MEMORANDUM
TO Dr. J. G. Harrar
FROM Dr. Norman E. Borlaug.

SUMMARY OF RECENT TESTS AND PROPOSED
FUTURE STUDIES WITH AGRICULTURAL CHEMICALS

Attached is a summary of the proposed research which we have outlined for this year. This summary does not include any information on control of diseases by development of resistant varieties, and consequently is restricted to chemical control, with some consideration given to cultural practices which influence development of diseases.

This summary, which I understand is to be used in compilation of a report to the Secretary of Agriculture, is tentative and may be altered somewhat if the chemicals which we have ordered do not arrive in time for our field tests.

This information is restricted to proposed studies on wheat, corn and beans. Perhaps some mention should also be made of the disease problems of other important or potentially important crops such as barley, potatoes, vegetables and fruits.

CHEMICAL TREATMENT OR DISINFECTION OF SEED AS A MEANS OF INCREASING YIELDS OF CORN, WHEAT, BEANS AND SOYA.

Within the past ten years seed treatment has become a generally accepted practice with many cereal and vegetable crops in the United States, Canada and certain European countries. Extensive field experiments over a period of years conducted by reliable investigaters, have demonstrated that it is usually profitable to treat wheat, oats, barley, corn, beans, peas, cotton, peanuts and vegetables.

The increases in yields which result from seed treatment are attributable to killing parasitic fungi and bacteria which are carried on the seed, and which normally either reduce germination or which weaken or kill the young seedlings. Moreover under certain conditions some fungicides protect young seedlings against attack by soil fungi for a few days after germination until they can develop a more extensive root system and thus survive despite subsequent infection.

Whether the results on seed treatments which have been obtained in the United States or elsewhere are directly applicable to Mexican conditions is questionable. The following intemelated factors all influence the response which is obtained with seed treatments:

1.- Microflora of seed lot.- Different lots of seed often possess distinctly different microflora, depending in part upon the climatic conditions under which the seed was produced and on the variety.

2.- Disinfectant Used and Rate of Application.- Experimentation has shown that certain chemicals are beneficial on some crops and of no value or may even be injurious on other crops. Other seed treatments are objectionable because of toxicity to workmen. This specificity of treatment has necessitated continued research for better and safer seed

treatments, and within the past three years at least two new compounds of definite merit have been commercialized. Several other new chemicals of definite merit have been released for limited trials to some investigators. These materials need further testing before they can be recommended for general use.

3.- Soil Microflora.- The microflora of the soil may greatly influence response of seed lots to chemical treatments. Better stands and healthier seedlings are sometimes obtained when treated seeds are planted in seed beds which have previously exhibited damping off when planted with untreated seed.

4.- Type of Soil.- The chemical, and perhaps also the physical makeup of the soil may apparently influence the response of seed lots to treatment. Some chemicals are quickly inactivated in soils which contain certain reactive materials (i.e. organic mercury compounds are quickly converted to mercury sulfides when placed in contact with soils which contain reactive sulfides), whereas another chemical, such as tetramethylthiuram disulfide (Arasan), may give prolonged protection against "damping-of-fungi" in the same soil.

5.- Time of Planting.- Soil temperature at time of germination influences the amount of damage which is caused by "damping-of-fungi". Since soil temperature at time of germination is indirectly influenced by time of planting, this factor must also be taken into consideration in planning field experiments.

6.- Rate of Planting.- Before the advent of seed treatments as a means of increasing stands, heavy rates of seeding were often resorted to in order to offset poor germination and losses from seedling blights. The cost of treatment, which makes possible lighter rates of seeding

and better stands of healthier seedlings results in monetary gain for the farmer.

Seed Treatment Tests for 1945.

Obviously it is impossible to conduct tests this year which will be sufficiently extensive to take into consideration all of the factors mentioned above. Consequently for the coming season it appears advisable to design our tests in such a manner that it will be possible to determine satisfactory seed treatments for the corn, wheat, and beans in the largest producing areas of each of these crops.

- CORN SEED TREATMENT TESTS FOR 1945 -

Part I.- Practical Seed Treatment Tests.

Two lots of seed, Chapingo Type I, and Urquisa, will be treated with the following chemicals:

a).- "Arasan" (tetramethylthiuram disulfide) Applied at the rate of 2 ounces per bushel.

b).- "Semesan Jr." (ethyl mercury phosphate) Applied at the rate of 2 ounces per bushel.

c).- "Spergon" (tetrachloro-para-benzoquinone) Applied at the rate of 2 ounces (of active material) per bushel of seed.

d).- "U. S. Rubber #604" (2,3 dichloro 1,4 naphthaquinone) Applied at the rate of 1 ounce per bushel.

e).- "Barback C" (ethyl mercury, cyanamid) Applied at the rate of 2 ounces per bushel.

Each treated lot of seed will be planted in three row plots, 20 meters long, in a randomized plot design wherein each treatment will

be replicated six times. Plantings will be made at Chapingo, Querétaro and Atlixco.

Information will be collected on stand counts (percentage of seedlings emerging in comparison with number of seeds planted), vigor of seedlings, and yield of various treatments.

Part II.- Response of Various Seed Lots to Seed Treatment.

Twelve lots of seed from the various parts of the principal corn growing regions of Mexico will be tested to determine what percentage of these lots will respond to seed treatment. All samples will be treated with "Arasan", applied at the rate of 2 ounces per bushel, and planted in a randomized plot design, where the unit of treatment will be three row plots, 20 meters long, with each treatment replicated five times. Plantings will be made at Chapingo only. Both stand and yield data will be obtained in these tests.

Part III.- Evaluation of New Chemicals as Seed Treatments for Corn.

A number of experimental chemicals will be evaluated in single row plots, planted in a randomized plot design, replicated five times. The experimental compounds will be directly compared to standard treatments. Only one lot of seed shall be used in these tests and planting shall be restricted to Chapingo. The following chemicals will be evaluated:

1.- Arasan (tetramethylthiuram disulfide)
2.- Semesan Jr. (ethyl mercury phosphate) } Standards
3.- Spergon (tetrachloro-para-benzoquinone)
4.- Phenyl mercury stearate.
5.- Phenyl mercury salicylate.

6.- Phenyl mercury oleate.

7.- Zinc dimethyl dithiocarbamate.

8.- Copper dimethyl dithiocarbamate.

9.- Ferric dimethyl dithiocarbamate.

10.- Biphenyl-maleimide.

11.- O-Tolylmaleimide.

12.- 2,4 Dinitrophenyl-thiocynate.

13.- 2,2' dihydroxy 5,5' dichloro diphenylmethane.

14.- Dithane (disodium ethylene bisdithiocarbamate).

15.- "Lorol" dimethyl benzyl ammonium chloride.

Objective of 1945 Seed Treatment Tests on Corn.

1).- To determine what percentage of seed lots will respond to seed treatments and what increase in yield can be anticipated.

2).- To select the best seed treatment for Mexican conditions.

- 1945 SEED TREATMENT TESTS FOR BEANS -

Diseases and insects greatly reduce the yield of beans in Mexico. Many of these diseases organisms are carried on the seed and give rise to poor emergence, and often kill or reduce the vigor of the young seedlings. Moreover thereby the disease organisms are often carried over from one crop to the next on the seed and thus make it possible for a "build up of innocul" which may later result in serious damage to the established plants. There is little doubt but that seed treatment of beans will be profitable since most of the seed lots are badly infected with a number of pathogenic fungi, especially the bean anthracnose organism, Colletotrichum Lindemuthianum. However in order to be certain that our research program has a sound basis our research for the coming year will be divided into three phases, similar to

our Corn Seed Treatment Tests.

Part I.- Practical Seed Treatment Tests on Beans.

TO DETERMINE EFFECT ON YIELD.- Two lots of beans (bush type) will be selected for this test. The units of planting shall be 3 row plots, 6 meters long, replicated six times in a randomized block design. The following treatments shall be used in this test:

1).- Spergon (tetrachloro-para-benzoquinone) 2 ounces per bushel.

2).- Arasan (tetramethylthiuram disulfide) 2 ounces per 100 lbs. seed.

3).- 2% Ceresan (ethyl mercury chloride) 2 Ounces per bushel of seed.

4).- Semesan (hydroxy mercurichlorophehol) 3 ounces per bushel.

5).- Zinc dimethyldithiocarbamate, 2 ounces per bushel.

Both stand and yield data will be obtained from this test.

Part II.- Response of Various Seed Lots to Seed Treatment.

In order to determine what percentage of seed lots will respond to seed treatments, twelve lots of seed collected from various important bean growing regions of the Republic will be treated with Arasan, applied at the rate of 2 ounces per 100 lbs. of seed. All lots will be planted in three row plots replicated six times. Both stand and yield data will be obtained.

Part III.- Evaluation of New Chemicals as Seed Treatments for Beans.

The same list of experimental chemicals which are included in the corn test (Part III) will be evaluated in the same type of test on beans.

Objective of Bean Seed Treatment Tests.

1).- To determine what percentage of seed lots will respond to seed treatments and to determine what increase in yields can be anticipated when bean seed is treated.

2).- Select the two best treatments for recommendation for 1946.

- 1945 SEED TREATMENT TESTS ON WHEAT -

Observations made in wheat fields during the past two years have established the importance of both "loose smut" and "bunt" of wheat as factors in reducing yields. Fields have been observed where from 40 to 60% of the heads were infected, and infections of 15 to 20% are common.

"Bunt" or "Covered Smut" (caused by Tilletia Levis or Tilletia Tritici) can be readily controlled by treating the seeds with chemicals (i.e. organic mercury compounds), whereas "Loose Smut" can only be eliminated from infected seed lots by hot water treatment.

Part I.- Effect of Seed Treatment for Bunt Control on Yield:

During the forthcoming season tests will be established to determine the effect of chemical seed treatment on the reduction of bunt and the reduction of seedling blights. The following treatments will be evaluated in three plot rows, replicated six times, in a randomized plot disign:

1).- New Improved Ceresan, ½ ounce per bushel.

2).- U. S. Rubber #604 (2,3 dichloro-naphthaquinone) at 1 ounce per bushel.

3).- Arasan (tetramethylthiuram disulfide) 2 ounces per bushel.

Stand, yield and bunt data will be obtained.

Part II.- Response of Various Seed Lots to Seed Treatment for Bunt Control.

Twelve seed lots of wheat selected from the principal wheat growing regions will be treated with New Improved Ceresan at the rate of ½ ounce per bushel. The seed shall be planted in three row plots, six meters in length, replicated six times, in a randomized plot design.

Part III.- Evaluation of New Chemicals as Controls for Bunt and Seedling Blights of Wheat.

The same list of chemicals recorded under Part III of the Corn

Seed Treatment Tests will also be evaluated for bunt and seedling blight control of wheat.

Objective.

Determine what percentage of seed lots will give increased yields as result of chemical treatments which control bunt and seedling diseases. Select two best treatments for general recommendation for treatment of wheat.

- CONTROL OF LOOSE SMUT OF WHEAT -

It appears advisable, in view of the abundance of loose smut in most wheat fields, that a campaign be initiated to reduce the losses from this disease. In view of the fact that the "hot water treatment" is the only effective method known at present for controlling this disease, it appears advisable that this program should be carefully controlled by some government agency. The recommended treatment of soaking the seed in hot water for 10 minutes at 129° F. is very treacherous and must be carefully controlled. Slightly too long exposure or subjecting the seed to slightly too high temperature greatly reduces germinations whereas a slightly lower temperature than the recommended treatment is ineffective in controlling the disease.

It appears advisable that seed lots of the various types of wheat should be treated via the hot water method, under direct supervision of some government agency, and then increased in isolation plots. After the "sanatized seed" has been increased it should be released to the farmers, through some type of arrangement which must be worked out. An educational or extension program must be carred on simultaneously to make certain that the lots of seed free of loose smut are not mixed with infected seed.

- CULTURAL FACTORS AS THEY RELATE TO DISEASE AND YIELD OF WHEAT -

Much of the wheat growing regions near Amecameca, Puebla, Tehuacán, and Atlixco is characterized by very poor stands. For stands are the general rule on both the "dry land" and irrigated fields. However occasionally one finds fields with excellent stands capable of producing 30 or more bushels per acre adjacent to one with poor stands which would probably produce less than five bushels per acre. Obviously there are many interrelated factors which determine what stands will be obtained but it is fundamental to increasing wheat yields, that research be initiated to improve stands density. Undoubtedly the following factors all influence the stand obtained in these wheat growing areas.

1).- Rate of seeding.

2).- Time of seeding.

3).- Method of seeding (i.e. surface seeding, plowing down seed, etc.)

4).- Amount and frequency of irrigation (on irrigated lands only)

Many of the farmers with whom we have talked appear to favor thin stands in order to minimize damage by rust (Puccinia Graminis Tritici, Puccinia Glumarum, and Puccinia Triticina). However the very fact that they resort to growing these very thin stands greatly reduces their yield, regardless of all other considerations. Moreover other gorwers keep the water off their fields so long, in order to reduce rust infection, that yields are undoubtedly lowered as a result of injury from drought.

It therefore appears advisable to establish tests during the coming fall which will determine:

1).- What differences in stand density can be obtained when one rate of planting is used with various methods of seeding.

2).- Determine best time for planting.

3).- Determine what density of stand, and what frequency of irrigation can be

maintained without obtaining rust infections which will greatly reduce yields, with the present varieties.

Objective of Experiment.

To determine what changes in cultural practices can be employed to increase wheat yields with present varieties recognizing the susceptibility to currently grown varieties to rust is one of the factos which must be taken into consideration. However the questions which will be answered by this type of test are fundamental even to the subsequent introduction the development of new resistant varieties of wheat, which is discussed in detail in another part of this report.

- DEVELOPMENT OF EFFECTIVE SPRAY OR DUST TREATMENT FOR BEANS -

Losses from diseases and insects are one of the limiting factors in the production of beans in Mexico. Most of the varieties grown are susceptible to a number of very destructive diseases, i. e. Anthracnose (Colletotricum Lindamuthianum), rust (Uromyces Apprendiculatus) and bacterial blight (Phytomonas - Phaseoli). In addition, the Mexican bean beetle (Epilachna Corrupta), the bean leaf beetle (Ceratoma Trifurcata) and the bean pod weevil (Apion Godmani), are very destructive.

Even with the development of varieties which possess better resistance to these diseases and insects it will be necessary to resort to spraying or dusting as a means of controlling these pests. Consequently during the coming season we will conduct tests to determine the most effective and economical chemicals for controlling these pests.

Spray Program for Beans 1945.

Spray tests will be conducted at Chapingo during the forthcomign summer. Bush beans will be planted in three row plots, six meters long, and each treatment will be replicated six times. Only the center row of each of the three row

plots will be sprayed and the yield data will be taken from the sprayed rows only. Spray applications will be made at approximately seven day intervals throughout the growing season.

The spray test will be divided into three parts as follows:

1.- Fungicides alone: The following chemicals will be used in this test.

a).- Fermate (ferric dimethyl dithiocarbamate)

b).- Bordeaux Mixture.

c).- Zinc dimethil-dithiocarbamate.

d).- Copper dimethyl-dithiocarbamate.

e).- Thiosan (tetramthylthiuram disulfide)

f).- Dithane - sodium ethylene bis-dithiocarbamate.

g).- Copper A compound.

2.- Insecticide alone:- The following chemicals will be used in this test.

a).- Cryolite.

b).- Magnesium arsenate

c).- Lead arsenate.

d).- D.D.T. (dichlorodiphenyl trichloroethane)

e).- Phenothiozine.

f).- D.D.T. - and Phenothiozine.

3.- Combination Test with Fungicide and Insecticide on Beans.

a).- "Copper A" and Magnesium arsenate.

b).- "Copper A" and D.D.T.

c).- "Copper A" and Rotonone

d).- "Copper A" and Lethane

e).- Fermate and D.D.T.

f).- Fermate and Magnesium arsenate.

g).- Fermate and Rotonone.

h).- Fermate and Lethane.

i).- Dithane and Magnesium arsenate.

j).- Dithane and D.D.T.

k).- Dithane and Rotonone.

l).- Dithane and Lethane.

m).- U. S. Rubber #604 and Magnesium arsenate.

n).- U. S. Rubber #604 and D.D.T.

o).- U. S. Rubber #604 and Rotonone.

p).- U. S. Rubber #604 and Lethane.

q).- Biphenylmateimide and Magnesium arsenate.

r).- Biphenylmateimide and D.D.T.

s).- Biphenylmateimide and Rotonone.

t).- Biphenylmateimide and Lethane.

u).- Puratized N5X and Magnesium arsenate.

v).- Puratized N5X and D.D.T.

w).- Puratized N5X and Rotonone.

x).- Puratized N5X and Lethane.

y).- Phynyl mercury oleate (1N5499) and D.D.T.

DUST TESTS.

Dusts are often employed instead of sprays for the control of diseases and insects. They have the advantage that they are more easily applied and in some ways more "fool-proof". However it is questionable whether dusts will give as good control as sprays under conditions of heavy and frequent rains, such as are encountered in Mexico during the summer months. In order to obtain information on this point a test is planned wherein the same amount of chemical (active) is applied both as a spray and a dust. The following combinations will be applied both as sprays and dusts:

1).- Fermate and D.D.T.

2).- Fermate and Magnesium arsenate.

3).- Formate and Lethane.

4).- Fermate and Rotonone.

5).- Dithane and D.D.T.

6).- Dithane and Magnesium arsenate.

7).- Dithane and Rotonone.

8).- Copper A and D.D.T.

9).- Copper A and Magnesium arsenate.

ADHESIVITY OF CHEMICAL SPRAYS UNDER CONDITIONS OF HEAVY RAINFALL.

Within the past few years several products have been commercialized for increasing the "load" of fungicide or insecticide deposited on plants from sprays. These "load-builders", or "stickers" as they are sometimes called, may be of special value under conditions of heavy rainfall. We plan to conduct tests with at least three of these "load-builders", with Fermate and Magnesium Arsenate and Copper "A" and Magnesium Arsenate used as the two insecticides.

MISCELLANEOUS TESTS WITH CHEMICALS FOR CONTROL OF INSECTS

Corn Ear Worm:- (Eliothis Obsoleta).- This insect appears to be very destructive to corn under Mexican conditions and limited tests are planned using D. D. T., Lethane, and Cryolite as dusts and sprays. Plants will be dusted and sprayed at weekly intervals after the corn reaches the "silk" stage of development.

Seed Corn Maggot: (Hylemya sp.).- Under some conditions, especially when corn is planted in dry land where germination is retarded, this insect appears to be

rather destructive. Limited tests conducted at San Gaspar during the current season wherein D.D.T. was combined with the fungicide seed treatments (i. e. Arasan) appear to have value. Further experimentation is essential to establish this point and further tests will be conducted at Chapingo this summer.

Thrip Damage on Corn Planted Under Dry Conditions: Within the past year considerable damage to young corn seedlings caused by heavy infestations of thrips has been observed both in the Bajío and near Cuernavaca. The damage occurs soon after the seedlings emerge, and depending upon the severity of the infectation may either "stunt" or kill the seedlings. It was necessary to resort to spraying at San Gaspar in order to protect the corn breeding plots which were planted in December. Nicotine Sulfate and soap reduce the population but three applications at weekly intervals were necessary to protect the corn through the critical period. Limited experimental applications of D.D.T. showed this material to be of value when applied as either a spray or dust in our tests as San Gaspar. We plan to continue tests with D.D.T., Rotonone, Lethane and Nicotine Sulfate this spring.

WEED CONTROL.

As an outgrowth of our chemical spray program for control of diseases and insects we will conduct limited tests on chemical weed-killers. It is probable that certain of these chemicals may prove of value especially in the production of fruit or vegetable crops, but they may also prove of value in checking the encroachment of particularily destructive weeds into corn, wheat or bean lands. Our tests will include Ammate (ammonium sulfamate), Dow-2-4 (2,4 Dichlorophenoxyacetic acid), and Triox (Arsenic trioxide), three of the newest and most promising chemical "weed-killers".

PLANTING PLAN FOR COOPERATIVE CORN SEED TREATMENT

Test at Canada de Negros - 1945.

Date Planted _____

Stand Counts. (Date) _____

Treatment No. 1 - Arasan
Treatment No. 2 - Semesan Jr.
Treatment No. 3 - Untreated Control (check)

Rows - 20 meters long
Hills - 1 meter apart in row, with 3 seeds per hill.

Row No.