THE EFFECT OF FIVE FUNGICIDES AT SIX RATES OF TREATMENT ON THE GERMINATION AND EMERGENCE OF BIRDSFOOT TREFOIL, LOTUS CORNICULATUS, L.

THE EFFECT OF FIVE FUNGICIDES AT SIX RATES OF TREATMENT ON THE GERMINATION AND EMERGENCE OF BIRDSFOOT TREFOIL, LOTUS CORNICULATUS, L.

By

David Paul Weston

Bachelor of Science

Oklahoma Agricultural and Mechanical College

1940

Submitted to the Department of Agronomy

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

1951

APPROVED BY:

Roy A. Chessmore
Chairman, Thesis Committee

Melvin Jones
Member of the Thesis Committee

H. P. Murphy
Head of the Department

D. C. McIntosh
Dean of the Graduate School

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to his major advisers, Mr. Roy A. Chessmore, Mr. Hi W. Staten, and Dr. M. D. Jones for their advise and constructive criticism; Mr. L. A. Brinkerhoff of the Plant Pathology Department for his advise and particularly for his assistance in making photographs; Mr. Herman Hinrichs of the Horticulture Department for his advise and assistance in the greenhouse, and Mr. Buford Jones, State Department of Agriculture, for his assistance in the germinator studies.

TABLE OF CONTENTS

INTRODUCTION

Birdsfoot trefoil, Lotus corniculatus L., is one of the best legumes for pasture improvement in the Northeastern United States and the Pacific Northwest and also is promising in many other sections. It is a fairly long-lived perennial that is drought and cold resistant. It is slow in getting established, but once established, it is a good competitor. As a forage producer, it compares very favorably with alfalfa. There has never been a case of bloat of livestock reported from grazing birdsfoot trefoil.

Birdsfoot trefoil reproduces both vegetatively and from seed (21)[1/]. It is an erratic seeder and may have new blooms and seed of all stages of maturity on the same plant. This makes it difficult to get a good seed crop. For this reason, seed is scarce and it is highly important to increase germination to get the best possible stands from the seed available. The main sources of seed at present are New York, the Pacific Northwest, and Italy. At the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma, the Italian strain has proved to be the most successful. The Italian seed have a consistently higher percentage of germination. Seed of strains grown in New York sometimes germinate as low as 6 to 8%.

Seed of many superior legumes, including birdsfoot trefoil, were in short supply during 1940, and it is likely that these shortages may continue to exist in the future. This has brought about a renewed interest in the fungicidal treatment of legume seeds (19).

If seed treatment proves effective, it will give some promise of stretching limited seed supplies. If higher rates of germination can be attained, lower rates of seeding will give satisfactory stands, and the valuable seed can be

---

[1/] Figures in parenthesis refer to "Literature Cited ", p. 21.

used to plant larger acreages.

Although some work has been done in other states on the effect of various fungicides on germination of birdsfoot trefoil, the data are limited. There are no general recommendations available as to the proper fungicide or the proper rate of application. Since this forage legume offers promise as a pasture crop in Oklahoma, there is a need for information which will lead to improved stands.

The primary objective of this experiment was to determine the effects of kinds and rates of fungicides on the germination of birdsfoot trefoil.

REVIEW OF LITERATURE

Small Seed Legumes

Field experiments in Wisconsin with seed treatments on several legumes showed little increase in stands (1). Spergon retarded but did not decrease emergence of strawberry and Ladino clover in greenhouse trials. Spergon, Arasan, and New Improved Ceresan gave significant increases in emergence of alfalfa and alsike clover. New Improved Ceresan increased the emergence of sweet clover. New Improved Ceresan and Arasan increased the stand of red clover. Arasan and Spergon increased the stand of Ladino clover.

Workers in Pennsylvania reported that Spergon was beneficial to red clover, and that alfalfa stands were increased by Yellow Cuprocide (15). Seed treatments doubled stands when seed was planted in infested soils in the greenhouse.

Greenhouse trials with seed fungicides conducted in South Dakota by Buchholtz (2) resulted in increased stands of alfalfa and white sweet clover with only slight increases for alsike, red, and White Dutch clovers. Field trials showed wide variation in increasing alfalfa stands. Larger increases occurred in soils heavily infested with Pythium. Alfalfa stands were decreased by seed treatment when planted in soils which were nearly free of Pythium.

Chilton and Garber (4) used 5 fungicides on 18 species of forage legumes in greenhouse tests. None of these treatments proved beneficial to birdsfoot trefoil. The use of New Improved Ceresan resulted in the greatest increases in stands with most of the legumes treated. Subterranean clover was stunted by New Improved Ceresan at the highest dosage used.

New Improved Ceresan, Spergon, and Arasan increased alfalfa and red clover stands when planted in greenhouse experiments by Kreitlow, Garber, and Robinson (16). Total emergence of red clover was slightly increased in field trials, but alfalfa did not respond as well to seed treatment.

Whitehead (29), from experiments conducted in Oklahoma, reported that Arasan seed treatments were beneficial to cracked or damaged legume seed. Spergon and New Improved Ceresan increased emergence of soybeans and vetch in Oklahoma (7).

Alfalfa, Mung beans, Chinese red cowpeas, and yellow hop clover were significantly increased in stand by chemical seed treatment in Oklahoma (27). Dow 9B proved detrimental to hairy vetch at all rates.

After 5 years of testing in the New York seed laboratory, Crozier, Patrick, and Taylor (5) reported that treatment of all seed with organic mercurials materially increased the speed and accuracy of germination tests.

Large Seed Legumes

Experiments conducted in England by Weston, Hanly, and Booer (28) indicated that organic mercurials had, as their chief value, a protective action against fungus attacks on peas.

Treatment of peas with Spergon resulted in slight to highly significant increases at several locations in the United States (8, 10, 17, 18, 22, 23, 24). Larger increases were reported when experiments were conducted in infested soils. New Improved Ceresan and Yellow Cuprocide gave poor results at 1 location and tended to injure both seed and seedlings. Lima beans responded slightly to seed treatment but no significant increases in stand resulted (6, 11).

Highly significant increases in stands of peanuts were reported in 4 states when machine-shelled seed were treated with Arasan, 2% Ceresan, and Phygon. Treatment with Spergon produced significant increases in only 1 state, while no significant increases resulted from the use of Dow 9B. Hand-shelled peanuts did not respond to seed treatment at any of these locations (9, 26).

The rate of emergence of soybeans was accelerated and final stands were increased by seed treatment with Arasan, Spergon, Ceresan, and Dow #5 in Delaware (12). Dow #6 and Semesan had little or no effect on rate of emergence and final stand while Yellow Cuprocide decreased rate of emergence and final stand. Workers in Canada (13) reported that large increases in stand of soybeans were noted when poor quality seed was treated with Spergon. They recommended that seed be treated in years following a season in which the seed was damaged severely by weathering or when desirable to "stretch" seed by sowing less than the amount normally required.

In a recent review of literature, Leukel (20) states that Ceresan M is effective in treating peas and less toxic to most seed than New Improved Ceresan. Arasan is best suited for treatment of peas and peanuts. It is beneficial to emergence of most seeds and effective as a seed protectant. Spergon is used on peanuts, peas, and beans as a seed protectant and disinfectant. Phygon and Dow 9B also are used for treatment of peanuts.

The evolution of seed disinfectants has shown a change, according to Chester (3), from inorganic oxides and salts of heavy metals, such as Mercuric chloride, Copper sulfate and carbonate, Zinc and Copper oxides, and formaldehyde, to the mercury dusts and nonmetallic compounds.

MATERIALS AND METHODS

Seed treatment investigations were conducted in a Mangelsdorf Germinator and the greenhouse at Stillwater, Oklahoma, during the winter of 1950-51, to determine the effect of chemicals on germination and emergence of birdsfoot trefoil. Commercial seed of the Italian strain was used. The fungicides used were:

Ceresan M (Ethyl mercuric toluene sulfanilide)
Arasan (Tetramethylthiuran disulfide)
Spergon (Tetrachlora-p-benzoquinone)
Phygon (2, 3, dichlor-1, 4-napthoquinone)
Dow 9B (Zinc-2, 4, 5-trichlorophenate)

These chemicals were applied as a dust to 50-gram samples of birdsfoot trefoil seed at rates of 0, 2, 4, 8, 16, and 24 ounces per 100 pounds. When all the dust failed to adhere to the seed, water was added until the chemical was uniformly distributed. The most difficulty was encountered in getting Dow 9B to adhere to the seed at the higher rates.

Germinator Tests

One hundred seed of each treatment were tested in a Mangelsdorf Germinator set at a constant temperature of 20°C (25). The seed were germinated between indented paper blotters 3 by 3 inches in size. Normal seedlings were counted and removed from the blotters on alternate days beginning on the third day. Hard seed and diseased seedlings were removed on the seventh day, and the swollen seed were left on the blotters for an additional 5 days. On the twelfth day all normal, abnormal, damaged, and/or diseased seedlings were removed, and the remaining seed were considered as diseased and/or damaged.

The treatments were randomized in the germinator using 3 trays. The trays were changed end for end and alternated as to position each day, with the top tray being moved to the bottom, middle tray to the top, and bottom tray to the middle. The treatments were replicated 4 times.

Greenhouse Tests

One hundred seed of each treatment were planted in flats in unsterilized field soil. The seed were planted at a depth of about 1/8 inch in the soil and covered by an additional 1/8 to 1/4 inch of ground vermiculite. The rates of treatment for a chemical were randomized within 1 flat. The flats were randomized on the bench, and positions were changed each day to avoid uneven distribution of heat or light. Each chemical treatment was replicated 4 times. The temperature was maintained as nearly constant as possible at 20°C. Normal and diseased and/or damaged seedlings were counted and removed beginning the seventh day. Counts were made on alternate days thereafter through the thirteenth day. On the fourteenth day a final count was made of all remaining seedlings.

RESULTS AND DISCUSSION

Ceresan M

Ceresan M proved highly significant in reducing the number of normal seedlings in germinator tests as shown in Tables 1 and 8. At the same time, highly significant increases in the number of abnormal seedlings occurred as compared to untreated seed. At 2 and 4 ounces there was a slight increase in germination with no increase in abnormal seedlings. Treatment at 8 and 16 ounces reduced the number of normal seedlings slightly but did not greatly increase abnormal seedlings. The 24-ounce treatment reduced the number of normal seedlings over 50% and more than doubled the number of abnormal seedlings. This fungicide damaged young seedlings as shown in Figure 1. The seedlings were short and swollen and had damaged root tips. This damage was found when samples were treated with 16 and 24 ounces. The number of hard seed was significantly increased by treatment, although the rates of treatment were not consistent in producing hard seed.

The number of normal seedlings was increased slightly at most of the rates of treatment with Ceresan M in greenhouse trials. Treatment at the 4-ounce rate resulted in an average increase of about 26% over untreated seed. The number of normal seedlings was increased slightly at all other rates of treatment except the 2-ounce rate which reduced the number about 16%. Samples treated with Ceresan M produced an increase in diseased and damaged seedlings. This indicates that this fungicide may have little or no effect on post-emergence "damping off". Total emergence was increased about 30% at the 4, 8, and 16-ounce rates.

Phygon

Treatment with Phygon resulted in decreases in normal seedlings and increases in abnormal, diseased and damaged seedlings at all rates of application in the germinator (Tables 2 and 9). Treatment at 2 and 4 ounces had

Table 1.--Average effects of Ceresan M at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate	Germinator					Greenhouse		
oz/100 lbs	Normal Seed-lings	Hard Seed	Total	Abnormal and/or Diseased Seed-lings	Diseased and/or Damaged Seed	Normal Seed-lings	Diseased and/or Damaged Seed-lings	Total Emer-gence
0	52.7	14.5	67.2	17.8	15.0	30.8	3.8	34.5
2	54.8	16.7	71.5	16.0	12.5	25.5	6.0	31.5
4	54.5	15.0	69.5	14.0	16.5	38.8	5.5	44.2
8	45.5	20.2	65.8	19.8	14.5	32.5	10.5	43.0
16	45.5	15.2	60.8	23.5	15.8	34.2	11.5	45.8
24	23.3	23.5	46.8	40.0	13.2	31.8	8.0	39.8
F value	19.6**	3.6*	14.3**	18.5**	1.0	1.3	2.0	2.9*

*Indicates that the F value exceeds the value required for significance at the 5% level.

**Indicates that the F value exceeds the value required for significance at the 1% level.

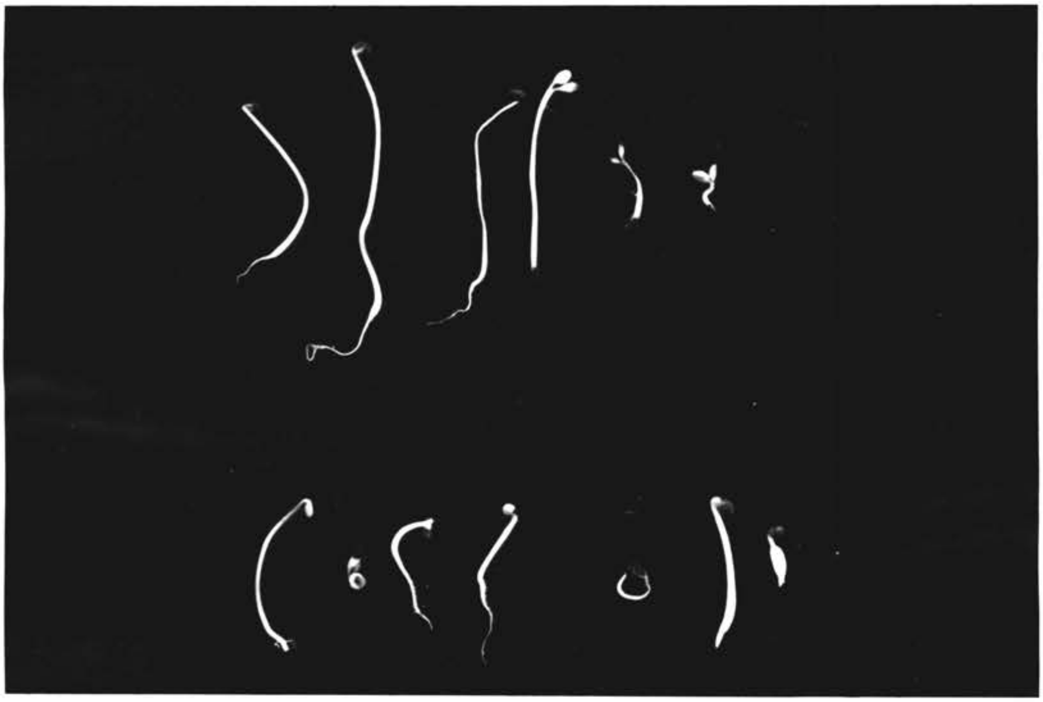

Figure 1.--Normal, abnormal and damaged seedlings found in germination studies of birdsfoot trefoil. Seedlings are enlarged $1\frac{1}{2}$ times natural size. Top row: 1, 2, and 3 normal seedlings; 4, 5, and 6 abnormal seedlings. Bottom row: 1 and 2 abnormal seedlings; 3 and 4 normal seedlings; 5 abnormal seedling; 6 and 7 seedlings damaged by Ceresan M at rates of 16 and 24 ounces per 100 pounds of seed.

Table 2.--Average effects of Phygon at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate	Germinator					Greenhouse		
oz/100 lbs	Normal Seed-lings	Hard Seed	Total	Abnormal and/or Diseased Seed-lings	Diseased and/or Damaged Seed	Normal Seed-lings	Diseased and/or Damaged Seed-lings	Total Emer-gence
0	52.7	14.5	67.2	17.8	15.0	27.0	7.5	34.5
2	45.2	17.8	63.0	24.5	12.5	17.2	10.2	27.5
4	42.2	16.8	59.0	24.0	17.0	22.2	4.8	27.0
8	30.5	18.0	48.5	33.5	18.0	26.5	1.2	27.8
16	20.8	17.0	37.8	34.7	27.5	14.0	1.0	15.0
24	21.2	23.5	44.7	33.8	21.5	13.8	1.2	15.0
F value	29.7**	2.2	24.2**	8.9**	10.1**	1.4	4.8**	2.6

**Indicates that the F value exceeds the value required for significance at the 1% level.

less effect than treatment at 8, 16, and 24 ounces. The latter three were equally injurious and approximately doubled the number of abnormal seedlings as compared to untreated seed. Treatment with this fungicide increased diseased and damaged seed at all rates except 2 ounces. This rate of treatment had less diseased and damaged seed than were found in untreated samples. The largest increases in diseased and damaged seed were found at the 2 highest rates. More hard seed were present in treated samples than untreated.

The number of normal seedlings was decreased somewhat by seed treatment in greenhouse trials. All rates of treatment reduced normal seedlings when compared with untreated samples except for the 8-ounce treatment which was approximately as good as the untreated samples. Diseased and damaged seedlings occurred less frequently in samples treated at 8, 16, and 24 ounces. Phygon retarded and reduced emergence in the greenhouse.

Spergon

Significant differences in the number of normal seedlings occurred in samples treated with Spergon in the germinator (Tables 3 and 10). Treatment at 2 ounces resulted in a slight increase over untreated seed. The number of normal seedlings was decreased over 50% by treatment at 4, 8, 16, and 24 ounces. These 4 treatments increased the amount of abnormal and/or diseased seedlings at the 1% level of significance. Treatment at 2 ounces resulted in fewer abnormal seedlings than untreated seed. The number of hard seed was larger at all rates of treatment than in untreated samples.

Spergon reduced emergence of normal seedlings at all rates of treatment in the greenhouse. There appeared to be a negative correlation between rates of treatment and occurrence of diseased seedlings with this fungicide. Fewer diseased seedlings were noted as the rates of treatment increased. This may indicate that Spergon has some effect on post-emergence "damping off". Spergon delayed and reduced total emergence in the greenhouse.

Table 3.--Average effects of Spergon at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Germinator					Greenhouse		
	Normal Seed-lings	Hard Seed	Total	Abnormal and/or Diseased Seed-lings	Diseased and/or Damaged Seed	Normal Seed-lings	Diseased and/or Damaged Seed-lings	Total Emer-gence
0	52.7	14.5	67.2	17.8	15.0	31.2	5.5	36.7
2	54.2	18.0	72.2	13.5	14.3	26.7	6.7	33.5
4	25.0	22.0	47.0	38.0	15.0	20.0	5.7	25.7
8	18.5	19.7	38.2	45.8	16.0	23.2	4.2	27.5
16	14.3	18.5	32.8	44.0	23.2	18.2	3.2	21.5
24	12.3	16.0	28.3	44.2	27.5	23.7	1.5	25.2
F value	45.2**	4.1*	57.3**	5.9**	23.1**	1.9	3.4*	12.6**

*Indicates that the F value exceeds the value required for significance at the 5% level.

**Indicates that the F value exceeds the value required for significance at the 1% level.

Arasan

Seed treatment with Arasan gave no significant differences in normal seedlings in the germinator (Tables 4 and 11). All rates of treatment resulted in fewer normal seedlings, with treatment at 24 ounces causing the greatest decrease. Only the 16 and 24-ounce rates produced more abnormal and/or diseased seedlings than untreated samples. Treatment at 24 ounces produced more diseased and/or damaged seed than other rates. Significant increases in hard seed resulted from treatment with Arasan.

The number of normal seedlings was increased at the 8, 16, and 24-ounce treatments in the greenhouse. These rates also decreased the number of diseased and/or damaged seedlings, which indicates that Arasan may be effective in reducing "damping off".

Dow 9B

No significant differences occurred in normal seedlings when seed were treated with Dow 9B in the germinator (Tables 5 and 12). The 16 and 24-ounce rates of treatment resulted in fewer normal seedlings than untreated seed, while more normal seedlings were found in samples treated at 2 ounces. Treatment at the 2-ounce rate also produced fewer abnormal and/or diseased seedlings, and fewer diseased and/or damaged seed. The number of hard seed was increased by seed treatments with Dow 9B and did not appear to be correlated with the rate of treatment.

The results of treatment with Dow 9B were very inconsistent in the greenhouse. Treatment at rates of 2, 4, 8, and 16 ounces resulted in fewer normal seedlings than seed not treated. The 24 ounce rate produced more normal seedlings and less diseased and/or damaged seedlings than untreated seed.

Table 4.—Average effects of Arasan at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Germinator					Greenhouse		
	Normal Seed-lings	Hard Seed	Total	Abnormal and/or Diseased Seed-lings	Diseased and/or Damaged Seed	Normal Seed-lings	Diseased and/or Damaged Seed-lings	Total Emer-gence
0	52.7	14.5	67.2	17.8	15.0	35.2	5.8	41.0
2	47.2	21.5	68.7	15.5	15.8	25.0	9.2	34.2
4	50.2	22.0	72.2	16.0	11.8	34.2	4.8	39.0
8	46.0	20.5	66.5	16.8	16.7	43.5	2.8	46.3
16	48.2	20.0	68.2	19.0	12.8	45.5	2.5	48.0
24	41.5	17.5	59.0	22.0	19.0	46.0	2.5	48.5
F value	2.2	4.0*	3.3*	1.6	4.0*	3.7*	2.2	2.2

*Indicates that the F value exceeds the value required for significance at the 5% level.

Table 5.—Average effects of Dow 9B at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate	Germinator					Greenhouse		
oz/100 lbs	Normal Seed-lings	Hard Seed	Total	Abnormal and/or Diseased Seed-lings	Diseased and/or Damaged Seed	Normal Seed-lings	Diseased and/or Damaged Seed-lings	Total Emer-gence
0	52.7	14.5	67.2	17.8	15.0	31.5	5.5	37.0
2	55.2	21.2	76.4	13.8	9.8	27.5	4.5	32.0
4	50.8	17.5	68.3	15.5	16.2	25.0	6.2	31.2
8	51.0	19.0	70.0	17.0	13.0	19.8	7.2	27.0
16	47.0	20.2	67.2	19.8	13.0	25.8	4.5	30.2
24	46.8	20.2	67.0	17.2	15.8	39.2	2.5	41.8
F value	1.7	2.1	1.3	0.6	2.7	2.0	1.0	2.0

During the course of the germinator tests several trends developed. The number of hard seed was increased by all chemicals at all rates of application as compared with untreated seed. Generally the lighter applications were best but Phygon and Spergon were detrimental to total germination at most rates (Table 6). Ceresan M produced a characteristic type of damage to the seedlings at the 16 and 24-ounce rates (Figure 1). All other types of abnormal, diseased and/or damaged seedlings were found in all samples of treated and untreated seed.

All chemicals gave wide variation between replications in the greenhouse. This was particularly true with the second replication which was watered to such an extent that germination was greatly retarded. According to Horsfal (14) the retarding effect of over-watering is probably due to the excessive moisture reducing the available supply of oxygen necessary for good germination.

Total emergence was increased by Ceresan M and Arasan at the higher rates of application (Table 7). Only the 24-ounce rate of Dow 9B produced higher total emergence than untreated seed. Both Phygon and Spergon reduced total emergence at all rates of treatment.

This experiment indicates that seed treatment tests in the germinator cannot be easily correlated with tests in the greenhouse. This may be due to several factors. The dilution effect of the soil may necessitate higher rates of application to obtain comparable control of soil-borne organisms. This dilution effect also may decrease chemical damage. It is more difficult to maintain uniform temperatures and moisture conditions in the greenhouse than in the germinator which may account for some variation in the results.

Table 6.--Average effect of 6 rates of application of 5 fungicides on total germination in the germinator.

Rate oz/100 lbs	Ceresan M	Phygon	Spergon	Arasan	Dow 9B
0	67.2	67.2	67.2	67.2	67.2
2	71.5	63.0	72.2	68.7	76.4
4	69.5	59.0	47.0	72.2	68.3
8	65.8	48.5	38.2	66.5	70.0
16	60.8	37.8	32.8	68.2	67.2
24	46.8	44.7	28.3	59.0	67.0

Table 7.—Average effect of 6 rates of application of 5 fungicides on total emergence in the greenhouse.

Rate oz/100 lbs	Ceresan M	Phygon	Spergon	Arasan	Dow 9B
0	34.5	34.5	36.7	41.0	37.0
2	31.5	27.5	33.5	34.2	32.0
4	44.2	27.0	25.7	39.0	31.2
8	43.0	27.8	27.5	46.3	27.0
16	45.8	15.0	21.5	48.0	30.2
24	39.8	15.0	25.2	48.5	41.8

SUMMARY

To determine the effects of different chemicals and rates of application on the germination and emergence of birdsfoot trefoil, Lotus corniculatus L., seed was treated with Ceresan M, Phygon, Spergon, Arasan, and Dow 9B at rates of 2, 4, 8, 16, and 24 ounces per 100 pounds of seed. A Mangelsdorf Germinator and the greenhouse were used in these trials. The experiment was conducted at Stillwater, Oklahoma, in 1950-51.

Ceresan M produced slight increases in normal seedlings in the germinator, while the 16 and 24-ounce rates produced a definite type of injury to the seedlings. Treatments increased the number of normal seedlings in the greenhouse when applied at the rates of 4, 8, 16, and 24 ounces.

Phygon delayed and decreased germination in the germinator and emergence in the greenhouse.

Spergon decreased germination at rates of 4 ounces or more in the germinator and delayed and decreased emergence at all rates of application in the greenhouse.

Arasan slightly decreased the number of normal seedlings at all rates in the germinator but increased normal seedlings about 23 to 30% above untreated seed when applied at 8, 16, and 24 ounces in the greenhouse. Arasan did not appear to be injurious to the seedlings at the highest rate.

Dow 9B was not effective in increasing germination but did increase the emergence of normal seedlings in the greenhouse when applied at 24 ounces.

All chemicals increased the number of hard seed at all rates of application.

Germinator and greenhouse results did not appear to be positively correlated.

Results of this experiment indicate that Arasan may be effective in increasing stands of birdsfoot trefoil.

LITERATURE CITED

1. Allison, J. L. and Torrie, J. H. Effect of several seed protectants on germination and stands of various forage legumes. Phytopath., 34: 799-804. 1944.

2. Buchholtz, W. F. Seed treatment as a control for damping-off of alfalfa and other legumes. Phytopath., 26: 88. 1936.

3. Chester, K. S. Nature and prevention of plant diseases. Blakiston Company; Philadelphia, Pennsylvania. 1942.

4. Chilton, S. J. P. and Garber, R. J. Effect of seed treatment on stands of some forage legumes. Jour. Amer. Soc. Agron., 33: 75-83. 1941.

5. Crosier, W., Patrick, S. and Taylor, L. Chemical treatments helpful in germination tests of seeds. Division of Seed Investigations, Geneva, New York. Phytopath., 27: 797-8. 1937.

6. Cunningham, H. S. and Sharvelle, E. G. Organic seed protectants for lima beans. Phytopath., 30: 4-5. 1940.

7. Davey, R. H. Further evidence of the fungicidal value of Spergon. U.S.D.A. Plant Dis. Rptr., 26: 162-63. 1942.

8. Felix, E. L. Tetrachloro-parabenzoquinone, an effective organic seed protectant. Phytopath., 32: 4. 1942.

9. Fenne, S. B. Report of the regional peanut seed treatment tests conducted in 1942. U.S.D.A. Plant Dis. Rptr., 30: 468-70. 1946.

10. Forsberg, J. L., Olson, E. and Binkley, A. M. Experiments with pea seed treatments in Colorado. Phytopath., 34: 753-59. 1944.

11. Gould, C. J. Vegetable seed treatment in Western Washington. U.S.D.A. Plant Dis. Rptr., 27: 594-601. 1943.

12. Heuberger, J. W. and Manns, T. F. Effect of organic and inorganic seed treatments on rate of emergence, stand and yield of soybeans. Phytopath., 33: 1113. 1943.

13. Hilderbrand, A. and Koch, L. W. Soybean diseases in Ontario and effectiveness of seed treatment. Phytopath., 37: 111-124. 1947.

14. Horsfal, J. S. Combating damping off. New York Exp. Sta. Bul. 683. 1938.

15. Kreitlow, K. W. Investigations on seed treatment of forage grasses and legumes for control of damping-off. U.S.D.A. Plant Dis. Rptr., 27: 111-112. 1943.

16. ______________, Garber, R. J. and Robinson, R. R. Investigations on seed treatment of alfalfa, red clover and Sudan grass for control of damping-off. Phytopath., 40: 883-98. 1950.

17. Leach, L. D. and Smith, P. G. Effect of seed treatments on production rate of emergence and growth of garden peas. Phytopath., 35: 191-206. 1945.

18. Ledingham, R. J. Effect of seed treatments and dates of seeding on emergence and yield of peas. Sci. Agr., 26: 248-257. 1946.

19. Lefebvre, C. L. and Hollowel, E. A. Seed treatment, does it pay? Crops and Soils 3: 18-24. 1950.

20. Leukel, R. W. Recent developments in seed treatment. Bot. Rev., 14: 235-269. 1948.

21. McDonald, H. A. Birdsfoot trefoil, Lotus corniculatus, its characteristics and potentialities as a forage legume. Cornell Agr. Exp. Mem., 261: 1-182. 1946.

22. McNew, G. L. Relative effectiveness of organic and inorganic fungicides as seed protectants. Phytopath., 33: 9. 1943.

23. Sharvelle, E. G. and Shema, B. F. A preliminary investigation of the value of a new seed protectant for canning peas in Minnesota. Phytopath., 31: 20. 1941.

24. ________________ and others. The value of Spergon as a seed protectant for canning peas. Phytopath., 32: 944-952. 1942.

25. U.S.D.A., P.M.A. Service and Regulatory Announcement No. 156. Rules and regulations under the Federal Seed Act of 1939 as amended. Reprinted with amendments, 1950.

26. Vaughan, E. K. Peanut seed treatment in Virginia. U.S.D.A. Plant Dis. Rptr., 28: 672-75. 1944.

27. Vlitos, A. J. and Preston, D. A. Seed treatment for field legumes. Okla. Agr. Exp. Sta. Bul., B-332. 1949.

28. Weston, W. A. R. D., Hanley, W. F. and Booer, J. R. Seed disinfection. Jour. Agr. Sci. (England), 27: 43-52, 53-66. 1937.

29. Whitehead, M. D. Fungous Flora, disinfectation and germination of field legume seed. Unpublished thesis. Oklahoma A. and M. College. 1946.

A P P E N D I X

Table 8.—Effect of Ceresan M at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Replication	Germinator					Greenhouse		
		Normal Seedlings	Hard Seed	Total	Abnormal and/or Diseased Seedlings	Diseased and/or Damaged Seed	Normal Seedlings	Diseased and/or Damaged Seedlings	Total Emergence
0	1	41	15	56	29	15	28	3	31
	2	47	17	64	20	16	20	2	22
	3	59	15	74	12	14	39	3	42
	4	64	11	75	10	15	36	7	43
2	1	44	17	61	27	12	29	4	33
	2	58	18	76	14	10	13	0	13
	3	57	15	72	13	15	22	12	34
	4	60	17	77	10	13	38	8	46
4	1	50	15	65	15	20	43	2	45
	2	50	22	72	14	14	23	4	27
	3	64	12	76	14	10	38	14	52
	4	54	11	65	13	22	51	2	53
8	1	36	22	58	31	11	29	4	33
	2	48	20	68	18	14	38	3	41
	3	52	15	67	17	16	24	26	50
	4	46	24	70	13	17	39	9	48
16	1	39	12	51	36	13	51	4	55
	2	48	16	64	21	15	16	4	20
	3	43	21	64	17	19	29	25	54
	4	52	12	64	20	16	41	13	54
24	1	12	20	32	52	16	42	2	44
	2	14	27	41	48	11	17	2	19
	3	37	19	56	29	15	32	20	52
	4	30	28	58	31	11	36	8	44

Table 9.—Effect of Phygon at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Repli- cation	Germinator					Greenhouse		
		Normal Seed- lings	Hard Seed	Total	Abnormal and/or Diseased Seed- lings	Diseased and/or Damaged Seed	Normal Seed- lings	Diseased and/or Damaged Seed- lings	Total Emer- gence
0	1	41	15	56	29	15	30	4	34
	2	47	17	64	20	16	16	8	24
	3	59	15	74	12	14	14	16	30
	4	64	11	75	10	15	48	2	50
2	1	34	22	56	29	15	24	7	31
	2	42	20	62	28	10	4	3	7
	3	53	16	69	19	12	6	19	25
	4	52	13	65	22	13	35	12	47
4	1	27	19	46	38	16	24	1	25
	2	48	12	60	27	13	6	0	6
	3	53	18	71	14	15	20	15	35
	4	41	18	59	17	24	39	3	42
8	1	6	24	30	51	19	41	3	44
	2	33	21	54	28	18	6	0	6
	3	45	11	56	21	23	33	2	35
	4	38	16	54	34	12	26	0	26
16	1	4	11	15	53	32	17	0	17
	2	24	22	46	30	24	7	0	7
	3	29	18	47	27	26	20	3	23
	4	26	17	43	29	28	12	1	13
24	1	7	25	32	44	24	27	2	29
	2	24	26	50	30	20	6	0	6
	3	26	26	52	31	17	18	3	21
	4	28	17	45	30	25	4	0	4

Table 10.--Effect of Spergon at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate	Repli-	Germinator					Greenhouse		
oz/100 lbs	cation	Normal Seed- lings	Hard Seed	Total	Abnormal and/or Diseased Seed- lings	Diseased and/or Damaged Seed	Normal Seed- lings	Diseased and/or Damaged Seed- lings	Total Emer- gence
0	1	41	15	56	29	15	38	3	41
	2	47	17	64	20	16	16	2	18
	3	59	15	74	12	14	20	14	34
	4	64	11	75	10	15	51	3	54
2	1	47	18	65	23	12	30	7	37
	2	53	20	73	14	13	10	2	12
	3	60	15	75	10	15	30	15	45
	4	57	19	76	7	17	37	3	40
4	1	18	22	40	44	16	27	7	34
	2	23	18	41	44	15	22	4	26
	3	40	20	60	27	13	23	10	33
	4	19	28	47	37	16	8	2	10
8	1	14	23	37	50	13	27	5	32
	2	12	17	29	57	14	22	2	24
	3	23	21	44	36	20	21	9	30
	4	25	18	43	40	17	23	1	24
16	1	14	22	36	46	18	34	2	36
	2	7	14	21	53	26	14	3	17
	3	24	15	39	37	24	19	7	26
	4	12	23	35	40	25	6	1	7
24	1	3	22	25	53	22	30	2	32
	2	6	15	21	51	28	17	0	17
	3	15	17	32	38	30	36	3	39
	4	25	10	35	35	30	12	1	13

Table 11.—Effect of Arasan at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Replication	Germinator: Normal Seedlings	Germinator: Hard Seed	Germinator: Total	Germinator: Abnormal and/or Diseased Seedlings	Germinator: Diseased and/or Damaged Seed	Greenhouse: Normal Seedlings	Greenhouse: Diseased and/or Damaged Seedlings	Greenhouse: Total Emergence
0	1	41	15	56	29	15	34	8	42
	2	47	17	64	20	16	28	2	30
	3	59	15	74	12	14	34	10	44
	4	64	11	75	10	15	45	3	48
2	1	42	25	67	18	15	27	9	36
	2	40	22	62	25	13	5	0	5
	3	51	20	71	10	19	26	18	44
	4	56	19	75	9	16	42	10	52
4	1	44	19	63	26	11	36	12	48
	2	43	21	64	19	17	8	0	8
	3	56	23	79	11	10	45	7	52
	4	58	25	83	8	9	48	0	48
8	1	38	24	62	26	12	55	1	56
	2	44	21	65	16	19	6	2	8
	3	50	20	70	13	17	57	2	59
	4	52	17	69	12	19	56	6	62
16	1	36	24	60	29	11	61	2	63
	2	43	21	64	23	13	21	1	22
	3	63	19	82	8	10	47	7	54
	4	51	16	67	16	17	53	0	53
24	1	22	25	47	34	19	59	3	62
	2	37	17	54	27	19	22	0	22
	3	46	16	62	18	20	57	4	61
	4	61	12	73	9	18	46	3	49

Table 12.--Effect of Dow 9B at 6 rates of treatment on the germination and emergence of 100 seed of birdsfoot trefoil.

Rate oz/100 lbs	Replication	Normal Seedlings	Hard Seed	Total	Abnormal and/or Diseased Seedlings	Diseased and/or Damaged Seed	Normal Seedlings	Diseased and/or Damaged Seedlings	Total Emergence
0	1	41	15	56	29	15	37	4	41
	2	47	17	64	20	16	18	0	18
	3	59	15	74	12	14	24	17	41
	4	64	11	75	10	15	47	1	48
2	1	52	23	75	15	10	24	7	31
	2	50	19	69	23	8	20	0	20
	3	61	16	77	11	12	36	7	43
	4	58	27	85	6	9	30	4	34
4	1	44	21	65	21	14	41	3	44
	2	47	18	65	20	15	12	0	12
	3	59	15	75	7	19	17	18	35
	4	53	16	69	14	17	30	4	34
8	1	39	26	65	22	13	25	6	31
	2	54	16	70	16	14	11	1	12
	3	57	13	70	15	15	8	20	28
	4	54	21	75	15	10	35	2	37
16	1	36	19	55	29	16	23	4	27
	2	38	18	56	26	18	2	0	2
	3	55	18	73	17	10	21	14	35
	4	59	26	85	7	8	57	0	57
24	1	42	23	65	16	19	48	0	48
	2	37	22	59	27	14	16	0	16
	3	46	14	60	20	20	38	6	44
	4	62	22	84	6	10	55	4	59

THESIS TITLE: The Effect of Five Fungicides at Six Rates of Treatment on the Germination and Emergence of Birdsfoot Trefoil, Lotus corniculatus, L.

NAME OF AUTHOR: DAVID PAUL WESTON

THESIS ADVISER: ROY A. CHESSMORE

The content and form have been checked and approved by the author and thesis adviser. "Instructions for Typing and Arranging the Thesis" are available in the Graduate School office. Changes or corrections in the thesis are not made by the Graduate School office or by any committee. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

NAME OF TYPIST: Virginia Brown Weston