O	1.4497	1.0433	1.2465	1.6070	1.1230	1.3650	1.2340	0.5790	0.9065
T + B + O	1.8393	1.0777	1.4585	1.1343	1.4013	1.2678	0.9570	0.5600	0.7585
T + O	1.4643	1.0277	1.2460	1.2423	1.1376	1.1900	1.0416	0.6187	0.8302
O	1.2920	1.0950	1.1935	1.1387	1.1800	1.1593	0.9927	0.6633	0.8280
Check	1.3113	1.2083	1.2598	1.0157	1.0283	1.0220	1.0760	0.5717	0.8238
$\bar{x}$	1.4713	1.0904	1.2808	1.2276	1.1741	1.2010	1.0603	0.5985	0.8294

TABLE XVII (continued)

A.O.V. WITH MEAN SQUARES FOR PER CENT POTASSIUM IN NEW LEAVES, OLD LEAVES, AND ROOTS FROM THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

Source	d.f.	New Leaves	Old Leaves	Roots
Total	29			
Reps	2	0.0886	0.1615	0.0174
Main Plot				
T_1	1	1.0883	0.0215	1.5989
Error	2	0.0264	0.0505	0.0030
Subplot				
T_2	4	0.0630	0.0979	0.0165
$T_1 \times T_2$	4	0.0974	0.1140	0.0234
Error	16	0.0875	0.0810	0.0408
Grand Mean		1.2808	1.2001	0.8294
L.S.D. .05	Mainplot	0.4422	N.S.	0.1491
	Subplot	N.S.	N.S.	N.S.
C.V. %	Mainplot	12.68	18.72	6.64
	Subplot	23.09	23.72	24.49

T_1 = Sterilization

T_2 = Inoculum

TABLE XVIII

MEAN PERCENTAGES OF IRON FOR FIVE INOCULUM AND SEED FUNGICIDE TREATMENTS FOR NEW LEAVES, OLD LEAVES, AND ROOTS FROM PLANTS PRODUCED IN POTS WITH STERILIZED AND UNSERTILIZED SOIL IN GREENHOUSE EXPERIMENT, STILLWATER, 1968

Treatment	New Leaves			Old Leaves			Roots		
	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$	Ster.	Unster.	$\bar{x}$
B + O	0.0671	0.0173	0.0422	0.0327	0.0306	0.0316	0.0923	0.1043	0.0983
T + B + O	0.0190	0.0153	0.0172	0.0357	0.0400	0.0378	0.1602	0.1778	0.1690
T + O	0.0107	0.0165	0.0136	0.0362	0.0203	0.0283	0.1078	0.1238	0.1158
O	0.0132	0.0153	0.0142	0.0335	0.0279	0.0307	0.1052	0.1187	0.1119
Check	0.0260	0.0098	0.0179	0.0343	0.0319	0.0331	0.0878	0.1097	0.0987
$\bar{x}$	0.0272	0.0149	0.0210	0.0345	0.0301	0.0323	0.1107	0.1269	0.1188

TABLE XVIII (continued)

A.O.V. WITH MEAN SQUARE FOR PER CENT IRON IN NEW LEAVES, OLD LEAVES, AND ROOTS FROM THE GREENHOUSE EXPERIMENT, STILLWATER, 1968

Source	d.f.	New Leaves	Old Leaves	Roots
Total	29			
Reps	2	0.0013	0.0002	0.0002
Main Plot				
T_1	1	0.0011	0.0001	0.0020
Error	2	0.0009	0.00003	0.0037
Subplot				
T_2	4	0.0009	0.0001	0.0051
T_1 x T_2	4	0.0007	0.0001	0.00002
Error	16	0.0006	0.0002	0.0017
Grand Mean		0.0210	0.0323	0.1188
L.S.D. .05	Mainplot	N.S.	N.S.	N.S.
	Subplot	N.S.	N.S.	N.S.
C.V. %	Mainplot	142.85	16.95	51.20
	Subplot	116.97	43.88	34.71

T_1 = Sterilization

T_2 = Inoculum

significantly higher in the percentage of magnesium than old leaves from sterilized soil. The roots of plants from sterilized soil were significantly higher in the percentage magnesium than roots from unsterilized soil.

The analyses of variance for percentages of potassium indicated that the new leaves, old leaves, and roots from the sterilized soil were significantly higher in potassium than new leaves, old leaves, and roots from unsterilized soil.

The analyses of variance for percentages of iron in plant parts from sterilized and unsterilized soil indicated no significant differences at the .05 per cent level. The percentages of iron tended to be highest in new and old leaves from sterilized soil. The roots from unsterilized soil were higher in percentage of iron than those from the sterilized soil.

There were no significant differences in the chemical composition due to inoculum treatments of the peanut plant parts analyzed. There were no significant interactions between the treatments for any of the four elements.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of these field and greenhouse experiments was to determine the emergence and yield of peanuts receiving various inoculum and seed fungicide treatments. Field experiments were conducted at two locations, the Agronomy Research Station near Perkins, Oklahoma, and Caddo Peanut Research Station near Fort Cobb, Oklahoma. Greenhouse studies were conducted in pots filled with Cobb fine sandy loam soil from the Caddo Peanut Research Station.

The soil for the greenhouse test was sterilized to kill the Rhizobium already present in the soil. The treatments were duplicated in a set of pots containing unsterilized soil. Sterilization of soil resulted in a marked decrease in yield of peanuts for all of the inoculum treatments over those grown in unsterilized soil. In an attempt to determine the cause of decreased yields from sterilized soil chemical analyses of the peanut plant parts were determined.

Fort Cobb and Perkins Field Experiments I

Results from field Experiments I at Perkins and Fort Cobb are summarized as follows:

1. There was no significant increase in emergence for the plots receiving preplant applications of nitrogen fixing bacteria and/or

seed fungicides. Stands were significantly lower on plots receiving the oil alone treatment than the untreated check.

2. Vigor scores were significantly lower for the plots receiving bacteria + oil (B + O) and oil treatments.

3. There were no significant differences in the nodulation ratings of plots receiving the different treatments.

4. There were no significant differences among treatments in the percentage of nitrogen in the plant parts.

5. Results of this experiment indicate that preplant application of inoculum and seed fungicides to peanut seed by using oil as a carrier may actually be detrimental to peanut stands and vigor.

Fort Cobb and Perkins Experiments II

Results from field Experiments II near Perkins and Fort Cobb include:

1. Plots receiving fresh inoculum + seed fungicide showed a higher mean percentage emergence than plots receiving inoculum only.

2. Vigor scores were significantly higher in plots receiving inoculum + seed fungicide.

3. Nodulation ratings were higher for plots receiving inoculum only and inoculum + Botran-Captan than for plots receiving inoculum + Thiram seed fungicide. The plants in Experiment II showed more nodulation than plants in Experiment I at Perkins.

4. There were no significant differences in the yields in Experiment II near Fort Cobb.

Greenhouse Experiment III

Results from the greenhouse experiment are summarized as follows:

1. Sterilization of soil significantly reduced the oven-dry weight of peanut plants compared with those grown in unsterilized soil.

2. There were no significant differences in yield among the inoculum treatments whether grown in sterilized or unsterilized soil.

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VITA

Douglas Eugene Freeman

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF APPLICATION METHODS OF INOCULUM AND SEED FUNGICIDES ON STAND AND YIELD OF SPANISH PEANUTS

Major Field: Agronomy

Biographical:

Personal Data: Born near Lindsay, McClain County, Oklahoma, September 21, 1945.

Education: Attended elementary school at Antioch, Oklahoma. Received high school diploma at Elmore City High School, Elmore City, Oklahoma, 1963. Undergraduate work at Murray State Junior College, 1963-1965. Received the Bachelor of Science degree from Oklahoma State University in 1967. Completed requirements for the Master of Science degree at Oklahoma State University in May, 1970.

Experience: Reared on a farm; employed as a research assistant on peanut research for Oklahoma State University, 1967-1969.

Organizations: Agronomy Club, Alpha Tau Alpha, and Collegiate FFA.