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Introduction

Chemical treatments of crop seeds has been investigated and practiced for the past 50 years or more in Western countries. The data accumulated are voluminous but available only in many text books, bulletins and Journal articles. Within recent years many new compounds have been produced some of which have general use while others are more specific in application. Seed treatment, at present, has two basic objectives (1) to control systemic organisms carried by seeds and thus produce a crop relatively free from the specific disease in question and (2) to protect germinating seeds from injury either by seed-or soil-borne organisms which cause seed decay, seedling blight or damping-off.

Practically all the published information on the effect of seed protectants on seed germination has emanated from countries in the temperate regions of the world and relatively few experiments have been conducted in tropical or subtropical areas. Fisher (1) and Oliveira (2) published accounts of seed treatment tests in Uruguay and Brazil. The writer (4) in 1951 reported on tests in Brazil and Paraguay. In general seeds of cereals and corn were not benefitted by treatment unless seed-borne pathogens were present on the seed or planting occurred when the soil was cold and moist or wet.

In January 1956 the senior author arrived in Lebanon and became a member of the Faculty of Agricultural Sciences in the American University of Beirut. In the spring months of that year some laboratory and field experiments were initiated with chemical treatments of field and vegetable crop seeds. In 1957 the junior authors began graduate work in seed technology and they assisted until June of 1959 in the numerous trials that were made with seed fungicides applied to seeds of barley, corn, lentil, oats, peas including garden, Canada field and Austrian winter, sorghum. spinach, sugar beets, sweet corn, vetch and wheat,

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All tests were made at the University Farm situated about 50 miles east of Beirut in the Bekaa plain which lies between the Lebanon and anti-Lebanon mountain ranges. The altitude at the farm is 1000 meters (3300 feet) and the climate is somewhat temperate in that temperatures during winter months reach −10 to−14°C. Frosts may occur as late as May and about November in the autumn. Mean air temperature between 1952 and 1958 ranged from 13.8 in May to 27.9°C in September. Mean relative humidity during the same period ranged from 44 in May to 32 percent in September. Annual raifall at the farm averages about 450 mm (18 inches) but it occurs mostly between November 1 and April 15 with the maximum usually in January and February. In some seasons there is little or no rainfall between March 15 and December 1. The rainfall and humidity patterns are such that most any crop produced at the University Farm matures seed between May and November when climatic conditions are unfavorable for the development of seed-borne organisms that adversely affect seed germination. In addition the soil is low in organic matter, it is hot and dry in summer, unless irrigated, and evaporation is so high after seeds of spring and early summer crops are planted that uniform germination is difficult to maintain unless irrigation is frequent and abundant. When fall-seeded crops such as cereals, vetches and field peas are planted the soil is usually dry and the seeds remain in the dry soil for sometimes a month before rains come to initiate seed germination. Seeds planted during late February and March or even in early April are subjected to low soil temperature and usually to fairly high moisture content. All these environmental factors influence the response of seeds to treatment with fungicides.

Materials and Methods

The seeds used in the experiments herein described were mostly from crop varieties grown on the University Farm although spinach seed was purchased from a local seed merchant, sorghum seed was imported from the United States and sugar beet seed was imported from European countries.

The dust fungicides used were purchased locally and the number of kinds was limited. Liquid fungicides were obtained from manufacturers in the United States and European countries. Rates of application were often those recommended by the manufacturers although variations were used as given in the discussion of results for each crop.

Dusts were applied to seeds by shaking them together in a can or glass fruit jar. The walls of the container were first coated with a film of the dust

and then a weighed quantity of dust was added to a given weight of seed. The liquid fungicides were diluted with water and the seeds either soaked for a given period and then dried or when small quantities of solutions were used the seeds were placed in an Erlenmeyer flask, the solution added. the seed shaken for a minute or two and then the flask was corked for a pre-determined period of time.

The soil at the University Farm is calcareous with a pH of about 8, it is low in organic matter, very cloddy when dry and difficult to pulverize, hence a good seed bed is not easily prepared. Nitrogen and phosphorus are generally deficient as evidenced by good response of most crops to fertilizers containing either one or both these essential plant food elements.

The planting designs in most cases consisted of a Latin-Square with 5 replications although other types were used involving only 3 replications in some cases. The rows were usually 5 meters in length with 30 to 50 cm between rows. For small seeds such as spinach 200 seeds were planted per row but for others like corn, peas, and cereals 100 seeds were used. In one or two cases only 50 seeds per row were planted. As soon as it was apparent that all the seedlings that were able to do so had emerged, counts were made and recorded. The results of the tests are reported by crops.

Results with Cereals Crops

1. Barley.

Experiments were undertaken from 1956 to 1958 with barley and wheat and with oats in 1958. In November, 1956 10 samples of local barley, produced by villagers living near the University Farm, were obtained and prepared for planting using Agrosan at the rate of 1¼ mg per gram of seed and Arasan, Phygon and Spergon each at the rate of 2.5mg per gram of seed. Treated subsamples together with non treated seed were planted in a Latin-square design with 5 replications. After emergence, counts were made and when the data were analyzed no significant differences between treatments or between treatments and the check were obtained for any of the 10 lots.The mean percentages of field germination were check 58.2, Agrosan 58.5, Arasan 59.2, phygon 58.9 and Spergon 57.6.

Laboratory germination tests in blotters gave a mean percentage for all 10 varieties and 5 treatments of 95.8 with no differences between treatments nor between treatments and check. No seed-borne organisms other than saprophytic forms were present on the non-treated seed.

In November 1958, seed of 2 barley varieties, Athenais and Tal Amara No.2 was obtained from the seed multiplication plots at the University Farm and prepared for planting using Panogen, Granosan M, Anticarie and Phygon as treatments together with non-treated seed. The rates of application of treatments were as follwos:

Anticarie 2.5 mg per gram of seed
Phygon 2.5 mg per gram of seed
Granosan 1 part to 3 parts of talc at 2 5 mg per gram of seed
Panogen 0.0625 ml in 5 ml H_2O applied to 50 grams of seed corked for 48 hours in an E flask at room temperature.

The planting arrangement was the same as in 1956 and after emergence of the seedlings counts were made and recorded. The results were similar to those in 1956 in that the mean percentages of field germination for the 2 varieties were check 68.3, Panogen 65.0, Granosan M 70.9, Anticarie 70.2 and phygon 69.4.

At the time of planting in 1956 and again in 1958 the soil was too dry for germination to be initiated and there was no rain until 3 to 4 weeks after planting. The possible effect of such conditions on germination of treated seed is discussed in a later section inasmuch as this pattern is encountered every year in Lebanon with fall-seeded crops.

Smuts of barley

Loose smut caused by *Ustilago nuda* of barley is of rare occurence in the Bekaa Plain in Lebanon but is found in Iran, Iraq and Tunisia. Experiments at the University Farm in 1956 indicated that effective control could be obtained by soaking the seed in Panogen 1 to 1000 for 3 hours followed by sealing the drained seed in a flash for 36 to 40 hours at a temperature of 23°C. The seed may be planted at once at the end of the test or dried and then planted.

Covered smut caused by *Ustilago hordei* occurs in Iraq and Iran to a limited extent but the disease is easily controlled by treatment with Panogen using a 3-hour soak without subsequent sealing or by dust treatments with Agrosan, Granosan M or Ceresan M. The 2 latter dusts should be used at the rate of 0.7 grams per kg of barley seed, unless Granosan is first diluted with talc

2. Oats.

In 1958 seed of 3 varieties of winter oats, namely Red Algerian, Nortex

and Ventura was available from the seed multiplication plots on the University Farm. Subsamples were treated with the same compounds as for barley (1958) except that 0.10 ml of Panogen in 8 ml of H_2O were applied to 50grams of seed and the 3 dusts were applied at the rate of 3.9 mg per gram of seed. The planting design and the date of planting were the same as for barley. The field germination counts gave, for the 3 varieties, mean percentages of 71.7 for Check, 59.6 for Panogen. 73.9 for Granosan M, 73.8 for Anticarie and 70.0 for Phygon. Panogen apparently depressed the germination but no difference was evident among the dust treatments nor between them and the check.

Both loose and covered smuts of oats occur on wild and cultivated oats to a limited extent and treatment of the seed with Panogen, Agrosan, Granosan M or Ceresan M before planting gives satisfactory control.

3. Wheat.

In 1956 seed of 15 lots of wheat was obtained from villagers. 5 additional lots were collected from Syrian wheat imported by a flour mill and treated with Agrosan 1 mg per gram of seed and Arasan, Phygon and Spergon each at the rate of 2mg per gram of seed. As with barley the same method of planting was used for wheat. The field germination counts gave percentages of 60.0 for the check, and 60.1, 53.5, 60.6 and 61.7 for the 4 dusts respectively. In the laboratory test the germination percentages were check 79.9, Agrosan 84.4, Arasan 85.6, Phygon 83.8 and Spergon 82.2. The differences in field germinatton were of no significance

Three of the Lebanese and all of the Syrian samples showed infestation with spores and smut balls of stinking smut caused by species of *Tilletia* hence counts were made in the field for the incidence of smutted heads.

The results of the counts were as follows:

Sample		Mean percentage of smutted. heads.				
Number	Source	Check	Agrosan	Arasan	Phygon	Spergon
1	Lebanon	21.6	0	0	0	0
2	„	15.6	0.9	1.7	1.4	0.2
3	„	0	0	0	0	0
4	„	0	0	0	0	0
5	„	27.6	0.4	1.6	1.1	8.9
6	Syria	50,3	8.2	13.5	6.9	7.3
7	„	53.5	8.4	9.4	15.4	1.0
8	„	30.4	4.3	6.2	8.6	2.9
9	„	41.3	12.9	10.3	12.7	7.2
10	„	49.4	9.3	6.7	6.7	3.1

The results obtained in smut control, although somewhat erratic indicated (1) a higher incidence of stinking smut in the samples from Syria than from Lebanon (2) a high degree of control in the Lebanese samples for all treatments except Spergon (Sample 5) and (3) indequate control of smut in the Syrian samples yet Spergon was the most effective. These results led to additional tests in subsequent years which will be described in a separate paper.

In December 1957, a planting was made with wheat infested with spores of stinking smut and treated with Anticarie, Granosan and $CuSO_4$ solution each repeated 4 times in a Latin square design together with non-treated seed. Counts for smut and yield in grams were obtained in July 1958 and the data obtained are summarized as follows:

Treatment	Rate	Total smutted Heads – 4 replications	Total Yield in grams*
Check	–	99	467
Anticarie	1–500	1	550
Granosan M	1–2000	17	657
$CuSO_4$	1–50 for 10 minutes	0	531

* From 8 rows 5 m x 30 cm.

A sample of wheat infected wih loose smut *(Ustilago tritici)* was obtained from Tunis and prepared for planting using 3 liquid mercury compounds each at the rate of 1–1000 in which the seeds were soaked 3 hours and then sealed in a corked Erlenmeyer flask for 40 hours at 23°C. The results in terms of total smutted heads in 4 replications (total of 4 rows each 5 m long) were as follows:

Check	20 heads	Panogen	2 heads
Mema	None	Setrete	None

All the treatments reduced germination by about 15 percent, hence an increase in seeding rates is necessary to obtain a satisfactory yield.

Tests in 1958

In November seed lots of wheat varieties Florence Aurore, Senator Capelli and Cyprus B x IPI were obtained, subdivided and treated with 4 different fungicides. Plantings were made using 5 replications in a Latin-Square design in rows 5 m x 40 cm. The rates of treatment and mean percentages of field germination are summarized below.

Treatment	Rate	Mean percent germination
Check	–	67.9
Panogen	0.05 ml in 4 ml H_2O sealed 48 hr.	68.7
Granosan M	1 part to 3 parts talc applied 2 mg per gram	68.8
Anticarie	2 mg per gram	71.5
Phygon	2 mg per gram	67.4

The preceding results are smillar to those obtained in 1957.

4. Corn – Field and Sweet

Corn must be grown in the summer months during which time no rain falls in any of the Middle Eastern countries except along the coasts of Turkey and in Ethiopia. As a result corn is planted to a limited extent only where irrigation water is available. Farmers have long followed a pattern of planting corn in the late spring except along the seacoast or in Egypt where the seasonal conditions are milder than in the interior of the Middle East and early planting is common. In the Bekaa Plain the common practice is to plant corn in May when danger of frost is practically over. Rains often cease before May hence irrigation of corn is necessary at planting time.

Field Corn

In 1956 a planting was made about April 15 at the University Farm using 3 samples of field corn each treated with Arasan at 2 mg per gram of seed. Each sample of the treated together with non-treated was planted with 3 replications using 200 seeds per replicate. The mean percentages of emergence were 76.8 for non-treated and 87.0 for the treated. The seedlings from the treated seed were more vigorous than from the non treated and the differences were signiffcant.

In 1959 a sample of 2-year old seed of field corn was obtained, subdivided into 5 lots and 4 treatments were made using Agrosan at one and Arasan, Phygon and Spergon each at 2 mg per gram of seed. The planting plan was a Latin-square design with 5 replications, 100 seeds per row planted at 2 different dates. The results of the tests are tabulated below.

Date of planting	Percentages of Seedlings by Treatments				
	Check	Arasan	Agrosan	Phygon	Spergon
March 19	33.8	52.4	51.4	60.0	53.4
April 10	52.2	54.8	63.0	51.4	52.4

The differences between the check and all treatments are significant only for first planting with an average gain from all the treatments of 63.6 percent. A short time before and after the second planting practically no rain fell, the soil became dry and because of soil variation in the plot germination was irregular and extremely erratic.

Sweet Corn

Treatments used, rates of application, and methods of planting were the same as for field corn. In 1956 Arasan was applied to 10 different lots of hybrid sweet corn and plantings were made with treated and non-treated seed about the middle of April. In every replication the treated seed gave a higher emergence rate than non treated seed and the mean percentages for all samples were 64 for non-treated and 76 for treated, the difference of 12 being significant.

A second test was made in 1956 with 2 additional lots of sweet corn treated with Arasan, Phygon and Spergon. The results are tabulated below.

	Percentages of field germination by treatments			
Sample No.	Check	Arasan,	Phygon	Spergon
1	64.0	73.0	71.0	76.0
2	38.0	45 0	57.0	47.0

The soil required irrigation which was not uniform and the germination was erratic and variable.

In 1959 a test with a 2-year old sample of sweet corn was prepared in the same manner as described for field corn. The results are as follows:

Date of Planting	Percentages of Seedlings by Treatments				
	Check	Arasan	Agrosan	Phygon	Spergon
March 19	20.0	46.6	36.0	36.4	36.2
April 10	35.8	54.9	45.4	51.7	46.4

For the first planting the percentage increase in emergence of the treated samples over the check was 94 which is significant.

These results with field and sweet corn are similar to what the senior author has obtained in Iowa (3) with corn planted early in the spring when the soil was cold and wet. The application of the principle involved in these tests is that by planting about 2 months earlier than the normal date followed

by farmers it will be possible to use the moisture from winter rains to initiate germination, develop a root system and establish the plants long before the hot dry period of the late spring and summer. It should be possible to grow a crop with less irrigation water and hasten the ripening period or even grow late maturing varieties for greater yields of silage corn. Seed treatment for early planted corn will contribute much to the development of a superior pattern of corn production in the Middle East.

5. Spring and fall seeded leguminous crop.

Chick peas, lentils, vetches and peas are common crops in Lebanon and other Middle Eastern countries. With the exception of peas they are commonly planted in October and November as winter crops.

a. Peas.

Six lots of pea seed were selected in the fall of 1956, sub-divided and treated with Agrosan, Arasan, Phygon and Spergon at the same rates as described for corn. Each lot was planted as a separate experiment with 5 replications and 100 seeds per row. The land was prepared and irrigated before planting but no rain fell untill about a month after the planting date in early November. A summary of the results is tabulated below.

Sample No.	Percentage Emergence by Treatments				
	Check	Agrosan	Arasan	Phygon	Spergon
1	41.6	44.2	56.0	52.6	48.4
2	5.8	8.8	17.8	14.2	15.0
3	14.0	28.6	49.2	47.2	55.0
4	25.8	25.2	31.2	35.2	37.0
5	44.8	59.4	62.6	61.6	68.0
6	35.6	47.8	59.8	57.2	55.8
Means	27.9	35.6	46.1	44.7	46.5

It is evident from the preceding data that Agrosan was not equal to the other treatments as a seed protectant and that in several instances the increase in emergence was exceptionally high. In general any of the 3 best compounds can be used in fall plantings of peas with considerable benefit to seed germination.

In the fall of 1957 and again in 1958 tests were made with peas using only 3 dusts. Similar plantings were made in March of 1957 and 1959.

The results are as follows:

Year	Period	Samples No	Mean Percentages of Emergence by Treatments Check	Arasan	Phygon	Spergon
1957	Fall	3	69.2	74.8	79.3	78.4
1958	Fall	1	64.8	67.8	66.4	66.2
1959	Spring	3	57.5	60.4	57.1	61.8
1959	Spring	1	53.2	62.0	69.0	72.6

Phygon and Spergon gave significant increases in the spring of 1959 and may be used on peas when planted in cold, wet soil.

b. Lentil.

Throughout the Middle East lentils are grown for human consumption and the seed hulls from processing are used as a protein supplement for animal feed.

In the spring of 1957 a test with Arasan (2 mg per gram of seed) gave 91 percent emergence of lentil seedlings compared to only 77 for non-treated seed. Additional tests were made in the fall of 1956, and during 1957 and 1958. Treatments used were Arasan, Agrosan, Phygon and Spergon at the same rates as for corn. Each lot was replicated 5 times in a Latin-Square Design using either 100 or 200 seeds per row. The data obtained are as follows:

Year	Period	No. Samples	Mean Percentage Emergence by Treatments Check	Agrosan	Arasan	Phygon	Spergon
1956	Fall	5	80.6	79.7	82.5	79.4	79.5
1957	Spring	5	85.7	87.3	88.3	86.3	88.4
1958	Fall	1	90.4	88.0	93.2	86.4	90.6

The data indicate no benefit from seed treatments other than in the first test in 1956.

c. Other leguminous crops.

Treatment tests were made with seeds of vetches, horse beans (*Vicia faba*), Austrain winter peas and Canada field peas. Rates of application were the same as for peas and lentils. A summary of the results is given below:

Crop	Year (Fall)	No. Samples	Mean Percentages of Emergence by Treatments Check	Agrosan	Arasan	Phygon	Spergon
Austrian peas	1959	1	88.4	87.8	74.2	86.2	83.8
Canada peas	1959	1	89.8	85.8	83.8	83.4	83.6
Vicia faba	1956	3	44.4	46.7	46.1	45.7	44.2
Vicia sativa	1956	2	79.2	80.7	82.7	81.7	82.6
Vicia sativa	1957	1	59.4	62.0	65.4	65.7	60.5
Vicia villosa	1959	1	75.8	82.8	78.2	77.6	73.4
Local	1959	1	83.8	82.6	84.4	83.6	78.2
Cyprus vetch	1959	1	87.2	88.0	85.6	88.0	90.2

The preceding data indicate no benefit from treatment of the species of *Pisum* or *Vicia* with the 4 seed protectants used.

6. Sorghum.

Tests with seed of sweet sorghum, variety Honey Drip, were conducted in 1957 and 1958. The seed was imported from the United States. Dust treatments were applied at the same rate as for corn. The seed was planted in April each year in a Latin-Square design using 5 replications with 200 seeds per replicate. The results are listed below:

Year	No. Samples	Mean Percentages of emergence by treatments Check	Agrosan	Arasan	Phygon	Spergon
1957	1	32.4	50.6	57.0	57.1	54.4
1758	1	21.0	23.4	29.9	31.9	29.4

The seed used in 1957 was 2-year old seed and that used in 1958 was from the same shipment hence it was 3-year old seed and had declined in vitality. The mean increase in germination obtained the first year from seed treatment (4 kinds) was almost 70 percent. Soil moisture supply in 1958 was low and germination was extremely variable.

7. Sugar beets.

Many Lebanese farmers who have access to a supply of irrigation water plant sugar beets because the yield is high when nitrogen is used and the price is such that good returns are obtained. Early planting before the rainy period ceases is desirable but because of low soil temperature heavy seeding rates are necessary followed by thinning to the proper stand. In 1958 a seed treatment experiment was conducted but soil moisture was low and seed germination was so variable that the

results were unreliable. In 1959 4 lots of 2-year old imported seed were subdivided into 6 separate samples and 5 were treated with fungicides as follows:

4 dust fungicides at 150 mg per 50 grams of seed

Panogen 1-500 soaked 3 hours and dried.

The seed was planted March 19 in a randomized block, each in a separate plan with 5 replications of each treatment. The data from this test are as follows:

Sample No	Mean number of seedlings per 100 balls by treatments					
	Check	Agrosan	Granosan M	panogen	Phygon	Spergon
1	25.6	51.2	55.2	27.2	57.6	58.2
2	37.4	55.6	50.2	27.2	64.8	44.0
3	28.8	33.4	63.2	30.0	43.6	34.2
4	43.2	55.0	52.0	48.0	62.2	58.2
Means	33.5	49.0	55.1	33.1	57.0	48.6

From the preceding data it may be concluded that Panogen was of no benefit, Granosan M and Phygon were outstanding in beneficial effects and Agrosan and Spergon were intermediate. The mean percentage increase in germination by Granosan M and Phygon over the non-treated seed was 67 which is of considerable importance in terms of savings on seed.

8. Spinach.

Only one test was made with one lot of spinach seed planted in April 1956. Arasan was applied at the rate of 2 mg per gram of seed. From 4 replications per treatment using 200 seeds per replicate each of treated and non-treated seed the percentages of germination were 81 for the former and 47 for the latter which is a highly significant difference.

Discussion and Summary of Results.

For a discussion of the climatic environment in the Bekaa Plain of Lebanon the reader should refer back to the introduction and brief literature review inasmuch as it is believed that the rainfall, tillage and temperature patterns have an important effect on seed germination in Lebanon and no doubt in other countries of the Middle East where similar conditions prevail.

The data presented in this paper show that with the exception of garden

peas chemical treatments had little or no sffect on seed germination of barley, oats, wheat, lentil, field peas, horse bean and other species of *Vicia*. planted in November. On the other hand treated seed of field corn, sweet corn, sorghum. sugar beet, peas and spinach when planted early in the spring during cool, rainy, periods gave a significantly greater number of seedlings than non-treated seed. In some cases the increase was as much as 94 percent, in others 60 to 74 percent. Seed treatment under the conditions described results in a saving of seed, stronger plants and permits earlier planting which makes use of the normal rainfall for early plant growth, thus reducing the water requirements from irrigation. Farmers plant corn in May in much of the Middle East except along the sea coast but tests show that this crop may be planted in March or early April will reasonable safety from frost. If, in an unusual season, frost damage occurs it will still be possible to replant in time to mature a crop. Sorghum which is an excellent summer forage crop and more drouth resistant but less cold resistant than corn can also be planted earlier than is the common practice and thus take advantage of the normal rainfall to initiate early growth.

In some crop areas of the United States corn is listed in deep furrows. Agronomists in the Middle East might well experiment with listing combined with early planting as a method of producing corn with less water from irrigation than is used at present. The same procedure may be successful with sorghum.

In areas of the United States where sugar beets are grown seed treatment is a standard practice because planting is made early and water is supplied either as rain or by irrigation. Seedling blight and damping-off are destructive factors, hence seed treatment permits both a saving of seed and earlier planting. There is reason to expect that similar benefits may occur in Lebanon and other Middle Eastern countries. The experiments herein described should be expanded in all parts of this great area where the cropping pattern permits early spring planting in cool, wet, or moist soil.

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