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Germinability of Treated and Untreated Lots of Vegetable Seed in Pythium-Infested Soil and in the Field

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SUMMARY

Seed lots of beans, beets, carrots, onions, peas, popcorn, soybeans, spinach, sweet corn and tomatoes were obtained from several sources. Tests with treated and untreated seed were made in sand, blotters or towels using the standard methods recommended in rules for seed testing. In addition, tests were made in soil naturally infested with *Pythium debaryanum* Hesse and *Pythium graminicola* Subr. as well as in the field. Temperature and moisture conditions in the field were occasionally optimum or nearly so but more frequently the temperature-moisture relationship was such as to provide an environment far below the optimum for germination. The data obtained from the several tests are summarized herewith.

1. The percentage of normal sprouts produced by a given lot of untreated seed in sand or other substrate under optimum temperature conditions for germination was seldom indicative of its ability to germinate under conditions unfavorable for germination of the particular kind of seed.

2. Field soil (Webster silt loam pH 7.5), infested with pythiaceous fungi such as *Pythium debaryanum* Hesse and *Pythium graminicola* Subr. and mixed with two parts of sand, furnished a medium that provided conditions unfavorable for the germination of the several kinds of untreated vegetable crop seeds, if in the initial period of germination the temperature of exposure was approximately 10° C.

3. The moisture content of the infested soil had a marked effect on the percentage of emerged seedlings. The drier the soil the greater the emergence. A moisture content of about 15 percent was used as standard. The higher the moisture content the less the emergence and the greater the number of emerged seedlings that damped-off.

4. The time of exposure at 10° C. was standardized at 3 days for beans and peas, 5 days for beets, carrots, onions and tomatoes, 7 days for popcorn, sweet corn and soybeans and 21 days for spinach. With the exception of spinach seed, the containers were transferred to a higher temperature after the initial exposure in cold soil. The temperature for the completion of the test was one considered nearly optimum for the germination of the particular kind of seed.

5. The percentage of emergence from untreated seed in the "cold soil" medium was nearly always less than in sand at optimum temperature, and in many instances 30, 50 and 70 percent less. The percentage seedling emergence in the cold soil medium was considered an index of the relative susceptibility or resistance of a given seed lot to infection by soil organisms that cause seed decay and pre-emergence blight of seedlings.

6. A germination test in Pythium-infested soil as described in this bulletin gives an indication of physiological decline in vitality resulting from age of seed. Seed lots of Kanro and Lincoln soybeans 2 years old produced a much lower percentage of emergence than did 1-year-old seed of the same germinability as measured by a favorable environment. One lot of Kanro seed grown in 1943 produced 49 percent emergence in the cold soil test in 1944 and only 13.8 percent in 1945.

7. Germination tests of treated vegetable crop seeds in Pythium-infested soil at 10° C. for part or all of the germinating period were found to provide a valuable index of the protection afforded by fungicidal dusts applied to the seed. The percentage emergence of treated seed varied from one to nine times that of untreated seed.

8. Germination tests of treated and untreated seed in the cold soil medium provided a fair to good index of field response when the environment was unfavorable to germination of the particular kind, lot or variety of seed being tested.

9. Arasan (or Thiosan) was one of the most effective protectants used on all the kinds of seed included in the tests. Spergon was nearly equal to Arasan for peas, sweet corn, soybeans, popcorn and onions. Semesan Jr. was nearly equal to Arasan and Spergon as a protectant for sweet corn, popcorn and soybean seed if conditions for germination were not severe or if the seed lot in question possessed considerable resistance to an unfavorable environment for germination.

10. Fermate, Semesan, Yellow Cuprocide, Red Cuprocide, Ceresan, zinc oxide, Semesan Jr. and Barbak DX received less extensive trial than Arasan and Spergon, yet their use as seed protectants appeared to be more limited than either Arasan or Spergon.

11. A higher rate of application for both Arasan and Spergon was required for the protection of seeds during germination if the temperature-moisture combination during germination was particularly favorable to seed decay and pre-emergence blight than if conditions were more favorable for seed germination.

Germinability of Treated and Untreated Lots of Vegetable Seed in Pythium-Infested Soil and in the Field[1]

By R. H. Porter[2]

Within the past decade many investigators have reported on the effect of *Pythium* spp. and other soil-borne fungi on seed germination in the field and greenhouse (2, 6, 10). Seed decay, pre-emergence damping-off and damping-off or seedling blight have been noted as of common occurrence when environmental conditions have been unfavorable for germination and favorable for infection by soil-borne fungi. In addition, the protective power of numerous experimental and commercial compounds when applied to seeds before planting has received considerable attention (1, 3, 5, 7, 9, 12, 14, 15, 16, 17, 18, 19, 23). Reports of cooperative tests by committees of the American Phytopathological Society have appeared in the Plant Disease Reporter of the United States Department of Agriculture the past 5 years (20). These tests have shown that the extent to which treatment of seed before planting is beneficial depends on the kind and quality of the seed, the place and time of planting, the kind and amount of treatment used and the soil moisture and temperature conditions at the time of planting.

Efficient and maximum production of food and feed crops demands that the quality of seed lots be determined as accurately as possible prior to planting, and quality as pointed out by Porter (16) includes the ability of seed to resist infection by soil-borne organisms. It has become necessary, therefore, to index certain seed lots as to their probable response to conditions unfavorable for germination. In addition it is necessary to know to what extent a seed lot can be protected from soil fungi by treatment. This necessity involves the indexing of chemical compounds as to their protective power during the critical period of seed germination. Seed testing, therefore, has come to include much more than the determination of seed purity or of viability under favorable conditions.

Laboratory methods designed to measure the response of field crop seeds to soil-borne fungi and the protective power of seed fungicides have received attention by Rice (21). Leukel and Martin (10) have shown the effect of seed- and soil-borne organisms on the germination of sorghum seed but have given no comparisons

[1] Project 427 of the Iowa Agricultural Experiment Station.

[2] The writer wishes to thank W. N. Rice, Sigmund Seaman, Frank Mar and W. H. Lillard for their valuable assistance in making the laboratory and field plantings and in determining the percentage emergence.

between laboratory and field tests. Machacek *et al.* (11) used non-sterile soil as a medium for germination tests of cereal seeds. Laboratory methods are desirable if they can be so designed as to give an indication of field performance. A great saving in time is effected by laboratory tests because several seasons of field trials may be required before the proper conditions are encountered.

This bulletin reports the results of laboratory trials with treated and untreated seed of sweet corn, popcorn, peas, spinach, onions, carrots, beets, tomatoes, lima beans, garden beans and vegetable soybeans under favorable and unfavorable conditions for seed germination. It describes and illustrates a laboratory method which serves as an index not only of seed germination under unfavorable conditions but also of the protective power of seed fungicides. In most cases field tests were made to compare with laboratory trials.

MATERIALS AND METHODS

Most of the seed samples used in the experiments were obtained directly from wholesale seed firms and represented large lots that were distributed to retailers and seed growers. A few samples were supplied by project leaders of the Committee on Vegetable Seed Treatment appointed by the American Phytopathological Society. The seed treatment compounds used were obtained directly from the respective manufacturers and were applied at the rates indicated by adding the dust to seeds which were placed in a bottle and rotated on a machine used in the seed laboratory as described by Porter (14).

Normal tests of treated and untreated seed were made in blotters, towels or sand at the temperature recommended in the Rules for Seed Testing (22) except as noted in a specific case. Seedlings were classified as normal or abnormal according to the criteria listed by Porter (16).

Cold tests were made in an unsterilized mixture of two parts washed screened sand and one part soil with a pH of about 7.5, from a field of Webster silt loam at the Agronomy Farm. Tests with alfalfa seedlings and isolations from this soil indicated that *Pythium debaryanum* Hesse and *Pythium graminicola* Subr. were present. Corn has been grown on the field regularly in a 4-year rotation of corn, corn, oats and clover. The temperature of the room in which the planted lots were placed in the initial period of the tests was about 10° C., and the duration of such exposure varied with the kind of seed. Transfers were made to a higher temperature (except with spinach seed) for the completion of the test as indicated for each kind of seed. Hereafter in this bulletin the term "cold soil" is used to mean Pythium-infested soil at an initial temperature of 10° C.

The mixing of the soil, sand and water was done as described by

Rice (21), and his tensiometer method of adjusting soil moisture was employed. The moisture content was about 15 percent. The top of the soil in each pan or flat was covered with a moistened blotter to prevent evaporation, and moisture was added as necessary to keep the blotters moist but not wet.

Field tests were made in Webster silt loam soil with a pH of 7.4 to 7.5 and each sample was replicated several times in randomized blocks with a design to fit the particular experiment. Analyses of the field data were usually made by the analysis of variance or other appropriate method.

EXPERIMENTAL RESULTS BY CROPS

PEAS

In March 1943, the American Phytopathological Society Committee on Vegetable Seed Treatment sent to several cooperators some treated and untreated samples of peas of the Thomas Laxton variety. Two sets were requested by the writer for the purpose of making a laboratory test to compare with the field test.

The treatment compounds used were Spergon, Thiosan and Fermate, each at the rates of .084 percent, .168 percent and .335 percent by weight. Field plantings were made early in April using a restricted random arrangement of five replications with 10 rows per replication and 100 seeds per row. Each row was 8 feet long, and the rows were separated by 2 feet. Stand counts were made in May.

Early in May, 4 x 100 seeds of each sample were planted in the greenhouse in cold soil in flats. The replicates were randomized so that only one replicate was planted in any one flat. The seeds were covered with an inch layer of the mixed sand and soil, and the flats were placed in a room with a constant temperature of 10° C. At the end of 3 days the flats were removed to a room with a tempera-

TABLE 1. LABORATORY AND FIELD GERMINATION OF THOMAS LAXTON PEAS, 1943.

Treatment		Percent germination	
		Laboratory cold soil*	Field
Untreated	......	49.8	71.4
Spergon	.084%	74.0	91.2
Spergon	.168%	90.8	90.6
Spergon	.335%	91.0	83.2
Thiosan	.084%	75.2	93.4
Thiosan	.168%	84.5	85.6
Thiosan	.335%	91.2	89.0
Fermate	.084%	78.2	87.4
Fermate	.168%	79.5	89.8
Fermate	.335%	86.8	91.4

*Soil naturally infested with *Pythium* spp. Three days at 10° C. followed by 5 days at 23-24° C.

ture of 23° to 24° C. Stand counts were made after 7 days at the higher temperature.

The results of the greenhouse and field trials are given in table 1. The data from the tests in cold soil show a highly significant difference in percentage of normal seedlings as between the untreated and all of the treated lots of seed. The heaviest dosage of each compound apparently gave the most protection. Similarly the percentages of germination of all treated samples in the field are significantly higher than the untreated. The least difference for significance as shown by the analysis of variance is 9.564, which added to 71.4, the percentage germination of untreated, is 81. Since none of the treatments gave significantly different percentages of germination, one might conclude that either of the three dosages was satisfactory, yet for both Spergon and Thiosan the lowest dosage gave the highest emergence.

It is evident that the conditions for germination were not as severe in the field as in the cold soil in the laboratory, hence a heavy dosage was not required. In the cold soil the heavy dosage was required for the maximum protection. The results of this experiment suggest that the conditions of the cold soil test may have been too severe, yet they do provide information as to the relative protective power of three seed fungicides.

In 1944 a second lot of treated and untreated seed of the Thomas Laxton variety was received from the same source as in 1943. The treatments were Arasan and Spergon at two rates of application and red copper oxide at one rate. The tests made were similar to those in 1943 except that one was made in sterilized sand at 20° C. The results are given in table 2.

The tests made in sterile sand show that no organisms capable of injury at 20° C. were present on the seed, because the untreated seed germinated as well as the treated. In the cold soil, however, the untreated seed was severely reduced in percentage of emergence, presumably by an attack of *Pythium* spp. alone or in com-

TABLE 2. LABORATORY AND FIELD GERMINATION OF THOMAS LAXTON PEAS, 1944.

Treatment	Percent germination			
	Laboratory		Field	
	Sand 20° C.	Cold soil*	First planting	Second planting
Untreated	97.5	49.8	89.4	94.4
Arasan.........1.5 oz.	97.8	84.8	95.8	95.8
Arasan.........2.0 oz.	98.0	87.5	95.2	96.8
Spergon.......1.5 oz.	98.5	91.8	96.2	95.4
Spergon.......2 0 oz.	99.0	94.5	97 2	96.8
Red Cuprocide	98.8	87.2	97.4	92.2

*Soil naturally infested with *Pythium* spp. Three days at 10° C. followed by 5 days at 23-24° C.

bination with other organisms. Arasan and red copper oxide were about equally effective in their protective power, and Spergon appeared slightly superior to both the other compounds. Two field plantings were made, one on April 17 and the other on April 28. Stand counts were made May 16 and May 29, respectively. The emergence in the plot planted first showed that all the treatments were about equally effective and gave significantly higher emergence than the untreated. The analysis of variance showed that the least difference for significance between means of the replicates was 4.23. Emergence in the second field planting was similar for all the treatments, including the untreated, which indicated that conditions for germination were so favorable that no protection for this particular lot of seed was needed at the time of planting.

TESTS WITH VARIETIES OF PEAS

Early in 1943, seed of 33 varieties of peas was obtained from a seed company. Each sample was divided into three parts, of which one was left untreated and the other two were treated separately, one with Arasan, the other with Spergon, each at the rate of .208 percent by weight. Plantings of 200 seeds per lot were made in sand at 20° C., and two plantings of 400 seeds each were made in cold soil as previously described. In 1944 treated and untreated seed of each variety was planted in the field on April 28, when soil conditions were optimum. The germination counts were made May 29 and 31.

The field planting plan was so arranged that 36 lots of seed were required, which meant that 3 lots were added to the original 33. A triple lattice 6 x 6 split-plot plan was used. There were three replications, and the 36 lots were randomized in each replicate. The rows were 8 feet long and 2 feet apart, and an alley 2 feet wide was left between each range. The three treatments for each lot were also randomized. The arrangement in the second replication is shown below. In each row 100 seeds were planted.

PLANTING PLAN FOR 36 LOTS OF TREATED AND UNTREATED PEA SEED IN 1944.

Replication 2. Numbers represent lot numbers, and letters represent treatments.

18 SCA	24 CAS	6 CSA	36 SAC	30 SCA	12 ACS
11 SAC	17 ASC	35 SCA	29 CAS	5 CSA	23 ACS
21 ACS	15 SAC	27 CAS	33 CSA	9 SCA	3 ASC
19 ASC	13 SAC	25 CSA	31 CAS	7 ACS	1 SCA
14 SAC	2 SCA	8 ACS	26 CSA	32 CAS	20 ASC
28 CSA	16 SAC	34 CAS	4 SCA	22 ASC	10 ACS

In the planting plan A=Arasan, C=untreated and S=Spergon. Each replication was 18 rows wide and 6 rows long.

TABLE 3. PERCENTAGE LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF 33 VARIETIES OF PEAS, 1943-44.

Variety and sample no.	Laboratory						Field		
	Sand 20° C.			Cold soil**					
	Ch.*	Ar.*	Sp.*	Ch.	Ar.	Sp.	Ch.	Ar.	Sp.
Onward.................. 1	89	93	90	7.0	72.5	66.5	86	87	85
Pride..................... 2	96	95	97	27.2	88.5	69.2	81	86	82
Glacier.................... 3	95	96	95	8.5	63.0	59.0	86	83	87
World's Record........... 4	91	95	94	10.7	67.7	73.0	88	92	91
Perfection................ 5	96	97	100	14.7	76.5	70.7	92	92	93
Teton..................... 6	91	95	94	4.2	26.2	33.0	70	76	73
Premium Gem............. 7	87	94	93	5.5	49.1	52.5	79	82	84
Mamm. Pod-Early......... 8	85	92	86	22.2	71.5	78.0	87	87	89
Gradus.................... 9	95	95	96	9.2	54.5	55.0	78	86	78
Thomas Laxton............10	97	97	97	16.7	83.5	82.5	89	93	90
Alderman (Dwarf).........11	85	85	83	6.0	39.2	44.5	63	61	69
Major.....................12	95	97	99	17.5	76.0	81.0	93	98	92
Alaska....................13	94	95	98	28.2	85.7	87.2	92	93	96
Nott's Excelsior..........14	97	97	95	18.2	52.7	56.0	72	83	79
Laxton's Progress.........15	98	99	96	4.4	80.6	72.7	83	90	90
Hundredfold...............16	87	83	88	9.0	76.5	76.5	81	73	81
H 40......................17	84	89	87	1.7	44.0	44.5	65	83	75
Canner King...............18	98	98	92	45.8	74.4	72.8	86	83	84
Dwarf Telephone..........19	90	98	88	18.9	55.2	49.9	44	56	54
Alderman.................20	97	95	96	3.2	58.5	66.7	75	80	75
Multifold.................21	95	96	93	4.7	49.7	53.7	73	82	78
Early Harvest.............22	99	100	98	7.7	75.7	70.0	88	93	92
Laxton's Superb...........23	60	76	77	7.7	53.7	58.5	69	70	69
Bountiful.................24	56	76	73	3.7	46.5	52.5	68	72	73
Shasta....................25	93	96	94	12.2	54.2	73.4	83	84	86
Res. Surprise.............26	95	98	96	7.0	64.7	65.2	89	92	92
Strategem.................27	95	92	96	22.8	79.4	72.6	87	94	86
Rice's Early Dwarf........28	90	97	98	29.0	85.1	83.1	86	86	89
Improved Gradus..........29	87	87	86	19.0	69.5	75.5	85	89	86
President Wilson..........30	89	94	89	1.7	41.2	47.5	79	79	80
Little Marvel.............31	89	88	93	29.5	60.1	71.5	71	72	79
Climax....................32	100	99	99	20.2	86.7	88.2	93	95	88
Profusion.................33	98	98	95	49.8	73.3	77.1	91	92	91
Totals....................	2993	3082	3051	493.8	2135.6	2183.0	2652	2764	2736
Mean......................	90.7	93.4	92.4	14.9	64.7	66.2	80.4	83.8	82.9

*Ch.=Check, untreated; Ar.=Arasan; Sp.=Spergon.
**Soil naturally infested with *Pythium* spp. Three days at 10° C., 5 days at 23-24° C.

The data obtained from the laboratory and field are given in table 3, showing the germination in sand at 20° C, germination in cold soil and germination in the field. The data from the three extra lots are omitted because they are not pertinent to this study. In the sand test at 20° C. all lots gave good percentages of germination except nos. 23 and 24, and in only about six instances were the germinations from treated seed significantly higher than from untreated seed. In the cold test the average of two tests with each lot gave exceptionally low germination from untreated seed. The treatments, on the other hand, gave unusually good protection and the differences between the germination of treated and untreated seed are highly significant. It is believed that the low emergence of seedlings from untreated seed was caused by the exposure at 23° to 24° C. after the 10-day period at 10° C. Evidence for this belief is presented in a subsequent experiment.

Germination of the seed in the field was about 10 percent lower than in sand but much higher than in cold soil. With a few exceptions there is good correlation between the sand and field readings but none between the cold test results and those in the sand or field. There are two factors that may account for the lack of close relationship between the cold soil test and the field response. In the first place the conditions for germination in the field were highly favorable at the time of planting, and in the second place the cold test was exceedingly severe. The response of lots 6, 7, 9, 11, 14, 15, 17, 19, 20, 21, 30 and 31 in the field is of interest because they did not germinate as well as most other lots. Such response would not be expected from the sand test. Since all seed lots represented seed produced in 1942 it is probable that aging of the seed was an important factor. The vitality of some varieties or lots was possibly less resistant to aging than others.

Analysis of variance of field data showed that the differences between the means of untreated and treated seed were highly significant, the least difference for significance being 1.33 at the 1 percent point.

In the spring of 1944, seed from 10 lots of Alaska and Superalaska peas was obtained and treated in the same manner as described for the 33 varieties obtained in 1943. The data from the sand test, the cold test and the field plots are given in table 4. It is noteworthy that the individual and average response of these lots in cold soil was much better than that of the 33 lots tested in 1943. The field plantings were made April 28 when soil conditions were favorable for germination, and the correlation between the sand test and the field test was high. The higher relative germination in the field of these 10 lots than of the 33 lots may have been caused largely by a year's difference in age of seed. On the other hand, the difference in resistance in the cold soil test was undoubt-

TABLE 4. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF ALASKA AND SUPERALASKA PEAS, 1944.

		Percent germination								
		Laboratory						Field		
		Sand 20° C.			Cold soil*					
Variety	No.	Untr.	Ar.	Sp.	Untr.	Ar.	Sp.	Untr.	Ar.	Sp.
Alaska	1	95.5	96.5	97.0	68	81	86	96.2	96.4	97.6
Alaska	2	97.0	97.0	98.0	67	88	90	97.8	95.6	95.0
Superalaska	3	97.0	95.5	97.5	76	96	96	95.4	91.2	94.6
Superalaska	4	97.0	96.5	97.0	90	92	96	97.2	96.4	96.0
Superalaska	5	94.0	93.5	96.0	86	83	85	94.0	94.6	94.4
Superalaska	6	91.0	97.5	96.5	79	92	92	95.4	93.0	93.2
Superalaska	7	95.0	97.5	98.5	86	97	95	96.2	94.6	97.2
Superalaska	8	97.5	95.0	95.5	58	89	92	94.6	94.6	95.2
Superalaska	9	96.5	97.5	96.5	69	92	92	94.8	94.2	94.6
Superalaska	10	93.0	90.5	94.0	61	91	90	91.0	91.4	93.2
Mean		95.4	95.7	96.7	74	91.1	92.4	95.3	94.2	95.1

*Soil naturally infested with *Pythium* spp. Three days at 10° C., 5 days at 23-24° C. Ar.=Arasan, Sp.=Spergon.

edly caused by inherent differences in resistance to *Pythium* spp. at low temperatures. Alaska and Superalaska are varieties with starchy, non-wrinkled seeds, whereas 32 of the 33 varieties subjected to the cold test in 1943 were varieties with wrinkled seeds and a higher sugar content than Alaska and Superalaska.

TESTS IN 1945

In the spring of 1945, two lots of Pride and three lots of Thomas Laxton peas were obtained from a seed producer. Each lot was divided into four fractions. One fraction was retained untreated, the other three were treated with Arasan, Ceresan (1 percent) and Spergon each at the rate of .208 percent by weight. Plantings were made using 200 seeds of each subsample on cellucotton and 200 in sand at 20° C. On the cellucotton, readings were made for normal and abnormal seedlings, dead, decayed and partially decayed cotyledons and for seeds or seedlings infected with either *Fusarium* spp. or saprophytic organisms. The data obtained from the cellucotton and sand tests are given in table 5. In the sand tests the germination of untreated and treated seed was much the same except for Thomas Laxton lot 3. On cellucotton it is noteworthy that the three fungicides markedly reduced fungous infection and in general resulted in a higher percentage of normal seedlings than when

TABLE 5. GERMINATION OF TREATED AND UNTREATED SEED OF PRIDE AND THOMAS LAXTON PEAS ON CELLUCOTTON AND SAND. IOWA, 1945.

			Percentages							
				Cellucotton						
									Infection	
Variety Lot	Treatment	No. Seeds	Sand	N*	Ab*	D*	Decayed	Partially decayed	Fusarium	Saprophytes
Pride 1	Untreated	200	89	75	3	22	22	4	1	27
	Arasan	200	89	87	5	8	8	2	1	4
	Ceresan	200	89	86	9	5	5	6	0	0
	Spergon	200	95	87	7	6	0	2	0	0
Pride 2	Untreated	200	91	89	5	6	6	5	2	13
	Arasan	200	94	93	3	4	1	3	0	3
	Ceresan	200	94	90	5	5	4	2	0	0
	Spergon	200	95	91	6	3	1	3	0	0
Thomas Laxton 1	Untreated	200	97	89	4	7	3	1	1	3
	Arasan	200	94	95	2	3	1	2	0	0
	Ceresan	200	95	92	4	4	2	1	0	0
	Spergon	200	93	92	4	4	2	3	0	0
Thomas Laxton 2	Untreated	200	92	87	2	11	10	4	3	11
	Arasan	200	96	92	5	3	1	2	0	0
	Ceresan	200	92	90	3	7	6	5	0	1
	Spergon	200	95	90	3	7	7	3	0	1
Thomas Laxton 3	Untreated	200	88	68	5	27	26	4	2	86
	Arasan	200	92	80	9	11	12	9	0	6
	Ceresan	200	93	71	9	20	19	7	0	3
	Spergon	200	94	75	8	17	19	4	0	2

*N=Normal, Ab=abnormal, D=dead.

TABLE 6. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF PRIDE AND THOMAS LAXTON PEAS. IOWA, 1945.

Variety	No.	Percentages normal emerged seedlings											
		Laboratory cold soil								Field			
		First*				Second**							
		Untreated	Arasan	Ceresan	Spergon	Untreated	Arasan	Ceresan	Spergon	Untreated	Arasan	Ceresan	Spergon
Pride	1	83.2	89	87	90.5	17.8	57.0	32.0	58.8	63.5	80.2	66.2	79.2
	2	84.8	93	91	92.0	33.8	83.2	53.5	72.8	86.8	88.0	87.8	87.0
Thomas Laxton	1	91.8	93	90	91.2	55.8	71.2	58.8	60.0	82.8	89.5	86.0	91.8
	2	88.2	91 8	91.2	90.2	55.0	66.8	60.5	73.2	87.2	86.0	84.5	87.2
	3	72.2	85 5	84 0	89.5	11.2	45.0	28.2	55.8	75.2	86 2	72.8	85.8

*First test means 3 days in Pythium-infested soil at 10° C. + 9 days at 20° C. Soil somewhat dry.
**Second test means 3 days in Pythium-infested soil at 10° C. + 6 days at 23-24° C. Soil moist (15%).

no treatment was used. The difference in germination of seeds planted on cellucotton and in sand is of interest. The seeds on the cellucotton were covered with moist paper towels until the epicotyls were an inch or more in length. This cover helped to keep the seeds moist, yet the average percentage of normal seedlings was significantly greater in the sand test.

The laboratory test in soil naturally infested with species of Pythium was made twice using 400 seeds per treatment. In the first test, the pans were placed at 20° C. after exposure to 10° C. for 3 days, and in the second the flats were placed at a temperature of 23–24° C. after 3 days at 10° C. The soil in the first test was somewhat drier than in the second test. Field plantings were made in April in a randomized block similar to the plan used in the previous year except that each treatment of a given lot was replicated five times.

The percentage emergence in the laboratory and field of each treated and untreated lot is given in table 6. In the first laboratory test in cold soil with both lots of Pride and lot 3 of Thomas Laxton, the untreated seed produced significantly fewer seedlings than did the treated, with no particular difference among the three treatments. In the second test in cold soil all the untreated subsamples gave much less emergence than seed treated with either Arasan or Spergon, but Ceresan gave much less protection. The inability of Ceresan to afford adequate protection is further illustrated in the field test by the results with Pride lot 1 and Thomas Laxton lots 1 and 3. It appears that under adverse conditions for germination in the laboratory or field it is possible to more nearly evaluate the protective power of seed fungicides than can be done under conditions more favorable to seed germination. The data in table 6 also show clearly the effect on germination of untreated seed when the moisture content of the soil is low or high.

SWEET CORN

In March 1943, the writer received treated and untreated seed samples of Golden Cross Bantam sweet corn from the Committee on Vegetable Seed Treatment of the American Phytopathological Society. The treatments used were Spergon and Arasan each at the rates of .75, 1.5 and 3.0 ounces per bushel, and Semesan Jr. at 1.5 ounces per bushel. Subsamples from each of the 8 treated lots (including untreated) were counted in 5 replicates of 100 kernels each and planted in the field in rows 8 feet long and 2 feet apart. The subsamples were randomized in replicates of eight rows per replication. On the date of planting, April 16, soil moisture was optimum. Stand counts were made May 11, and the data were recorded as emerged seedlings per row.

In May 1943, subsamples from each of the eight treated samples were planted in Pythium-infested soil in the greenhouse, using 4 x 100 kernels for each treatment. The flats containing the seeds were kept at 10° C. for 7 days, then transferred to a room with a temperature of 26-28° C. Within 4 days after the transfer the number of emerged seedlings from each subsample of 100 kernels was recorded.

The data obtained from the field and greenhouse tests are given in table 7. The field data were evaluated by an analysis of variance. It was found that there were significant differences and that the least difference between the means that was required for significance was 4.64; hence all of the Arasan treatments and two of the Spergon treatments gave a significantly higher percentage of emergence than was obtained from untreated seed. In the cold soil test in the greenhouse all treatments gave an emergence significantly greater than was obtained from untreated seed, but Arasan at the rates of 1.5 and 3.0 ounces per bushel was outstandingly superior in protective value to the other treatments. In both field and laboratory tests Arasan and Spergon averaged considerably better than Semesan Jr. at the rate of 1.5 ounces per bushel, which is the rate recommended by the manufacturer.

In March 1944, seed of Ioana sweet corn was received for field planting from the American Phytopathological Committee. The seed was of much lower quality than that of the Golden Cross Bantam used in the 1943 cooperative test. The untreated seed gave 67 percent germination in the laboratory test. Planting was made in the field on April 17 using the same arrangement as in 1943 except that there were nine treatments instead of eight. Stand counts were made May 16 giving mean percentage emergence as follows:

	Rate of application ounces per bu.	Percentage emergence
Untreated		5.2
Barbak C	1.5	6.8
Barbak C	3.0	8.4
Semesan Jr.	1.5	9.2
Semesan Jr.	3.0	16.8*
Arasan	1.5	34.6*
Arasan	3.0	42.8*
Spergon	1.5	23.0*
Spergon	3.0	31.8*

Analysis of variance of the data showed significant differences and showed that the least difference between means for significance was 6.7. The figures starred indicate the treatments which gave a significantly higher emergence than was obtained from untreated seed. The data further indicate that for this particular lot of seed, Arasan at either rate of application gave greater protection than any other treatment except Spergon at the rate of 3.0 ounces per bushel. Soil moisture and temperature from April 17 to May 5 were unfavorable for the germination of sweet corn seed, and the

TABLE 7. PERCENT EMERGENCE FROM TREATED AND UNTREATED SEED OF GOLDEN CROSS BANTAM SWEET CORN IN THE FIELD AND IN GREENHOUSE SOIL NATURALLY INFESTED WITH *Pythium* spp. AMES, IOWA, 1943.

Treatment	Emergence in	
	Field	Cold soil 10° C. 7 days 26-28° C. 4 days
Untreated	77.4	64.8
Semesan Jr. 1.5 oz.	81.0	79.5*
Arasan .75 oz.	85.8*	78.5*
Arasan 1.5 oz.	84.0*	91.8*
Arasan 3.0 oz.	84.2*	91.8*
Spergon .75 oz.	82.4*	86.5*
Spergon 1.5 oz.	80.0	80.5*
Spergon 3.0 oz.	86.4*	85.0*

*Significantly higher than untreated.

results show clearly what may happen if untreated seed of low quality is planted when conditions for germination are unfavorable.

TESTS WITH SEED OF SWEET CORN HYBRIDS

In the early spring of 1944, seed of 17 lots of sweet corn grown in Idaho was obtained from a seed company. Each lot was divided into four subsamples of which one was used as a check (untreated) and the other three were treated with Arasan, Barbak DX and Spergon, each at the rate of 2 ounces per bushel (.223 percent by weight). Germination of the untreated seed was tested by the seed company, and the percentages are given in table 8. Each subsample of treated and untreated seed was planted in cold soil with 4 replicates of 100 seeds each. Planting was randomized so that one untreated replicate and three treated replicates were planted in each flat. The flats were kept at 10° C. for 7 days, then transferred to a temperature of 26–28° C. for 4 days. The total emergence from each subsample of 100 kernels was determined at the end of the test. The data are given in table 8. Field plantings were made April 28 using 50 seeds per row, 4 feet long, with three replications of each subsample. Stand counts for total emergence were made May 20, and the data are presented in table 8.

An examination of the data reveals several interesting comparisons. Of primary interest is the fact that the percentage germination of untreated seed in the laboratory was no indication of its germination in cold soil in this particular experiment. In other words, the germination of sweet corn seed under favorable conditions may be entirely different from its response to adverse conditions. Furthermore, the environment provided by the combination of low and high temperature in unsterilized soil was more severe than that in the field for untreated seed. A comparison of the response of untreated seed of the 17 lots in cold soil with that in the field reveals some lack of correlation, yet the four samples that

TABLE 8. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SWEET CORN SEED FROM 17 LOTS PRODUCED IN IDAHO IN 1943. AMES, IOWA, 1944.

Variety	Lab. no.	Description	Date dried	Laboratory C*	Percentage emergence							
					Cold soil				Field			
					C*	A*	B*	S*	C*	A*	B*	S*
Golden Cross Bantam	1	Dried on the ear	10/14/43	99	32.5	65.0	34.8	75.0	68.0	72.6	55.4	74.8
" " "	2	Shelled, then dried	11/27	88	34.5	69.8	55.5	67.5	62.6	63.4	47.4	60.0
" " "	3	Combined, then dried	12/11	84	47.5	82.0	67.0	76.8	49.4	80.6	49.4	82.6
" " "	4	Combined, then dried	12/3	86	16.0	73.5	27.8	61.8	36.0	62.6	25.4	58.6
" " "	5	Dried on the ear	11/6	96	47.8	89.3	65.5	85.5	52.6	72.0	47.4	71.4
" " "	6	Dried on the ear	10/14	95	65.5	90.3	72.3	88.8	51.4	70.6	52.0	78.0
" " "	7	Shelled, then dried	12/31	78	49.3	67.8	53.8	69.8	55.4	64.6	48.6	70.6
" " "	8	Shelled, then dried	12/11	80	44.8	78.0	50.3	77.0	53.4	58.6	49.4	68.6
Golden Hybrid	9	Combined, then dried	11/27	87	33.5	86.3	44.8	83.3	52.6	64.6	41.4	59.4
Golden Hybrid	10	Dried on the ear	10/29	98	24.8	87.5	27.8	82.8	57.4	86.0	47.4	77.4
Ioana	11	Dried on the ear	12/11	98	25.5	93.5	21.5	64.3	56.0	75.4	47.4	65.4
Ioana	12	Combined, then dried	12/11	89	9.8	79.0	17.8	54.8	44.0	58.0	46.0	61.4
Ioana	13	Dried on the ear	10/7	99	45.0	92.5	48.8	79.8	70.6	75.5	52.0	71.4
Marcross	14	Combined, then dried	11/6	98	12.3	79.8	13.8	61.8	64.0	70.6	54.0	67.4
Marcross	15	Dried on the ear	9/22	97	32.0	83.5	33.3	74.0	64.6	74.6	56.6	67.4
Tendergold	16	Dried on the ear	11/6	95	28.7	91.7	26.0	79.3	59.4	78.6	41.4	70.6
Tendergold	17	Combined, then dried	11/27	91	9.3	80.5	9.8	62 5	54.6	65.4	50.6	73.4
Means	....	....	....	91 6	32.8	82.0	39.8	73.2	56.0	70.2	47.7	69.3

*C=Check (untreated), A=Arasan, B=Barbak DX, S=Spergon, each .223 percent by weight.

gave the lowest germination (samples 4, 12, 14 and 17) were among the lowest in the field.

The exceptional protective power of both Arasan and Spergon to all lots in unsterilized soil in the laboratory experiment is of great importance. For example, the emergence from Arasan-treated seed exceeded that from untreated seed by 450 percent for sample 4, 800 percent for sample 12, 650 percent for sample 14 and nearly 900 percent for sample 17. The emergence from sample 11 was increased from 25.5 to 93.5 percent by treatment. In the field test the protective power of Arasan and Spergon was not so marked as in the laboratory, yet it was of considerable significance. With the exception of three lots the emergence from seed treated with these two protectants was higher than that from untreated seed. Barbak DX gave very little protection in the laboratory test and apparently caused some injury in the field test.

The variable response of these 17 lots of untreated sweet corn seed in the cold soil in the laboratory as well as in the field suggests a marked difference in their resistance to Pythiaceous fungi during the period of germination. The factors affecting this resistance are too numerous to determine which one is more important in this experiment. Of the eight Golden Cross Bantam lots, those that were harvested with a combine and then dried apparently had less resist-

TABLE 9. GERMINATION AND FUNGOUS INFECTION OF TREATED AND UNTREATED SEED OF 22 LOTS OF SWEET CORN ON TOP OF MOIST BLOTTERS, 20-30° C. 1945.

(100 seeds used for each subsample.)

Sample no.	Percentage normal seedlings and fungus-infected seed											
	Untreated			Arasan			Semesan Jr.			Spergon		
	N*	F*	Sap*	N	F	Sap	N	F	Sap	N	F	Sap
1	94	6	70	93	1	26	94	2	40	94	0	34
2	95	3	36	97	1	6	95	3	36	96	1	30
3	92	1	77	95	1	7	95	1	7	94	0	17
4	83	3	46	91	0	6	86	1	20	78	1	16
5	95	2	69	97	2	6	98	0	8	95	0	12
6	92	8	53	96	0	5	92	1	15	93	0	13
7	88	6	64	89	2	12	89	5	24	89	4	25
8	80	4	64	82	3	9	83	3	22	81	2	31
9	89	3	72	94	2	25	93	2	26	91	2	32
10	85	8	65	88	3	22	86	3	23	89	0	27
11	87	0	49	93	0	15	92	2	22	91	0	19
12	79	2	90	83	1	6	84	2	21	84	0	20
13	90	2	96	92	1	21	92	3	26	93	2	28
14	96	2	32	95	0	4	95	0	5	94	0	7
15	94	2	63	95	0	16	91	2	29	94	0	18
16	84	11	60	93	3	22	91	3	48	88	0	26
17	86	2	64	92	2	16	90	3	18	91	0	16
18	86	0	92	90	0	6	92	0	5	89	0	12
19	92	0	65	95	0	8	96	0	10	95	0	15
20	77	0	75	83	0	20	78	0	30	79	0	25
21	85	0	88	91	0	22	90	0	23	90	0	60
22	88	0	85	93	0	9	90	0	19	90	0	17
Means	88.0	2.9	67.0	91.7	1	13.1	90.5	1.6	21.7	89.9	.5	22.7

*N=Normal, F=Fusarium, Sap=Saprophytes.

ance in both laboratory and field than those dried on the ear or shelled and then dried. It is to be noted that the four lots (4, 12, 14 and 17) with the lowest percentage of emergence in the cold soil were all combined and then dried.

In 1945, seed of 22 lots of sweet corn grown in Idaho was obtained for laboratory and field tests. Each sample was divided into four subsamples; one was retained as an untreated check, and each of the other three was treated with Arasan, New Improved Semesan Jr. and Spergon, each at the rate of .223 percent by weight.

A germination test was made on cellucotton using 200 seeds per subsample at 26–28° C. The percentages of normal sprouts and of kernels infected with species of Fusarium and saprophytic fungi are recorded in table 9. The development of saprophytic forms on the untreated seed of all lots was marked, yet reduction in germination either by these forms or by *Fusarium* spp. was minor. All three of the treatments gave marked control of the seed-borne fungi.

A second test was made in cold soil using 400 seeds from each subsample. The flats containing the seeds were kept at a temperature of 10° C. for 7 days, then transferred to a temperature of 26–28° C. At the end of 4 days after the transfer, emergence counts were made. The data are given in table 10.

For the field trials 3 x 100 seeds from each subsample were prepared and planted in a split-plot arrangement similar to that used for peas (table 3). Two composite lots were added to make 24 lots, which made it possible to arrange each replication with 4 ranges each with 6 lots of treated and untreated subsamples of 100 seeds each. There were three replications in the entire plot, which was 48 feet wide and 120 feet long. The plot was planted April 14 and stand counts were made May 15. The complete data are shown in table 10.

As was noted in the 1944 test there was no correlation between the germination on cellucotton and that in cold soil, although the variation among the 22 lots tested in unsterilized soil was less than among the 17 lots tested in 1944. The lowest test was 19.5 (no. 13) and the highest was 77.8 (no. 15). The correlation between the emergence from untreated seed in unsterilized soil in the laboratory and in the field was .655, thus indicating that field conditions for germination were severe and that the laboratory test in cold soil provided an excellent index of response in the field.

The value of Arasan and Spergon as seed protectants for sweet corn seed was well demonstrated by this experiment. The correlation between the test in unsterilized soil and in the field for each protectant was .66, .71 and .31, respectively. Semesan Jr. gave some protection but was inferior to both Arasan and Spergon in practically all cases. It is noteworthy that the germination of samples 11, 14 and 15 when treated with Semesan Jr. was nearly as high as when treated with either Arasan or Spergon, and those

TABLE 10. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SWEET CORN SEED FROM 24 LOTS PRODUCED IN IDAHO IN 1944. AMES, IOWA, 1945.

Variety	Lab. no.	Description	Date harvested	Germination on cellucotton	Percentage emergence							
					Cold soil				Field			
				C*	C*	A*	B*	D*	C*	A*	B*	D*
Golden Cross Bantam....	1	Dried on the ear............	12/ 7/44	94	48.5	90.2	53.5	82.8	54	87	71	79
" " "	2	Combined, then dried........	12/21/44	95	43.5	90.5	58.8	81.0	74	78	67	84
" " "	3	Dried on the ear............	11/23/44	92	47.0	88.5	63.5	77.8	60	81	63	79
" " "	4	Shelled, then dried...........	12/15/44	83	49.8	87.0	61.5	79.5	52	82	64	79
" " "	5	Combined, then dried........	11/23/44	95	52.5	96.0	62.2	85.2	67	92	74	90
" " "	6	Shelled, not dried...........	12/29/44	92	40.2	93.2	64.0	83.0	65	93	74	81
" " "	7	Dried on the ear............	12/ 7/44	88	42.2	82.8	63.2	78.0	35	74	51	60
" " "	8	Dried on the ear............	10/ 4/44	80	57.2	93.2	58.8	85.8	60	90	66	80
" " "	9	Shelled, then dried...........	12/21/44	89	40.2	77.2	56.0	79.5	41	74	60	69
" " "	10	Combined, then dried........	11/22/44	85	47.0	88.5	69.2	86.8	56	73	79	70
" " "	11	Combined, then dried........	12/21/44	87	70.8	94.5	81.8	91.0	61	87	72	84
" " "	12	Combined, then dried........	12/21/44	79	28.8	83.8	51.0	79.0	56	79	65	79
" " "	13	Combined, then dried........	12/13/44	90	19.5	86.8	61.8	81.5	29	80	55	75
" " "	14	Dried on the ear............	10/30/44	96	72.8	93.5	84.2	88.8	72	85	81	85
" " "	15	Combined, not dried.........	12/15/44	94	77.8	93.8	88.2	95.8	86	96	91	95
" " "	16	Shelled, then dried...........	12/13/44	84	61.0	87.0	74.0	79.5	66	79	74	81
Golden Hybrid 2439......	17	Shelled, then dried...........	12/29/44	86	65.5	90.5	87.5	92.2	67	77	74	65
Golden Hybrid 2439......	18	Combined, then dried........	12/ 7/44	86	59.0	91.2	79.0	87.5	39	92	77	82
Golden Hybrid 2439......	19	Dried on the ear............	12/ 1/44	92	48.8	94.0	74.5	90.8	69	73	80	73
Carmelcross.............	20	Dried on the ear............	12/ 7/44	77	54.0	72.0	68.5	73.5	52	67	63	68
Sachem.................	21	Dried on the ear............	12/ 4/44	85	43.0	87.5	71.5	86.2	48	70	71	63
Sachem.................	22	Dried on the ear............	11/24/44	88	50.8	95.2	69.0	93.5	68	88	79	87
Composite.............	23	Not treated on cellucotton ...	....	....	15.2	87.0	38.5	71.0	40.	85	53	77
Composite.............	24	Not treated on cellucotton....	....	....	64.0	94.0	76.0	73.0	72	79	74	79
Means.................	....	....	....	....	50.0	89.1	67.3	83.5	58.2	82.0	69.0	78.0

*C=Untreated, A=Arasan .223 percent, B=Semesan Jr. .223 percent, D=Spergon .223 percent by weight.

three possessed the most resistance to conditions adverse for germination. In subsequent tests it will be noted that Semesan Jr. is almost equal to Arasan and Spergon under conditions fairly favorable for germination or with lots less affected by adverse conditions. When a combination of severe conditions for germination and susceptible samples occurs, Semesan Jr. appears to have less protective power than either Arasan or Spergon.

POPCORN

In the winter of 1945 an Iowa popcorn producer sent the writer two samples of hybrid popcorn seed for germination test. Four other samples were obtained from Dr. J. C. Eldredge of the Agronomy Department. These lots were subdivided and treated in the same manner as the 22 lots of sweet corn seed to which reference has previously been made. The data obtained are given in tables 11 and 12 and are largely self-explanatory. The comparative protec-

TABLE 11. VIABILITY AND FUNGOUS INFECTION OF TREATED AND UNTREATED SEED OF SIX LOTS OF POPCORN GROWN IN IOWA IN 1944 AND TESTED ON CELLUCOTTON. AMES, IOWA, 1945.

Sample no.	Treatment	Percentage			Percentage infection				
		Normal	Ab-normal	Dead	D*	Gib*	Nig*	Fus*	Sapr*
1	Untreated	96	1.5	2.5	2.5	0.5	2	5.0	11.5
2	"	91	3.5	5.5	1.0	4.5	0	7.0	4.5
3	"	96.5	3.0	.5	0	0	0	1.5	24.0
4	"	98	1.0	1.0	0	0	0	0	40.5
5	"	96	1.5	2.5	0.5	2.5	....	3.0	11.0
6	"	96.5	2.0	1.5	1.0	0.5	1.5	0.5	2.0
Mean	"	95.7	2.1	2.2	0.9	1.3	0.6	2.8	15.6
Mean	Arasan	97.4	1.5	1.1	0.1	0	0	0.1	1.1
Mean	Semesan Jr.	97.8	1.0	1.2	0.5	0	0	0	1.8
Mean	Spergon	98.4	1.0	0.6	0.4	0	0.4	0	0.9

*D=*Diplodia zeae*, Gib=*Gibberella saubinetii*, Nig=*Nigrospora oryzeae*, Fus=*Fusarium* spp., Sapr=Saprophytes.

TABLE 12. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF SIX LOTS OF POPCORN. IOWA, 1945.

Lot no.	Name	Percentage emergence							
		Cold soil				Field			
		C*	A*	B*	D*	C	A	B	D
1	Yellow Hybrid............	82.2	95.2	96 0	95.8	60	88	79	81
2	Yellow Hybrid............	86.5	94.5	94.2	93.8	79	88	86	81
3	Iowa Hybrid 3118 (Yellow)	64.0	93.8	87.2	90.0	59	88	82	82
4	Iowa Hybrid 3129 (Yellow)	48.5	95.5	87.8	91.8	58	86	72	79
5	Iowa Hybrid 3064 (Yellow)	63.8	94.5	89.8	93.5	70	84	78	82
6	Iowa Hybrid 613 (White)	91.0	98.0	93.2	94.5	82	83	83	90
Means		72.7	95.3	91.4	93.2	68	86	80	82.5

*C=Check, untreated; A=Arasan; B=Semesan Jr.; D=Spergon; each at .223 percent by weight.

tion afforded by Arasan, Semesan Jr. and Spergon is well illustrated by samples 3, 4 and 5 in table 12. In the laboratory test in cold soil both Arasan and Spergon were superior to Semesan Jr., and in the field test Arasan was superior for all lots and Spergon was superior for lot 4. Samples 1, 2 and 6 were able to withstand the laboratory and field conditions provided in this experiment, and the difference in protective value of the three materials was less noticeable.

SOYBEANS

A sample of vegetable soybean seed, variety Bansei, was obtained in 1944 and divided into seven subsamples. Treatments were made with six of the subsamples using Arasan, Spergon and Fermate, each at the rate of 1½ and 2 ounces per bushel. Tests were then made in sand at 28° C., in cold soil and in the field. The number of seeds used was 200 in sand, 400 in the laboratory soil test and 500 in the field. The temperature in the test in cold soil was 10° C. for 7 days, followed by exposure for 5 days at 26–28° C. Field plantings were made May 20 and stand counts were made June 10. The results of these several tests are shown in table 13.

The data for the sand test show that the seed was of exceptionally high vitality. In the unsterilized soil test the percentage emergence of the untreated seed was 71.3; each treatment gave substantial protection, Spergon and Arasan exhibiting some superiority over Fermate. The emergence in the field plot, however, was exceptionally good and no significant difference between treated and untreated seed was exhibited. Of particular interest was the high percentage of "baldheads" (18.2) that was found among the emerged seedlings from untreated seed in cold soil. The plumules of the baldhead seedlings were either partially or completely rotted. Arasan and Spergon did not completely prevent the appearance of baldhead seedlings. Porter (17) has illustrated the types of baldhead seedlings in soybeans that occur when germination takes place in cold soil.

A sample of Kanro soybean seed also was obtained in 1944 and

TABLE 13. LABORATORY AND FIELD GERMINATION OF BANSEI SOYBEAN SEED. AMES, IOWA, 1944.

Treatment	Percentage normal seedlings			Percent baldheads cold soil
	Lab. sand 26-28° C.	Cold soil* 10° C., 26° C.	Field	
Check	98	71.3	94.2	18.2
Arasan 1½ oz. per bu.	100	93.4	92.2	1.8
Arasan 2 oz. per bu.	100	95.6	96.0	1.2
Spergon 1½ oz. per bu.	98	95.7	94.8	0.8
Spergon 2 oz. per bu.	99	94.7	93.0	0.5
Fermate 1½ oz. per bu.	99	90.4	94.6	4.8
Fermate 2 oz. per bu.	98	91.8	95.2	4.0

*Pythium-infested soil.

TABLE 14. PERCENTAGE LABORATORY AND FIELD GERMINATION OF TWO LOTS OF KANRO SOYBEAN SEED. IOWA, 1944 and 1945.

Normal seedlings and baldheads, 1945 test								1944 test	
			Lab. sand		Cold soil*				
Lot	Year grown	Treatment	Normal sprouts	Bald-heads	Normal sprouts	Bald-heads	Field emer-gence	Cold soil*	Field
1	1943	Check........	96	0	13.8	3.0	3.0	49.0	80.4
		Arasan 2 oz....	97	0	71.5	0.2	56.0	92.0	89.0*
		Sem. Jr. 2 oz...	100	0	14.5	6.2	5.6	90.0	85.4*
		Spergon 2 oz...	96	0	71.2	3.0	39.0	90.0	85.2*
2		Check	95.5	0	68.8	8.2	53.8		
	1944	Arasan 2 oz....	95.5	0	95.5	2.0	83.8		
		Sem. Jr. 2 oz...	97.5	0	77.2	7.2	68.2		
		Spergon 2 oz...	96.0	0	92.8	1.2	83.4		

*Pythium-infested soil.

tested in the manner described for the Bansei lot. A remnant of untreated seed of the Kanro lot was retained for a test in 1945, and seed was saved from the field plot in the 1944 test. There was thus available in 1945 seed of Kanro produced in 1943 (lot 1) and 1944 (lot 2).

In the spring of 1945 each lot of Kanro seed was subdivided into four samples, and three were treated separately with Arasan, New Improved Semesan Jr. and Spergon, each at the rate of 2 ounces per bushel. Plantings were made in sand (26–28° C.), cold soil (10° C. and 26–28° C.) and in the field. The date of planting in the field was April 17 and stand counts were made May 15. All the data are shown in table 14, together with the laboratory and field results obtained in 1944 for lot 1.

The data in table 14 show that the viability of the seed of lot 1 harvested in 1943 was high when tested in sand in the laboratory in 1945. There were no baldheads, and the untreated seed gave 96 percent normal sprouts. A year earlier the field germination was good even though planted when the soil was fairly cold and wet (May 20). An analysis of variance of the field data showed that the least difference for significance between the means was 4.72, hence all three treatments gave significant increases in stand. In cold soil the untreated seed gave 49 percent emergence and each treatment gave good protection. When untreated seed of this identical lot was divided into four lots in 1945, three lots treated as in 1944 and planted in cold soil and in the field, the results were strikingly different from those of the previous year. The untreated seed in both tests gave very low percentages of emerged seedlings, and Arasan and Spergon gave over 500 percent protection in cold soil. Protection in the field was even more complete. Inability of Semesan Jr. to afford protection to old seed under adverse conditions for germination is clearly indicated. And even for the seed produced

TABLE 15. GERMINATION OF SEED OF TWO LOTS OF LINCOLN SOYBEAN SEED IN SAND AND IN COLD SOIL FOR 7 DAYS AT 10° C., 5 DAYS AT 26° C. AMES, IOWA, 1945.

Lot	Year grown	Percentages								
		Sand 26-28° C.	Normal				Baldheads			
			C*	A*	B*	D*	C	A	B	D
1	1943	92	5.0	62.5	16.0	64.5	7.5	7.2	17.5	12.8
2	1944	98	43.8	98.2	72.8	95.0	39.2	0.5	19.5	2.2

*Treatments are the same as in table 14. C=Check, A=Arasan, B=Semesan, D=Spergon.

in 1944, Semesan Jr. was inferior to Arasan and Spergon in both the laboratory and field tests.

This experiment clearly indicates that seeds may exhibit high vitality under favorable conditions for germination, but a test under more severe conditions is necessary to determine resistance to such environment.

The data in table 15 further emphasize the effect of age of seed on its ability to resist the attack of soil fungi at temperatures unfavorable for germination. Two lots of Lincoln soybean seed, one produced in 1943, the other in 1944, were tested in sand and in cold soil in May 1945. In sand there was no important difference

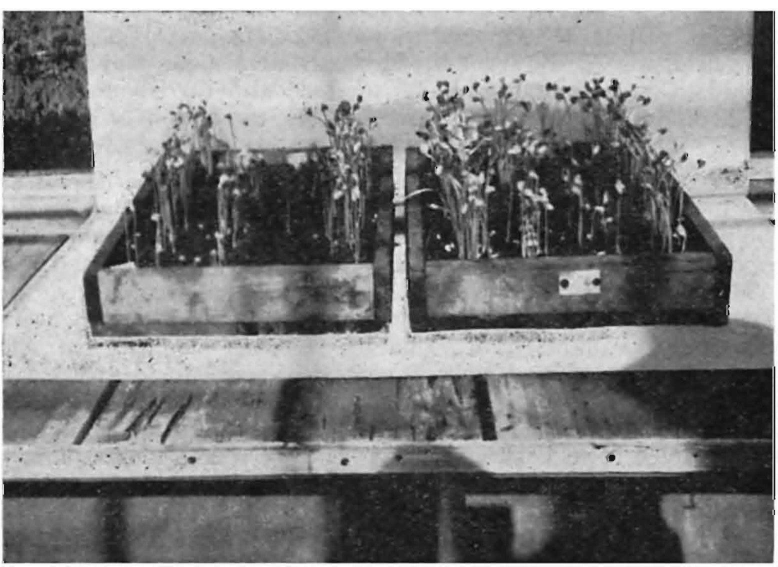

Fig. 1. Cold test of Lincoln soybean seed. Left flat, 1943 crop seed, right flat, 1944 crop seed, both tested in May 1945. Treatments by row in each flat from left to right—Arasan, Semesan Jr., untreated, Spergon.

in percentage of normal seedlings, but in the cold soil the seed produced in 1944 was clearly superior to that grown in 1943. The relative superiority of Arasan and Spergon over Semesan Jr. is also clearly shown in this particular test. Figure 1 shows the relative protective power of seed protectants on Lincoln soybeans germinated in cold soil.

The data in tables 14 and 15 also indicate the same response shown in table 13, namely that baldheads may be induced in good seed when placed in cold soil at low temperature. Semesan Jr. offered less protection against plumule infection than did either Arasan or Spergon.

SPINACH

Laboratory and field germination tests with spinach seed were conducted in 1943, 1944 and 1945. In 1943 only one sample was used. Treatments used were zinc oxide at 2 percent by weight and Thiosan and Fermate each at the rates of 0.25, 0.50, 0.75 and 1.0 percent. The laboratory tests were made in sterile sand at 10° C. and in cold soil at 10° C. for 10 days and 20° C. for 8 days. The field planting was made April 8 using 5 replications of 100 seeds in a randomized block; stand counts were obtained May 22. The data for 1943 are given in table 16.

The response in sterile sand showed that all the treatments were beneficial in that the percentage of emerged seedlings produced by untreated seed was significantly lower than that produced by treated seed. In cold soil the differences were much greater, indicating remarkable protection against invasion by soil-borne organisms as a result of seed treatment. In the field, Thiosan at two dosages and Fermate at three dosages gave percentages of germination significantly higher than untreated seed as indicated by an analysis of variance of the data. The least difference for significance was found to be 9.56.

TABLE 16. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SPINACH SEED. IOWA, 1943.

Treatments	Percentage emergence in: Sterile sand 10° C.—21 days	Cold soil 10° C.—10 days 20° C.— 8 days	Field
Untreated	61	37.6	54.8
Thiosan .25%	81*	79.0*	56.8
Thiosan .50%	86*	82.0*	64.4*
Thiosan .75%	81*	77.6*	68.0*
Thiosan 1.00%	82*	78.3*	63.2
Fermate .25%	89*	81.0*	68.2*
Fermate .50%	94*	87.0*	68.0*
Fermate .75%	84*	81.0*	64.6*
Fermate 1.00%	86*	89.6*	56.2
Zinc oxide 2%	85*	83.3*	56.6

*Significantly higher than untreated.
Least difference for significance was 9.56.

In 1944 seed of eight varieties of spinach produced in 1943 was obtained and prepared for planting. The treatments used were Arasan and Fermate, each at the rate of 0.5 percent by weight, and zinc oxide at the rate of 2 percent by weight. Plantings were made in sterile sand and in cold soil using 4 x 100 seeds for each subsample. The boxes and flats containing the seed were kept at 10° C. for 21 days. Field plantings consisted of 5 replications of 100 seeds for each subsample arranged in a split plot with randomization of varieties and of treatments for each variety. The plot was planted April 17 and stand counts were made May 18.

The complete data obtained from these several tests are presented in table 17. It may be noted that in the sterile sand the percentage germination of treated and untreated seed was practically equal, indicating that none of the seed lots carried any organisms sufficient to interfere with germination. The logical conclusion is that all seed lots were of high quality. The behavior in cold soil and in the field was very different from that in sterile sand. All treatments resulted in a significantly higher emergence of seedlings than was obtained from untreated seed, but Arasan and zinc oxide were superior to Fermate in both tests. It is significant that untreated seed of these eight varieties exhibited marked variability of resistance to soil-borne fungi, and, although the correlation between laboratory and field soil tests is not high for individual varieties, untreated seed of Viking gave the highest germination in cold soil and in the field, and seed of Old Dominion gave the lowest in both places. The correlation between the mean percentages of emergence of all varieties in the laboratory soil and field was high. In the cold soil test a high percentage of damping-off occurred among the subsamples of untreated and Fermate-treated seed. This test in 1944 illustrates the value of the laboratory soil test in evaluating the resistance of seed lots to soil-borne organisms and the protective power of seed fungicides.

In 1945 seed of two varieties totaling five lots was obtained and treated in the same manner as in the previous year except that Semesan was substituted for Fermate. All lots were produced in 1944. The rates of application by weight were 0.5 percent for Arasan and Semesan and 2 percent for zinc oxide. Field plantings were made April 10 and stand counts were made May 20.

The complete data are presented in table 18. Results were similar to those of the previous year except that the differences between the germination of untreated and treated seed in the field plot were not so marked. The value of the three protectants appears to have been about equal. The differences between untreated and treated seed when germinated in sterile sand were relatively small and of no significance.

TABLE 17. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF EIGHT VARIETIES OF SPINACH. IOWA, 1944.

Variety	Mean percentage emergence in											
	Sterile sand, 10° C.				Cold soil, 10° C.				Field			
	C*	A*	F*	Z*	C	A	F	Z	C	A	F	Z
Bloomsdale	89	94	89	94	48.5	84.5	77.5	81.5	41.6	59.8	47.4	53.2
Dark Green Viroflay	88	94	91	92	66.7	77.5	62.5	70.2	39.8	57.8	60.6	52.6
Virginia Savoy	89	91	88	89	53.0	72.0	63.0	82.7	31.4	52.8	46.2	55.0
Viking	97	94	96	97	78.0	82.7	72.0	86.5	48.4	58.4	56.8	54.4
Old Dominion	91	94	94	94	23.5	84.2	42.5	78.5	25.2	64.0	50.8	56.4
Giant Nobel	90	90	91	87	58.0	70.2	73 0	67.7	34.8	41.6	43.4	48.8
Bloomsdale	97	96	98	92	38.2	70.0	60.5	84.7	41.4	48.8	46.6	50.0
Long Standing Hollandia	97	97	98	98	72.0	87.5	70.2	88.5	37.2	63.2	48.4	48.6
Mean	92.3	93.8	93.1	92.9	54.7	78.6	65.2	80.0	37.5	55.8	50.3	52.5
Mean percentage damped-off	....	....	....	....	17 5	6.8	22.0	4.0	....	....	....	....

*C=Check, untreated, A=Arasan, F=Fermate, Z=zinc oxide.

TABLE 18. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF FIVE LOTS OF SPINACH. IOWA, 1945.

Variety	No.	Percentage emergence in											
		Sterile sand 10° C.				Cold soil 10° C.				Field			
		C*	A*	B*	D*	C	A	B	D	C	A	B	D
Giant Nobel	1	84	89	91.5	91	54	90.2	81	93	54	67	61	71
	2	59	68.5	61.5	65.5	21	57.5	69.5	55.5	46	58	54	61
	3	72.5	75 5	73 0	76 5	16.5	49.2	75.0	41.0	37	65	57	55
Bloomsdale	1	79.0	81.0	83.5	83.0	19.8	67.2	63.2	63.2	41	54	42	57
(Dark Green)	2	91.0	86.5	93.0	95.5	51.8	76.5	79.8	84.2	59	61	69	57
Means	....	77.1	76 1	80 5	82.3	32.6	68.1	73.7	67.4	47.4	61.0	56.6	60.2

*C=Untreated, A=Arasan 0.5 percent, B=Semesan 0.5 percent, D=zinc oxide 2 percent.

ONION SEED

Seed of one variety of onion was obtained in March 1943 and divided into seven subsamples. Six of these were treated separately using Fermate 1.5 percent, Thiosan 1.5 percent, Semesan 0.3 percent, zinc oxide 4 percent, Yellow Cuprocide 0.75 percent and Spergon 2 percent, each by weight. Tests were made in blotters at 20° C. and in cold soil at 10° C. for 5 days, then at 20° C. for 10 days. The results of these two experiments are given in table 19.

The untreated seed tested in blotters was well covered with saprophytic fungi at the end of the 14-day test, which made it difficult to determine if parasitic forms were present. It is not known what organisms were responsible for the lower germination of untreated seed, but Fermate and Thiosan were particularly beneficial. In the cold soil test all treatments gave good protection against soil-borne organisms, but Fermate, Thiosan and Yellow Cuprocide were the three most effective protectants.

In 1944 two tests were undertaken with onion seed. In the first test, seed of four varieties (lots) was used and each was divided into four subsamples of which three were treated separately with Arasan, Spergon and Fermate, each at the rate of 1 percent by weight. Laboratory tests were made in blotters at 20° C. and in cold soil, using 4 x 100 seeds from each subsample. The results of the tests are given in table 20. Only small differences occurred in percentage germination in blotters between untreated and treated seed, but in the cold soil tests the treatments gave a significant increase in stand for the varieties Yellow Bermuda and Southport Red Globe. The period of exposure in the cold soil at 10° C. was apparently too short to test adequately either the resistance of the seed to fungous infection or the protective power of the several fungicides.

A fifth lot of treated and untreated onion seed was received from the New York Agricultural Experiment Station at Ithaca in 1944. Six treatments each at two rates of application had been made and plantings were made at Ames, Iowa, in blotters and in cold soil using

TABLE 19. GERMINATION OF TREATED AND UNTREATED ONION SEED IN BLOTTERS AND IN COLD SOIL. IOWA, 1943.

Treatment	Percent germination	
	Blotters 20° C. 14 days	Cold soil
Untreated	83	63.5
Fermate 1.5%	95	86
Thiosan 1.5%	97	90.5
Semesan .30%	91	81.2
Zinc oxide 4%	93	83.2
Yellow Cuprocide .75%	88	88.2
Spergon 2%	90	79.0

TABLE 20. PERCENTAGE GERMINATION OF TREATED AND UNTREATED SEED OF FIVE LOTS OF ONION IN BLOTTERS AND COLD SOIL. IOWA, 1944.

Variety	Treatment	Blotters 20° C. 14 days	Cold soil	Lot 5		
				Treatment	Blotters 20° C.	Cold soil
Yellow Bermuda	Untreated	69.5	64.8	Untreated	72	73
" "	Arasan	74.5	75.0	Cu_2O,0.5%	81	78
" "	Spergon	71.5	70.0	Cu_2O,0.1%	91	79
" "	Fermate	77.0	71.5	Arasan .5%	84	84
Ebenezer	Untreated	91	91	Arasan 1%	83	89.5
"	Arasan	94.5	92.5	Fermate .5%	90	88.5
"	Spergon	90.0	86.5	Fermate 1%	89	81
"	Fermate	95	89.5	Semesan .3%	88	82
So. Port R. Globe	Untreated	72.5	63	Semesan .5%	88	83.5
" " " "	Arasan	79.0	81	Spergon .5%	82	77.5
" " " "	Spergon	80.0	82	Spergon 1%	84	78.0
" " " "	Fermate	78.5	75.8	Vasco 1%	90	78.5
Yell. Sw. Spanish	Untreated	83.0	78.5	Vasco 3%	92	83.0
" " "	Arasan	88.5	77.0			
" " "	Spergon	85.0	70.8			
" " "	Fermate	89.0	80.0			

4 x 100 seeds for each subsample. The data are given in table 20 and are self-explanatory.

In 1945 five lots of onion seed were obtained, representing the varieties Yellow Danvers and Ebenezer. Treatments used were Arasan and Spergon, 1 percent by weight, and Semesan 0.5 percent by weight. Plantings were made in blotters and in cold soil using 4 x 100 seeds per subsample. In the field there were 5 replications of 100 seeds from each subsample in rows 5 feet long. The data from all the three tests presented in table 21 are self-explanatory.

BEET SEED

In 1943, 1944 and 1945 a total of six lots of beet seed representing two varieties were tested in blotters at 20–30° C., in cold soil for 5 days at 10° C. and 14 days at 20–30° C., and also in the field. In the laboratory tests 4 x 100 seeds from each subsample were used but in the field tests 5 replicates of 100 seeds each were planted in a randomized block. In the blotter tests the number of balls with sprouts out of each hundred planted was recorded, but in the laboratory soil and field tests the number of sprouts per 100 balls was used as a measure of germination.

The data from these several tests are given in tables 22, 23, 24 and 25 together with the rates of application in percent by weight of each compound. The time of exposure was 5 days at 10° C. in cold soil followed by a temperature of 20–30° C. for 14 days. In each table an asterisk indicates treated seed which produced a significantly higher percentage of sprouts than untreated seed.

In 1943 the field germinations per row and replicate were too variable for accurate evaluation of the means. In the infested soil test all but two of the treatments gave a significantly higher per-

TABLE 21. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF FIVE LOTS OF ONIONS. IOWA, 1945.

		Percentage germination											
		Laboratory blotters, 20° C. 14 days				Cold soil 10° C. 5 days 20° C. 10 days				Field			
Variety	No.	C*	A*	B*	D*	C	A	B	D	C	A	B	D
Yellow Danvers.	1	93.5	96.8	95.5	89.0	89.5	95.5	88.0	89.5	57.8	63.5	63.8	64.0
Yellow Danvers	2	84.0	78.8	75.5	77.5	66.2	75.8	72.2	65.0	42.5	57.5	50.2	48.8
Ebenezer.......	1	84.0	91.5	86.8	82.8	77.2	82.2	78.5	83.2	65.8	62.2	61.2	54.5
Ebenezer.......	2	97.2	99.2	97.2	99.0	96.5	95.0	97.2	96.0	65.5	73.2	66.8	62.2
Ebenezer......	3	80.0	80.0	78.0	91.0	60.8	83.8	75.0	83.8	46.8	54.2	44.5	44.0
Means.........	....	87.7	89.3	86.6	87.9	78.0	86.5	82.2	83.5	55.7	62.1	57.3	54.7

*C=Untreated, A=Arasan 1 percent by weight, B=Semesan 0.5 percent, D=Spergon 1 percent.

centage of emerged seedlings than the untreated seed. The blotter tests indicated high quality seed since no benefit from treatment was in evidence. This is in contrast to the results obtained in 1944 (table 23) when one lot of marked low quality and another of medium quality were used. The percentage germination of untreated seed of both these lots in the infested soil was proportionately much lower than that of the good lot the previous year. Leach (8) found that in general the lower the viability of beet seed, the greater the

TABLE 22. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED BEET SEED, VARIETY DETROIT DARK RED. IOWA, 1943.

Treatment	Percent seed balls germinated 20—30° C.	Number sprouts per 100 balls	
		Cold soil	Field
Untreated	92	140	75.8
Cuprocide 1%	86	180.5*	89.6*
Cuprocide 2%	92	162*	73.0
Cuprocide 3%	90	170*	84.0*
Thiosan .25%	84	171*	85.0*
Thiosan .50%	91	171.5*	79.4
Thiosan 1%	89	162*	79.6
Ceresan .5%	90	151.5	81 8
Ceresan 1%	91	164.5*	84.8*
Ceresan 1.5%	89	151.2	85.0*

*Significantly higher than from untreated seed.

TABLE 23. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF TWO VARIETIES OF BEETS. IOWA, 1944.

Variety	Treatment	Percent seed balls germinated 20—30° C.	Number sprouts per 100 balls	
			Cold soil	Field
Detroit Dark Red	Untreated	52.5	7	15.4
	Arasan 1% by weight	72*	104*	24.6*
	Spergon 1% by weight	70*	21 5*	20.6
	Ceresan 1% by weight	73*	19.0*	19.0
Asgrow Wonder	Untreated	77	24.0*	35.6
	Arasan 1% by weight	84.5*	133.0*	42.2*
	Spergon 1% by weight	88.5*	49*	29 2
	Ceresan 1% by weight	84.0*	110*	39.4

*Significantly higher than from untreated seed.

TABLE 24. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED BEET SEED, VARIETY DETROIT DARK RED. IOWA, 1944.

Treatment	Percent seed balls germinated 20—30° C.	Number sprouts per 100 balls	
		Cold soil	Field
Untreated	80 2	85	22.8
Arasan .25%	79 2	116*	40.4*
Arasan .50%	78.5	120*	35.6*
Arasan 1%	83.2	121*	46.4*
Ceresan 1%	80.0	120*	31.8
Yellow cuprous oxide 1.5%	76.5	119*	36 6*

*Significantly higher than from untreated seed.

TABLE 25. LABORATORY AND FIELD GERMINATION OF SEED OF TWO LOTS OF BEETS, VARIETY DETROIT DARK RED. IOWA, 1945.

Lot	Treatment	Percent seed balls germinated 20—30° C.	Number sprouts per 100 balls	
			Cold soil	Field
1	Untreated	75	7	47.2
	Arasan 1% by weight	80	111*	61.8*
	Ceresan 1% by weight	79	70*	50.2
	Red Cuprocide 1% by weight	82.5	72*	49.2
2	Untreated	70.5	4	19.8
	Arasan 1% by weight	69.5	120*	33.8*
	Ceresan 1% by weight	66	71*	35.6*
	Red Cuprocide 1% by weight	65.5	60*	18.8

*Significantly higher than from untreated seed.

protection in the field from seed treatment. Arasan proved decidedly superior in the infested soil tests to Ceresan and Semesan, and was the only compound that gave a significantly higher germination than untreated seed in the field test. The data for 1945 show results in the infested soil and field tests similar to those in 1944.

CARROT SEED

Five lots of carrot seed representing two varieties were tested in 1944 and 1945. The procedures were the same as for beet seed except that the tests in cold soil were kept at 20–30° C. for 21 days after exposure for 5 days at 10° C. The rates of application for each compound and the percentages of germination in each of the three types of tests are given in tables 26 and 27. The data, which are largely self-explanatory, indicate less benefit from seed treatment than was obtained with other kinds of vegetable crop seed. Only in cold soil did any treatment give a significantly higher percentage of emergence than did untreated seed. Arasan gave protection more consistently than did other compounds.

TABLE 26. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED CHANTENAY CARROT SEED. IOWA, 1944.

Treatment	Percent germination		
	Blotters 20—30° C.	Cold soil	Field
Untreated	56.5	32.5	9.2
Arasan .5%	61.0	48.0*	16.0
Arasan .75%	58.5	43.0*	15.4
Spergon .5%	55.0	38.5	14.2
Spergon .75%	62.5	30.5	18.6
Semesan .42%	54.0	37.0	14.4
Red Cuprocide 1%	59.0	37.0	17.0
Zinc oxide 1%	56.0	49.5*	16.8

*Significantly higher than from untreated seed.

TABLE 27. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF TWO VARIETIES OF CARROTS. IOWA, 1945.

Variety	Lot	Treatment	Percent germination		
			Blotters 20—30° C.	Cold soil	Field
Imperator	1	Untreated	94	68.5	47.0
"	1	Arasan .75%	89	84.0*	50.0
"	1	Semesan .4%	87	72.0	39.0
"	1	Spergon .75%	92.5	69.0	45.0
Imperator	2	Untreated	76.5	30.0	38.0
"	2	Arasan .75%	69.5	58.0*	44.0
"	2	Semesan .4%	70.0	33.0	36.0
"	2	Spergon .75%	71.0	22.0	35.0
Chantenay	1	Untreated	89.5	64.0	50.0
"	1	Arasan .75%	84.0	74.0*	53.0
"	1	Semesan .4%	84.5	78.0*	51.0
"	1	Spergon .75%	84.0	68.0	52.0
Chantenay	2	Untreated	63.0	44.0	33.0
"	2	Arasan .75%	56.5	53.5*	38.0
"	2	Semesan .4%	47.0	49.0	30.0
"	2	Spergon .75%	63.0	46.5	31.0

*Significantly higher than from untreated seed.

TOMATO SEED

One lot of tomato seed was subjected to test by three methods, the same as used for beet seed. The blotter test indicated that the seed was of very high quality, the untreated seed germinating as well as treated seed. In cold soil all treatments afforded good protection, but in the field only Ceresan dust and Arasan gave evidence of protecting seeds during the germinating period. Field planting was made April 19. Vaughan (24) used ethyl mercury phosphate for treatment of tomato seed.

TABLE 28. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED TOMATO SEED. IOWA, 1944.

Treatment	Percent germination		
	Blotters 20—30° C.	Cold soil	Field
Untreated	93	75.5	35.2
Ceresan dip	93.5	95.0*	39.0
Ceresan dust	95 5	92.0*	47.0*
Spergon	93.0	86.0*	36.8
Semesan	94.0	91.0*	37.2
Yellow Cuprocide	95.0	88.0*	32.0
Arasan	92.0	96.0*	43.8*

*Significantly higher than from untreated seed.

BUSH LIMA AND GREEN POD BEANS

In the spring of 1945 seed of three lots of bush lima and two of green pod beans was available for test from the 1943 crop. Tests were made in sand at 20–27° C., in cold soil (3 days at 10° C.

and 5 days at 26–28° C.) and in the field. The number of seeds used per subsample was 2 x 100 for both laboratory tests and 5 x 100 for the field test. The treatments used were Arasan and Semesan each at .208 percent by weight. Field plantings were made April 24. The percentages of normal seedlings obtained in the sand test and of emergence in the infested soil and field tests are presented in table 29.

TABLE 29. LABORATORY AND FIELD GERMINATION OF TREATED AND UNTREATED SEED OF LIMA AND GREEN POD BEANS, 2 YEARS OLD. IOWA, 1945.

		Percentage emerged						
			Cold soil			Field		
Variety	Lot	Sand 20—27° C.	Un-treated	Arasan .208%	Semesan .208%	Un-treated	Arasan .208%	Semesan .208%
Clark's Bush Lima	1	65	24.5	36.8	45.2	2.0	15.5	15.0
Henderson Bush Lima	2	48	3.0	10.0	13.7	.2	2.0	.8
Henderson Bush Lima	3	89	26.4	33.3	31.0	5.8	9.0	8.0
Bountiful	4	77	19.7	70.0	78.7	56.8	61.0	63.2
Landreth's Green Pod	5	86	34.5	82.8	83.7	70.0	76.8	81.0

The lima bean seed showed marked inability to withstand the unfavorable conditions for germination in either the cold soil or the field test. Lot no. 2 was particularly low in resistance. The green pod beans, however, showed a decided superiority to the lima beans as indicated by these tests. Both treatment compounds afforded protection in the infested soil and field tests. It is well to state that field conditions for germination were unfavorable for bean seed from April 24 to May 5. Undoubtedly the age of the lima bean seed was a factor of importance also.

A second experiment in 1945 had to do with four lots of bush lima bean seed produced in 1944 and one lot of green pod beans produced in 1944 and hand shelled to prevent threshing injury. No field plantings were made, but 2 x 100 seeds from each subsample of untreated seed were planted in sand at 20–27° C. and 4 x 100 of treated and untreated seed were planted in cold soil. Arasan at the rate of .208 percent by weight was used as a treatment in comparison with untreated seed. The exposure in cold soil was 3 days for the lima bean seed and 7 days for the green pod seed followed by 6 days at 26–28° C. for all lots. In the sand test the percentages of normal and baldhead seedlings were recorded, but in the infested soil an additional count of emerged seedlings was made.

The complete data are given in table 30. The protection afforded by Arasan for all lots planted in infested soil is evident, and the response of untreated seed of the four lots of lima beans is not as might be expected on the basis of the test in sand. Lots 3 and 4 showed the highest percentages of normal sprouts in sand and the lowest in infested soil. The 2-year-old untreated seed of hand-

TABLE 30. GERMINATION OF TREATED AND UNTREATED SEED OF LIMA AND GREEN POD BEANS IN SAND AND COLD SOIL. IOWA, 1945.

Kind	Lot	Percentage							
		Sand 20—27° C. Untreated		Cold soil					
				Emerged		Normal sprouts		Baldheads	
		Normal	Baldheads	Untreated	Arasan	Untreated	Arasan	Untreated	Arasan
Bush Lima............	1	78.0	4.0	71.8	78.0	58.0	75.5	7.5	3.5
" "	2	76.0	2.0	73.0	82.5	62.0	78.0	10.0	4.5
" "	3	91.0	2.0	64.2	78.2	52.8	70.8	7.8	9.8
" "	4	81.0	2.0	48.0	65.8	24.0	55.2	10.5	9.2
Green Pod—hand shelled	5	99.5	0	92.5	99.8	85.8	99.8	2.5	0
Mean..................	....	85.1	2.0	65.9	80.9	56.5	75.7	7.7	5.4

shelled green pod was remarkably resistant to the severe test in infested soil, and Arasan gave complete protection from injury.

One striking fact about this test with beans is the greater percentage of baldheads among seedlings produced in cold soil from untreated seed, as compared with the percentage in sand. Arasan afforded some protection against the baldhead condition in lots 1, 2 and 5. This condition in lima and garden beans is similar to that described by Porter (17) in soybeans and suggests that the percentage of baldhead seedlings which occurs in the field may be in part dependent upon the soil temperature and soil moisture conditions that prevail during the period of germination. A cold, wet field soil may favor fungus invasion and result in the development of baldhead seedlings.

DISCUSSION AND CONCLUSIONS

The evaluation of seed lots for planting is of major concern to those engaged in crop production and is the primary function of seed laboratories. The ability of seeds to germinate when planted in the field or garden and to produce a uniform and sufficiently dense stand to insure maximum yield is one of the most important factors to be considered in seed testing. Numerous factors determine seed viability and germinability. Kind or variety, time of harvesting, methods of harvesting, threshing and processing, storage environment, age and pathological condition of seed all affect seed germination. Furthermore, the time of planting, soil temperature and moisture and fungous flora of the field soil have a marked effect on the germination of seed.

It is seldom possible to foresee the time or place of planting for a given lot of vegetable crop seed, hence no prediction can be made as to the environmental conditions to which such seed will be subjected after planting. The standard criterion for measuring the viability of seed has been to determine (1) the optimum conditions for germination of the kind of seed in question and (2) the maximum percentage of normal seedlings that are produced under the optimal environment. Numerous tests have been made (13, 15, 21) which indicate that when optimum field conditions for seed germination prevail, one can expect field germination to equal that obtained in the laboratory under similar conditions. The same seed planted at a less favorable time may respond very differently.

Those who grow vegetable crops on a commercial basis and even home gardeners find it profitable and satisfying to plant many kinds of seed earlier than is commonly practiced. Under such conditions the seeds are often subjected to temperatures considerably below the optimum for a particular kind, and if soil moisture is high the resultant moisture-temperature combination is particularly injurious to germination. Rice (21) has shown how the germination of a given lot of seed can be reduced by an increase in the moisture content of Pythium-infested soil at a given temperature. The data from the test with peas in 1945 as presented in this bulletin illustrate a similar effect.

The experimental data reported in this bulletin illustrate clearly that within kinds or varieties of vegetable crop seeds there is extreme variation in germination of the seed when planted in Pythium-infested soil and kept at a temperature of 10° C. for any given number of days. Some lots withstand the attack of soil-borne organisms exceptionally well, others are highly susceptible, and in the latter case low germination is the result. When such facts are known about a given lot of seed it is possible to plan the time of planting more intelligently and to avoid serious reduction in stand. The "cold test" as described and tested in this bulletin serves to index the probable response of seed lots when planted under conditions unfavorable for germination.

The protection of seed during the germinating period is also of great importance to the home or market gardener. Numerous compounds have been produced commercially and new products are being developed constantly. Determination of the protective power of these numerous compounds may require several years of trial in the field before conditions severe enough for a critical test are encountered. The cold test herein described has proven of considerable value in indexing the protective power of seed treatment compounds and is recommended as a dependable procedure in the testing of seed protectants. Further study should result in greater refinement of the method than has been achieved thus far.

The time required to index seed lots for their resistance to soil-borne organisms or to index the protective power of seed fungicides is relatively short, and the results correlate reasonably well with those obtained in the field when conditions for germination are far below optimum.

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