SEED TREATMENTS FOR INSECT CONTROL, WITH SPECIAL REFERENCE TO THEIR EFFECT UPON GERMINATION

by

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INTRODUCTION

In the control of those insects which have a habit of attacking germinating seeds a very desirable method would be to apply a repellent to the seeds at the time of planting. The Kansas Agricultural Experiment Station has been confronted for several years with the problem of controlling the kafir ant, wireworms, false wireworm and other underground insects which annually take their toll of the farm crops by attacking seeds at or near germinating time. A desirable repellent, however, must have several qualities other than repelling insects; namely:

1. The treatment must not injure the germination qualities of the seed.

2. The material used must repel insects.

3. The repellent on the seed should not interfere with the operation of planting machinery.

The Kansas Agricultural Experiment Station has been conducting repellent work for eight years in connection with Project No. 100, "The Control of Underground Insects", under the direction of the late Professor J. W. McColloch.

The purpose of this paper is to attempt to answer some of the questions in connection with the above mentioned requirements.

The writer wishes to express his appreciation for the many valuable suggestions and advice so freely offered by the late Professor J. W. McColloch; to Mr. H. R. Bryson for his cheerful assistance and advice both in the conducting of the experiments and the writing of this paper; to Dr. W. P. Hayes for his clear and concise notes which were made available for this work.

METHODS

The methods employed by the writer in general were essentially the same as those followed by Dr. Hayes (16). The material, seeds treated, and the length of time allowed for the treatments varied considerably.

The writer did not have access to all of the methods used by him, but from the data on hand the following methods were evident.

One hundred seeds were used in each test. The seeds were taken from 52 different varieties of crop plants. The majority of the tests involved the seeds of corn, kafir and sorghums, but a few were with cowpeas, soy beans, alfalfa and clover, while others belong to the grass family.

Hayes (unpublished) dipped and soaked the seeds in many materials. He used various recommended commercial

products, and other materials which he believed might prove useful. These were used at different strengths, and the resultant treatments were handled in various ways, chief of which were drying on paper, drying in air, rolling in dust to remove excess moisture, and planting the seeds wet. There were 53 different materials used in his work. Most of his tests were planted and germinated in the greenhouse. He recorded the germination of the seeds, but did not record temperatures of the soil or surroundings, neither did he calculate the moisture content of the soil.

Hayes (1913) made some tests of repellents against the kafir ant. These experiments were conducted by first, putting treated seeds in jars with a known number of kafir ants and second, by planting treated seeds in a field infested with an unknown number of kafir ants. A record was kept of the resultant germination and growth.

In the first instance the actual number of seeds and ants were known from which data the percent of injury could be calculated. In the case of the treated fields the rate of germination and the amount of growth was recorded, but repellent action of the materials and their effect upon germination could not be determined.

In the writer's experiments 100 seeds each of Pride of Saline corn and Black Hull White kafir were counted out.

These were treated and planted in the field. The field selected for this purpose was an area of soil uniform in texture and structure. In the summer of 1928 the writer assisted with the field tests mentioned above, the data from which is embodied in this thesis. The experiments conducted in the greenhouse were of the same lot of seeds, but only 25 seeds for each material were used.

The seeds after being counted out were placed in cheese cloth bags and a rubber band wrapped around them before dropping into the glasses containing the materials.

The chemicals were used at a 5 percent strength except in a few cases, and the volume of material in each glass was kept as near 100 cubic centimeters as possible. As soon as the materials were ready the seeds were dropped into the solutions after which the glasses were covered. The temperatures of the solutions and the room were recorded during the soaking period. The seeds were soaked for 15 hours, after which they were laid out on paper until dry enough to handle. As soon as the soaked seeds were spread out to dry the dipped seeds were treated and spread out in a similar manner, therefore, the dipped and soaked seeds had the same amount of time in which to dry. When the seeds were dry their colors were recorded. Notes were also taken to determine whether the material had actually entered the seed or whether it was on the seed coat. They

were then sacked up in paper bags, and taken to the greenhouse to be planted.

The planting bed was a ground bed four and one-half feet wide by 33 feet long, and lying in a north and south position. The only unexposed part of the bed was at the south end, and the writer planted the seeds so none would be in the unexposed area. A row of heat pipes was on the west side of the bed, and the seeds were planted so that they were as far away from the pipes as possible. The area nearest the pipes required more water than did the rest of the bed due to the drying effect of the heat upon the soil.

The soil in the bed was fine silt loam, and of uniform texture throughout. The bed was covered by a screen cage that stood 18 inches above the top of the bed. This cage was constructed to keep out rats and mice. Since the entire bed was covered by the screen this factor should have no bearing on the results.

Before planting the seeds the soil was carefully spaded, and then hoed and raked until there were no clods. Any ungerminated seeds that were left from previous plantings were taken from the bed so that they would not interfere with the new test being planted.

When the soil was thoroughly worked and clods removed, the seeds were planted one and one-fourth inches deep in

rows running across the short length of the bed. The seeds were planted one and one-half inches apart in the rows. The rows were four and one-half inches apart. The seeds were then covered and watered.

The dipped and soaked seeds of the same treatment were planted next to each other, so any difference in germination or growth could be noticed at once. Untreated seeds were planted in every sixteenth row along with the treated seeds.

The corn was planted at one end of the bed one time and at the other end the next time, and kafir was alternated the same way. This distributed to both corn and kafir any advantage or disadvantage that the seeds may have had in relation to soil or position.

The order of planting was changed every time also, so that no one treatment of seeds were planted in the same row twice. This distributed the seeds over the bed for each planting, and changed any advantage that might be present in the soil or location around to each treatment.

Stakes bearing the kind of treatment, the kind of seed, and the name of the treatment were placed at the head of each row. This did away with any confusion when taking notes.

The rate of germination, or rather the rate of appearance of the germinated seeds above ground was recorded every day, and the bed watered as needed. No record was taken of the amount of water added to the soil, because this problem was not conducted with that idea in mind, but an attempt was made to maintain the soil at a uniform moisture content. The amount of evaporation and drying due to the heat pipes made it necessary to water that side of the bed more than the rest.

The temperature of the soil and the greenhouse were taken, but they varied as to the amount of heat in the greenhouse, and the amount of sunlight.

The rate of germination was taken until the number of plants became constant and the writer felt sure that no more seeds would germinate. The height of the individual plants was recorded and averaged, and the effect of the materials on plant growth and appearance were also recorded if the material had any marked effect on the subsequent plant growth.

When one test was over another was planted as soon as the ground and the seeds were ready. There were ten different tests started but the rats and mice took two of them.

The field work done during the summer of 1928 was typical of the methods previously employed at the Station.

One hundred seeds were planted four inches apart in the row and the rows averaged 15 inches apart.

REVIEW OF LITERATURE

A review of the literature pretaining to the effects of seed treatment shows that considerable work has been done upon the various phases of the problem.

A discussion of the results of other workers may be considered under two main headings; first, the effect of seed treatment upon the germination of the seeds; second, the effectiveness of seed treatment against insects.

The literature reveals the fact there are several natural factors that affect germination of seeds, chief of which is temperature. Crocker (8) made the calculations from data he had on wheat to show the relation of temperature to the longevity of seeds. He concluded, "With a fixed water content a temperature of 30° C. the seeds will have a longevity of two years; at 20° C. sixteen years; 10° C. 128 years; 0° C. 1024 years." He adds, "The effect of temperature on seed germination has long been recognized, and in many places is the limiting factor in the germination and growth of plants."

Shull (44) and Crocker (8) show as a result of their work with Xanthium that too little oxygen causes delayed

germination while increased oxygen or hydrogen provides increased germination. Shull (44) also states in a later paper, "An increase in oxygen supply brings about an immediate, and rapid increase in the rate of oxygen absorption and an immediate germination of the seed." He states further that, "Light forces the germination of many seeds that would otherwise be dormant, and inhibits many that would grow in darkness."

Shull (43) found the character of the seed coat to vary for the different seeds, with different permeabilities when placed in various solutions. The dry seeds of Xanthium were impermeable to dry alcohol, ether, chloroform, and acetones, but the seed coat was a semipermeable membrane in the presence of other solutions, some going in freely, others more or less retarded.

Whitter (55) added some Sudan III to kerosene in a test of corn seeds, and upon examining the soaked seeds found that 76 percent of the seeds showed no entrance, 14 percent only slightly, and the remaining 10 percent showed deep staining, indicating that considerable kerosene had entered. This indicates that seed coats of the same grain will not act the same way in the presence of various solutions. An interesting phenomena mentioned by Whitter (55), but which he did not attempt to explain, was that seeds

soaked in kerosene several days were not injured nearly as much as those soaked for 30 minutes. Carbolic acid affected the seed coat and the germination of the seeds the same way.

Hayes (16) found that carbolic acid had a detrimental effect upon germination.

The materials discussed in the literature include the compounds of sodium, copper, calcium, coaltar, mercury and arsenic.

Petroleum derivatives, oils, nicotines, nitrates, organic acids, inorganic acids, patent insect remedies, and miscellaneous materials were also mentioned.

Petroleum derivatives have a detrimental effect as has already been mentioned by Whitter (55).

Painter, Fluke and Granovsky (35) found the arsenicals very good in poison bait and as a repellent, but they seriously injured the germination of seeds. Melchers and Tolinson (32), Tisdale and Taylor (48), Coons (7), Kirby (29), Heald (17), Hungerford (22), Darnell and Smith (9), Heald, Zendal and Boyle (18) report no injury to seed germination using copper carbonate for smut control of wheat.

Hamitt and Stone (21), Fraser and Simmons (12) report no injury to seeds treated with formaldehyde and copper sulphate solution.

Higgins (20) using copper sulphate for disease of peppers reports good control and no germination injury. Tisdale, Taylor, Griffiths (49) using formaldehyde, "cholorophyll", copper carbonate for smut control found no injury to germination. The next year Tisdale, Taylor and Leukel(50) duplicated the experiments with the same results.

Johnston and Melchers (27) using formaldehyde, Corona 620, copper sulphate, copper carbonate, and "Seed-o-San" proved the best results obtained from soaking seeds in copper sulphate, or dusting with copper carbonate. Johnson, Leukel and Dickson (26) using the same materials found the results checking in every case with Johnston and Melchers (27).

Tisdale and Taylor (48) reports Bordeaux mixture as having no injury to seed germination.

Coons (7), Tisdale and Leukel (47) found two uses for lime water: (1) hastens and does not injure germination, (2) by washing off other materials that might do injury after they had been used for treatment.

Metcalf (33) using mercuric chloride on forest seeds, finds that the treated seeds germinated nearly as readily as the untreated seeds after soaking them 30 days. Barnsteller (2) showed that if the seeds were dipped in alcohol before treating them with mercuric chloride the

rate of germination decreased, and Walker (53), Orton (34), Clayton (5) all report retardation of growth and reduction in yield.

Shull (43) using organic and inorganic acids found that they had a detrimental effect on the germination of seeds, because of the injury to the seed coat acting as a semipermeable membrane.

Tapke (45) using hot water for smut control reports an average reduction of 12 percent in the treated seeds. Tincher (51) advocates the use of water for grass seeds, but reports injury by water to crimson clover, and dwarf beans. Walker (53) upholds the water treatment for black leg of cabbage and says, "Hot water for 30 minutes at 50° C. is the best control for black leg, and there was no injury to the rate of germination. The seeds that were injured had defective seed coats, and the water brought about internal injuries."

Albert and Flint (1) using heat to kill insects in stored seeds found that there could be from two to 15 percent moisture in the seed at 125° F. and there would be no injury to germination, but above 15 percent moisture in the seed the percent of germination was cut down considerably.

When materials are treated under field conditions for their repellent properties, the literature shows that very little has been done.

Forbes (11) working out a control for the corn root aphis was afforded quite a surprise when he found that the treated seeds did not germinate nearly as well as he expected, but he was more surprised when the yields of the treated plots were greater than from the untreated plots. He states that plants grown from seeds treated with lemon oil, formalin, kerosene and carbolic acid gave higher yields than the checks. The field was very much infested with corn root aphis, and corn field ant. These pests were repelled by the above mentioned materials.

Ingram (24), Riley and Stanley (40) noted that arsenicals would repel certain insects before the insects would eat poisons made with arsenicals.

Hyslop (23) using two-thirds of a pound of arsenate of lead in water, and strychnine sulphate, two-thirds ounce in water and coal tar water per bushel reported negative results in the control for wireworms. Johannason and Patch (25) using corn seed heavily coated with arsenate of lead found that the wireworms went right through the material and it did not kill nor repel them. They also used "Bug Death", "Sherwin Williams Soil Fungicide", and other patent insect repellents, and found them to have no repellent effect whatsoever on wireworms.

Fernald (10) using strychnine against wireworms reports negative results, but using coaltar and rolling the seeds in Paris green was effective in repelling wireworms. He reports no injury to germination.

Johannason and Patch (25) report that tobacco dust seems to be an attrahent rather than a repellent for insects.

SUMMARY OF REPELLENT WORK AT KANSAS STATE AGRICULTURAL COLLEGE

As has been mentioned it was a part of the writer's problem to summarize the notes which had been taken on repellent work undertaken at this Station. The investigation covered a period of eight years, during which time 53 different materials were used, and 52 different varieties of seed were germinated. Not all varieties were treated with the same chemicals, but in general the experiments were conducted in much the same manner, and with the same idea in mind.

To give some idea of the amount of work done on repellents at this Station, there were 657 different tests of which each test had from two to twenty parts, and when summarized they could be placed into the following groups:

Group	Tests	Seeds Treated	Treatment
1	220	Sorghums and kafir	Dipped
	160	Sorghums and kafir	Soaked
2	173	Corn	Dipped
	80	Corn	Soaked
3	24	Soy beans	Dipped
	21	Soy beans	Soaked
4	23	Cowpeas	Dipped
	20	Cowpeas	Soaked

The above figures do not include any of the work on kafir ant, or wireworms, nor do they include any of the tests in which the seeds were soaked longer than 24 hours. They are only the dipped and 24-hour soaked seeds.

The writer has listed in Table I the results which were obtained from the summarized work, using only the notes obtained where standard varieties were treated. These include the following:

CORN

Boone County White
Reid's Yellow Dent
Kansas Sunflower
Hildreth Yellow Dent
Pride of Saline

KAFIR, SORGHUMS, CANE, ETC.

Black Hull White Kafir
Kansas Orange
Red Amber Cane
Pink Kafir
White Milo
Yellow Milo
Freed's Sorghums

SOYBEANS

Taha Soybeans
Manchurian
Sooty

COWPEAS

Whipperwill

The check which is listed with the treated material is an average of the individual checks, and in the same manner, the treated is an average of the treated for one kind of treatment over the eight-year period.

Table I* shows without much explanation the effects of the treatments on the treated seeds by comparison with the check or untreated seed.

There has been considerable work done on crude carbolic acid as a repellent and since this material was so highly recommended a few years ago, it would be well to show the effects of crude carbolic acid and other materials on seeds and insects.

To test for the entrance of crude carbolic acid and kerosene into the seeds 100 seeds each of Boone County white corn and Freed's sorgo were soaked for one month. Some Sudan III was added to make it easier to find whether the materials had entered. After one month 13 percent of the corn germinated from crude carbolic acid treatment while only one percent of the sorghum germinated. Kerosene was not so detrimental, the corn having a germination of 65 percent, and the sorghum 7 percent. The seeds were examined for the presence of the material. The results show that the material had entered one-half of the corn, 93

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*Any figure appearing in a table in this paper is expressed in percent unless otherwise designated.

TABLE I. THE EFFECTS OF CHEMICALS UPON DIPPED AND SOAKED SEEDS

Chemical Used	CORN Dipped No. TTS	CORN Dipped TTD	CORN Dipped CK	CORN Soaked No. TTS	CORN Soaked TTD	CORN Soaked CK	KAFIR Dipped No. TTS	KAFIR Dipped TTD	KAFIR Dipped CK	KAFIR Soaked No. TTS	KAFIR Soaked TTD	KAFIR Soaked CK	SOY BEANS Dipped No. TTS	SOY BEANS Dipped TTD	SOY BEANS Dipped CK	SOY BEANS Soaked No. TTS	SOY BEANS Soaked TTD	SOY BEANS Soaked CK	COW PEAS Dipped No. TTS	COW PEAS Dipped TTD	COW PEAS Dipped CK	COW PEAS Soaked No. TTS	COW PEAS Soaked TTD	COW PEAS Soaked CK
Crude Carbolic Acid	7	20.5	77	3	18.4	86.9	12	15.8	44.2	3	8.2	48.6	2	6.6	26	1	0	22.4	1	9	32	2	12.6	27.1
Turpentine	4	73.6	82.4	3	78	88.9	7	30.9	44.3	3	19.2	45	1	44.7	27.2	1	20.1	22.4	1	29.8	32	1	18.1	27.1
Kerosene	12	61	85.1	9	69.7	90.1	15	33.4	42.9	9	28.2	43.0	2	42.5	38.1	2	18.6	21.9	2	31.1	32.7	2	13.5	38
Black Leaf 40	10	79	84	8	77.1	90.1	17	34.4	39.9	9	29.7	44.1	2	32.4	38.1	2	9.3	21.9	2	33	49.3	2	7.8	38
Bordeaux 4-5-50	9	86.6	86.5	4	91.6	90.7	5	42.8	35.4	4	48.4	41.9	2	40.2	38.1	2	17.8	21.9	2	44.3	49.3	2	13.2	35.5
Lime Sulphur	7	73.9	81.7				7	32.9	35.8	3	29.3	45.7	1	25.7	27.2	1	19	22.4	1	34	32	1	19	27.1
Carbon Bisulphide	4	87.5	92.8	1	0	92	4	40.3	40.3	4	15	41.7	1	33	27.2	1	17	22.4	1	45	32	1	17	27.1
Lee's Poultry Dip	4	29.5	92.2	4	22.2	90.7	4	11.6	39.8	4	5.4	40.4	2	4.7	38.1	2	4	21.9	2	6	46.3	2	6	27.1
Nitro Benzine	4	9.8	90.7	4	3.5	89.2	4	10.4	39.5	5	7.4	41.3	2	14.5	33.1	2	5	19.2	2	6.9	49.3	2	4.5	35.5
Water	11	86.9	92.2	8	85.3	89.7	11	48.9	51.2	8	51.2	51.8	2	14.8	19.8				2	48.3	49			
Formalin 4%	4	67.7	94.6	3	10	94.5	3	9.1	44.4	3	.3	45	2	16.1	38.1	2	5	21.9	2	13	38.5	2	4.25	38
Napthaline							2	47.6	41.6	1	10.3	56.3	1	29	27.2	1	15	22.4	1	24	32	1	15	27.1
Potassium Cyanide							3	15.8	41	3	2.7	45	1	38	27.2	1	4	22.4	1	29	32	1	4	27.1
Potassium Dichromate	4	58.6	80.1	2	37.8	84	5	36.1	36.3	4	6.1	41.8	1	38	27.2	1	2	22.4	1	24	32	1	2	27.1
Copper Sulphate	7	86.2	93.5	7	78.2	91.3	10	52.4	50.6	10	40.1	51.5	1	37	27.2				1	37	32	1	17	27.1
Aniline							3	2.6	41	3	1.1	42.3	2	10	27.2	2	0	22.4	1	5.5	32	1	0	27.1
Dr.Hess' Poultry Dip	2	45.1	92.4				4	5.8	44	2	0	47.3												
Lime Water	1	71.9	79.5	1	86.6	79.5	2	19.1	28.0	1	22.8	33.6												
Dry Lime Sulphur	1	53.3	71.9				1	16.4	41.6															
Sublimed Sulphur	1	48.6	75				1	16.2	19.8															
Fish Oil	2	29.1	52.5				1	6.6	19.8															
Lime	1	85.8	84.7	1	79.9	84.7	1	32.8	30.1	1	18.4	33.1												
Bordeaux Water	2	85.8	84.3	2	89.8	84.3	4	38.2	31.8	4	46.3	32.5												
Paris Green	8	76.5	92.4	8	70.3	91.1	10	41.4	50.9	10	23.3	52												
Napthaline in Alcohol	1	75.8	87.6	1	3.9	87.6	3	35.8	37.9	3	1.2	37												
Potash	1	80.1	83.2				1	35.8	55.9															
Dried Blood	1	78.4	83.2							1	63.2	55.9												
Special Bone Meal	1	88.4	83.2				1	53.3	55.9															
Road Oil	4	80.5	93.1	3	75.9	89.9	3	18.4	42.9															
Complete Fertilizer	1	86.2	83.2				1	34.8	55.9															
Complete Fertilizer 2-10-2	1	80.9	83.2				1	40.6	55.9															
Copper Carbonate	7	80.2	92.1	7	86.5	90.7	10	66.2	53.7	7	55.8	55												
Oil of Cloves							3	2.6	41	2	5	36.5												
Acid Phosphate	1	81.6	83.2				1	40.2	55.9															
Tobacco Oil	1	53.1	58.9				3	22.5	22.9															
Dry Sublimed Sulphur	1	44.8	81.3																					
Crude Carbolic Acid plus Bordeaux 1-1	2	10.6	69.8				2	95	21.5															
Crude Carbolic Acid plus Bordeaux 1-4	2	17.3	68.8				2	3.4	21.5															
Crude Carbolic Acid plus Bordeaux 1-10	2	44.2	68.8				2	13.2	21.5															
Crude Carbolic Acid plus Bordeaux 1-25	2	65	68.8				2	16.3	21.5															
*CCA + Lime Sulphur 1-1	2	13.7	69.8				2	1	21.5															
CCA + Lime Sulphur 1-4	2	6.1	61.8				2	10	21.5															
CCA + Lime Sulphur 1-10	2	32.8	68.8				2	10.8	21.5															
CCA + Lime Sulphur 1-25	2	34.6	68.8				2	14.6	21.5															
CCA + Black Leaf 40 1-1	2	24.9	69.6				2	16	21.5															
CCA + 95% Alcohol 1-1	2	5.4	68.8				2	20	21.5															
CCA + 95% Alcohol 1-4	2	32.8	68.8				2	5.9	21.5															
CCA + 95% Alcohol 1-10	2	43.9	68.8				2	8	21.5															
CCA + Water 1-1							1	0	32.7															
" " " 1-2							1	1	32.7															
" " " 1-3							1	2	32.7															
Sanax Dip							3	7.7	39.8															
Camphor							3	31.2	49.3															
Formalin 5%							3	12.1	46.1															
Formalin 40%							5	1.7	44.1															
CCA Dried in Dust							1	21.	27															
Sanax 1-50 Water							1	31	27															
Alcoholic Menthol							2	7.5	43.2															
Prostine							1	4	21															
Insective							2	14	15.7															
Sodium Nitrate							2	2%	55.9															
Coal Tar							3	3.9	37.1															

*No. TTS - Number of Tests; TTD - Treated; CK - Check. **CCA- Crude Carbolic Acid.

percent of the sorghum showed entrance. It can be seen from this data that soaking for one month was very detrimental to germination.

In another test using crude carbolic acid and kerosene the seeds were soaked from one day to one year and then germinated. The effects of crude carbolic acid was so deleterious that the corn seeds were dead after 50 hours of soaking. The kerosene did not cause as much injury as indicated by the fact that 5 percent of the seeds germinated after soaking for two months.

A variety test on sorghums and kafir using crude carbolic acid, kerosene, and Black Leaf 40 for different lengths of time is tabulated in Table II.

As is shown, crude carbolic acid seriously injured the seeds after soaking only three hours. There was apparently no difference between the effects of soaking three hours and soaking six hours in kerosene. Black Leaf 40 seemed to stimulate germination.

The next test was to determine whether or not the chemicals left on the seed had any effect on the germination so some of the seeds of kafir dipped in crude carbolic acid were dried on paper, others rolled in flour and still others planted wet. A check was planted with this test. The results were as follows:

TABLE II. VARIETY TESTS OF SORGHUMS AND KAFIRS WITH CRUDE CARBOLIC ACID, KEROSENE AND BLACK LEAF 40

Variety	Treatment											
	Crude Carbolic Acid			Kerosene			Black Leaf 40					
	Ck	Hrs* Skd	% Germ	Hrs Skd	% Germ		Hrs Skd	% Germ		Hrs Skd	% Germ	
Feterita	6	3	0	3	2		6	0		3	12	6	19
Spur													
Feterita	13	3	0	3	0		6	1		3	8	6	19
Red Amber	54	3	3	3	23		6	19		3	42	6	34
Hegari	4	3	1	3	8		6	7		3	18	6	23
Schrock													
Kafir	49	3	0	3	18		6	23		3	45	6	42
Sumac	84	3	1	3	51		6	60		3	52	6	90
Darso	30	3	0	3	6		6	12		3	24	6	26
Yellow Milo	45	3	0	3	13		6	13		3	33	6	27
Dwarf White													
Milo	66	3	0	3	13		6	18		3	46	6	56
White Milo	42	3	0	3	10		6	9		3	24	6	18
Kansas													
Orange	20	3	0	3	9		6	2		3	21	6	14
Black Hull	8	3	0	3	30		6	24		3	48	6	49
Kafir													
Freed's													
Sorgo	37	3	0	3	9		6	14		3	28	6	22
Dawn Kafir	3	3	0	3	22		6	32		3	38	6	33
Sudan Grass		3	5	3	37		6	30		3	16	6	25
Red Kafir	36	3	0	3	19		6	21		3	35	6	38
Pink Kafir	62	3	0	3	55		6	45		3	91	6	86
Sunrise													
Kafir	62	3	0	3	26		6	42		3	78	6	73

*Hrs. Skd - Hours soaked

*% Germ - Percent germination

TREATMENT	PERCENT OF GERMINATION
Check	54.4
Planted dry	24.7
Planted wet	25.9
Rolled in flour to remove moisture	24.8

There apparently was no injury to the germination from the material left on the seed.

Crude carbolic acid mixed with other chemicals were tested on both corn and sorghums. One-hundred seeds of each variety were used and the results are shown in Tables III and IV.

The test using Bordeaux mixture, 25 parts to one part of crude carbolic acid is the only test that gave approximately as high percent of germination as the check.

Seeds of corn and kafir soaked for many months in kerosene and turpentine show a gradual loss of germination as the time was lengthened for soaking in both materials.

The effects of turpentine on the germination of soaked seeds of commercial white corn, pink kafir, red amber cane, and Freed's Sorgo, one-half of which were dried before planting, the other one-half planted wet are shown in Table V. The seeds were soaked for different lengths of time as indicated in the table.

TABLE III. FIELD TESTS WITH CRUDE CARBOLIC ACID MIXED WITH OTHER CHEMICALS ON SORGHUMS

One part Crude Carbolic acid mixed with	Treatment	Blackhull White Kafir No. TTS	Blackhull White Kafir Av. % Germ.	Pink Kafir No. TTS	Pink Kafir Av. % Germ.	White Milo No. TTS	White Milo Av. % Germ.	Yellow Milo No. TTS	Yellow Milo Av. % Germ.	Kansas Orange Cane No. TTS	Kansas Orange Cane Av. % Germ.	Red Amber Cane No. TTS	Red Amber Cane Av. % Germ.	Sumac No. TTS	Sumac Av. % Germ.	Freed's Sorghum No. TTS	Freed's Sorghum Av. % Germ.	Averages of Averages
Crude Carbolic Acid Concentrated	Dipped	4	0	4	2.7	3	.3	4	2.5	5	1.8	4	10.7	4	0	5	0	2.2
Nicotine Sulphate 40%, 1 part	Dipped	4	0.2	4	4.5	2	0	3	4.6	5	1	4	9.2	4	4	5	0	2.9
Bordeaux 4-5-50 1 part	Dipped	4	0	4	2	3	0	4	1	5	0.2	4	4.6	4	0.2	5	0.2	1.0
Bordeaux 4-5-50 4 parts	Dipped	3	2.6	2	0	3	0	2	0.2	3	1.3	2	12.5	2	7.5	4	2.7	3.3
Bordeaux 4-5-50 10 parts	Dipped	3	0	2	2	3	9	2	16.5	3	5.6	2	48	2	22	4	4	13.4
Bordeaux 4-5-50 25 parts Lime	Dipped					3	19	1	25							4	10.7	18
Sulphur 1 part Lime	Dipped	4	0.5	4	2.2	3	2.3	4	0.5	5	0.2	2	1.5	4	0.7	5	0	.9
Sulphur 4 parts Lime	Dipped	3	1	3	12.6	3	15.3	3	1.3	4	2.7	2	14	3	23.6	4	6.2	9.6
Sulphur 10 parts Lime	Dipped	3	1	2	5.5	3	17.6	2	6	3	4	2	15	2	21	4	7.7	9.7
Sulphur 25 parts	Dipped					3	18	1	14							4	6.7	13
Check	Dipped	4	2.5	4	25.5	3	10	4	26	5	13.4	4	30.7	4	43	5	20.8	21.5

*No. TTS - Number of Tests

**Av. % Germ.- Average percent of germination.

TABLE IV. FIELD TESTS WITH CRUDE CARBOLIC ACID MIXED WITH OTHER CHEMICALS ON CORN

One part crude carbolic acid mixed with:	Treatment	Commercial White Corn		Boone Co. White Corn		Hildreth Sunflower		Reid's Yellow Dent		Pride of Saline		Kansas Sunflower		Iowa Silvermine		Silver King		Freed's White Dent		Roseland White		Shawnee White		Midland Yellow Dent		Colby's Bloody Butcher		20th Century		Sherrod White Dent		Average of Averages
		No. TTS*	Av. % Germ.**	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	No. TTS	Av. % Germ.	
Crude Carbolic Acid Concentrated	Dipped	4	6.2	4	1.7	3	6.5	1	0	4	12	4	5.5	1	12	2	15	2	12.5	1	52	1	32	1	7	1	9	1	3	1	5	11.1
Black Leaf 40, 1 part	Dipped	2	67	2	2	2	15	1	1	2	18.5	2	41	1	17	2	3	2	15	1	16	1	41	1	25	1	80	1	15	1	23	25.9
Bordeaux 4-5-50 1 part	Dipped	4	7.7	4	1.5	4	0.7	1	3	4	15	4	6	1	14	2	10	2	7.5	1	3	1	10	1	13	1	25	1	20	1	7	10.3
Bordeaux 4-5-50 4 parts	Dipped	3	18.3	3	14.3	3	23.6			3	21	3	10.3			1	18															17.6
Bordeaux 4-5-50 10 parts	Dipped	3	61.3	3	41	3	35.3			3	35	3	47			1	46															44.3
Bordeaux 4-5-50 25 parts	Dipped	2	81.5	2	63	2	53.3			2	61	2	64																			65.4
Lime Sulphur, 1 part	Dipped	4	9.2	4	3.2	4	5.3	1	30	4	10	4	4.2	1	19	2	15	2	9	1	4	1	28	1	19	1	30					14
Lime Sulphur, 4 parts	Dipped	3	29.6	3	32	3	18	1	2	3	7	3	15.6			1	10	1	9													15.9
Lime Sulphur, 10 parts	Dipped	3	46.3	3	44	3	19.3			3	24	3	23			1	36															32.1
Lime Sulphur, 25 parts	Dipped	2	65	2	44.5	2	35			2	30.5	2	31																			34.1
95% Grain Alcohol 1 part	Dipped	2	4	2	6	2	10			2	1	2	5.5																			5.2
95% Grain Alcohol 4 parts	Dipped	2	36.5	2	20.5	2	42.5			2	35	2	32																			33.3
95% Grain Alcohol 10 parts	Dipped	2	25	2	41.5	2	58			2	42	2	52.5																			43.8
Check		4	84.7	4	43	4	73.7			1	48	4	48.5															1	75	1	59	67.1

*No. TTS - Number of tests

**Av. % Germ. - Average percent germination

TABLE VI. EFFECT OF DRYING SEEDS BEFORE PLANTING

Time	Commercial White Corn				Pink Kafir				Red Amber Cane				Freed's Sorgo			
	Wet		Dry		Wet		Dry		Wet		Dry		Wet		Dry	
	CK*	TTD*	CK	TTD	CK	TTD	CK	TTD	CK	TTD	CK	TTD	CK	TTD	CK	TTD
1 Minute	85	26	36	12	21	4	23	13	19	13	5	10	5	6	6	11
5 Minutes					1	1	9	2	11	9	7	9	23	4	5	5
10 Minutes	71	46	23	21	4	5	26	29	31	7	13	14	22	13	28	15
15 Minutes					12	3	30	20	36	9	15	12	14	8	12	6
20 Minutes	75	30	46	28	11	2	22	11	19	12	9	18	2	0	15	1
1 Hour					9	4	24	17	13	9	6	8	5	0	13	5
2 Hours	76	19	41	16	10	5	33	22	32	19	11	8	25	21	13	30
3 Hours					15	6	28	20	40	7	10	9	28	12	14	16
6 Hours					8	6	11	24	19	3	10	10	33	13	16	5
8 Hours	36	31	44	17	16	1	12	25	18	4	16	11	13	4	8	0
24 Hours	86	16	45	42	19	2	28	27	9	7	2	4	23	4	11	4

*CK - Check
*TTD - Treated

Corn and sorghum seeds were dipped into lime sulphur and Black Leaf 40 at different strengths, the germinated seeds gave the following results:

	Corn		Sorghum	
Lime Sulphur	% of Germination: Treated	Check	% of Germination Treated	Check
Straight	53	74.1	26.7	30
LS - H_2O 1-1	62.3	74.1	26.3	30
" 1-4	64.6	74.1	30.3	30
" 1-10	68.9	74.1	32.0	30
" 1-25	77.4	74.1	36.3	30
" 1-100	76.4	74.1	35.1	30
" 1-200	74.1	74.1	31.2	30
Black Leaf 40:				
Straight	85	77.1	36.1	39.9
BL 40-H_2O 1-1	77.7	77.1	39.5	39.9
" 1-4	73.2	77.1	44.2	39.9
" 1-10	78.6	77.1	39.9	39.9
" 1-25	76.1	77.1	39.4	39.9
" 1-100	77.1	77.1	37.3	39.9
" 1-200	76.8	77.1	31.0	39.9

The data show that the germination was not seriously injured in any case.

In testing out repellents against kafir ant McColloch (unpublished) conducted some experiments using kerosene, turpentine, "Black Leaf 40", oil of lemon, camphor, refined carbolic acid, crude carbolic acid, and two brands of commercial chicken dip composed largely of crude carbolic acid and creosote. The results are shown in Table VI.

Table VI. Efficiency of Crude Carbolic Acid as a Repellent

Treatment	Percent germ.
Dipped in Kerosene	20
Dipped in Turpentine	23
Dipped in Black Leaf 40	50
Dipped in Oil of Lemon	17
Dipped in Camphor	9
Dipped in Refined Crude Carbolic Acid	0
Dipped in Crude Carbolic Acid	80
Dipped in Commercial	87
Dipped in Commercial	89
Check	90

The rate of germination showed by some of these materials, especially crude carbolic acid and those materials composed mostly of crude carbolic acid, gave good indication that a repellent had been found which was not injurious to the germination of kafir seeds. In a late test using the same materials, and in the presence of the kafir ant, Solenopsis molesta, these materials gave even better results as a repellent. Results of the various repellents given in Table VII.

Table VII taken from Hayes (15) shows the excellent rate of germination of the carbolic acid group in comparison to the others in this particular instance. The field in which this test was tried was one very heavily infested with kafir ants, and from the data it is shown that the carbolic acid group not only gave a very high rate of germination, but also repelled the ants. This material was immediately recommended as a repellent, but the next year or two shows the following disasterous results:

	Check	Turpentine	Crude Carbolic Acid	Camphor	Kerosene
May 8	5576	6856	934	6014	6445
May 16	433	150			539
			636		1132

These tests were actual field tests using the above listed materials. The actual number of ants was unknown, but the only comparison we have of the repellent power is to compare the figures planted on the same day. In some cases there was no check test planted, but we can get some comparison by looking at the amount of germination as each test for the different days was planted with the same amount of seed. From the data kerosene appears to be a promising repellent.

Material	No. ants	No. tests	Treated		Check	
			% germ.	% injury	% germ.	% injury
Bordeaux	124	4	34	1	28	2
Black Leaf 40	165	4	22	6	10	7
Kerosene	137	2	18	2	24	0
Crude Carbolic acid	200	1	0	0	12	0
Turpentine	200	1	12	4	12	0
Lime Sulphur	200	1	8	0	8	0
Alcohol Naphthaline	200	1	8	0	8	0
Paris green	200	1	12	0	8	0
Copper sulphate	200	1	54	0	8	0

It is quite evident here that crude carbolic acid is injurious to germination. A reason for the good showing of crude carbolic acid in the former test was that the seeds that year had unusually high vitality and strong seed coats. Later, tests were carried on with poorer seed, and this not only shows the injurious effects of crude carbolic acid, but suggests that the best seed should be used in all repellent work.

Other laboratory tests using both kafir ants and wireworms are given in the following results. Twenty-five black hull white kafir seeds were used, and a colony of ants were introduced. These tests were in crocks as were the former.

	Percent Germination	Percent Injury
Tobacco oil	38	0
Nicotine Resinate	22	0
Black Leaf 40	26	2
Check	40	2

Using 25 seeds of commercial white corn to which ten wireworms were added:

	Percent Germination	Percent Injury
Tobacco oil	80	1
Nicotine Resinate	24	0
Black Leaf 40	88	0
Check	88	5

Using 10 seeds of commercial white corn and 10 wireworms:

	Percent Germination	Percent Injury
Tobacco oil	75	1
Nicotine Resinate	40	0
Black Leaf 40	45	1
Check	100	2

The injury caused by the wireworms was done after the seed had germinated and the plant started its growth. All of the materials seem to have good repellent powers, but more tests should be conducted before drawing definite conclusions.

In 1917, McColloch (unpublished) treated 25 kafir seeds with each of the following: turpentine, "Creso", Black Leaf 40 (1-100), and "Treat It". There was an average of 40 per

cent germination in all the tests except "Creso", and with this material there was no germination at all. The only injury by the ants was to the check and five grains had been destroyed.

A few years ago several tests with Nitrobenzene were conducted at this Station. The seeds were fumigated for different lengths of time with the following germination results.

Time	Kafir	Corn
1 hour	23.6	
3 hours	21.5	
6 hours	20.3	
12 hours	26.6	
24 hours	26.3	96.8
48 hours	23.5	97.5
Check	22.7	95.1

There apparently was no injury to either corn or kafir treated with nitrobenzene on the germination, but since nitrobenzene has a tendency to soften the brain of man and animals if used in sufficient quantities, the tests were discontinued.

McCulloch (unpublished) in 1917 made several tests on corn and sorghums with fertilizers. The fertilizers were used with several other chemicals to find their effect upon the germination of seeds. Tables VIII and IX show the results of this work.

TABLE VIII. THE EFFECTS OF FERTILIZERS MIXED WITH CHEMICALS ON SEED GERMINATION OF CORN

	Black Leaf 40	Lime Sulphur	Treat-it	Coal Oil	Turpentine	Bord-eaux	Creso Dip
Sodium Nitrate	63.5	36	43.7	59.7	68.3	21.7	4
Potash	75	32.3	45.7	62.1	79.1	34	3
Dried Blood	71.4	42.6	51.7	67.7	84.5	53.2	2.1
Special Bone Meal	83	44	78.2	73.4	89.7	63.5	2.3
Complete Fertilizer 2-10-2	75.4	43.6	71.7	62.4	85.1	58.5	6.8
Acid Phosphate	77.7	50.6	73	56.3	79	68.6	11
Complete Fertilizer	89.6	45	59.2	65.5	81.1	67	2.8
Sulphate of Potash	79	53	66.5	40.5	84.3	74.5	12.6
Check	83.4	75	59.2	82.5	82.1	53.7	76.5

TABLE IX. THE EFFECTS OF FERTILIZERS MIXED WITH CHEMICALS ON SEED GERMINATION OF SORGHUM

	Black Leaf 40	Lime Sulphur	Treat-it	Coal Oil	Turpentine	Bord-eaux	Creso Dip
Sodium Nitrate	18.4	31.4	33.3	25.6	27	5.5	1.5
Potash	24	39.5	32.2	29.5	31.4	18.8	.9
Dried Blood	11.2	31.7	29	19.6	22.2	32.9	1.6
Special Bone Meal	31.6	43.3	37.6	38.2	36.2	37.3	.8
Complete Fertilizer 2-10-2	30.2	44.2	36.7	32.7	30.2	39.1	1.3
Acid Phosphate	28.3	46.7	33.3	25.1	37.3	47.6	3
Complete Fertilizer	21.4	43.2	37.1	21.9	15.5	36.1	2
Sulphate of Potash	14.3				19.8		
Alone	25.8	46.7	36.2	23.5	38.4	40.1	5.3
Check	35.8	37.7	43.3	40.4	66.4	45.4	50.1

TABLE X . BORDEAUX USED WITH OTHER MATERIALS ON CORN AND CANE

	Red Amber Percent Germination	Kansas Sunflower Percent Germination
Bordeaux 1 part plus Crude Carbolic Acid	12	22
Bordeaux 1 part plus Crude Carbolic Acid plus 10 Percent alcohol, 1 part	45	27
Bordeaux 1 part plus Black Leaf 40, 1 part	47	86
Bordeaux 1 part plus Black Leaf 40, 1 part, plus Water 100 parts	56	79
Bordeaux 1 part plus Lime Sulphur 1 part	65	99
Bordeaux 1 part plus Turpentine 1 part	70	61
Bordeaux 1 part plus Creso Dip 1 part	47	3
Bordeaux 1 part plus Treat-it 1 part	45	86
Check	38	68

This work was done in connection with the corn root aphis. The data show that the rate of germination was not appreciably decreased, except those tests using lime sulphur, "Creso Dip". It appears that the use of

fertilizers may prove very good, not as a repellent alone, but to act as a stimulus for the plant. This stimulating effect would in some cases put the plant out of danger of attack before the insect attacked.

In another test on sorghum using Bordeaux mixture mixed with several other materials the data shown in Table X gives the results.

THE WRITER'S WORK

In addition to summarizing the work that had already been done the writer carried on experiments in the greenhouse. Seeds of corn and kafir were the only seeds used. The writer tested 34 materials for their effect upon the germination of the seed, several of which were recommended repellents. The remainder were commercial products or materials that might prove to have repellent properties.

The following is a list of materials that were used in the writer's work: Lemon oil, Corona copper carb, mercuric chloride, lime sulphur solution, "Derresite", "Cresol U.S.P.", "Sunco Emulsion", stove polish, arsenic, "Nico Fume", "Seed Protecto", kerosene emulsion, copper sulphate emulsion, Paris green, water, sodium nitrate, "Rodent poison", "Rat embalmer", sodium fluosilicate, sodium bicarbonate, copper sulphate, "Korn Protector", paradichlorobenzene, creosote, sodium arsenite, sulphur, soap solution, carbon bisulphide, kerosene, Black Leaf 40 (straight) and Black Leaf 40 at rates of 5 percent, 15 percent, and 25 percent.

The seeds treated with these materials were not all planted at one planting. They were planted 17 at a time, and then those that made no showing after the second time were discarded and others added.

The temperature in the greenhouse was kept fairly constant. It never went below 65° F., and was usually between 75° and 85° F. The soil temperature ranged from five to ten degrees below the room temperature. The average soil temperature taken, over the length of time in which experiments were going on was 71.5° F. The temperature of the soaking room ranged from 47° F. up to 75° F. with an average temperature of around 61° F. The temperature of the materials was about five to seven degrees below the soaking room temperature. The materials never went below 40° F. nor above 75° F., and that much deviation will not injure seeds as was shown in the literature by Tapke (45).

The actual germination rate of each material can be found in Table XI by comparing it to its corresponding check. Each figure under the treated is an average of the treatments using a certain material. The check is an average of the untreated seeds that were planted along with the treated seeds.

The table itself needs little explanation, but the writer feels that each material should be discussed and explained.

TABLE XI. THE EFFECTS OF CHEMICALS ON CORN AND KAFIR SEEDS

Chemical	No. TTS	Corn				Kafir			
		Dipped		Soaked		Dipped		Soaked	
		TTD	CK	TTD	CK	TTD	CK	TTD	CK
Lemon Oil	4	96	92.7	56	90.1	53	50.5	42.6	70
Corona	2	86	91	88	91	60	45	62	50
Mercuric chloride	3	16	91	0	91	20	42.6	2	50
Lime and Sulphur Solution	2	72	91	38.8	91.2	52	45	48.3	46.8
Derresite	2	64	91	0	91	56	45	2	50
Cresol U.S.P.	2	2	91	0	91	32	45	22	50
Sunoco Emulsion	2	82	91	86	91	68	45	48	50
Stove Polish	2	96	94	80	94	54	56	22	45
Arsenic	2	92	92	64	92	20	56	24	45
Nico-Fume	1	84	92	76	92	36	38	24	32
Seed Protector	1	92	92	88	92	10.3	28.7	32	32
Kerosene Emulsion	1	54	95	60	94.5	52	74	32	45
Copper sulphate Emulsion	1	92	97	92	97	4	74	44	58
Paris green	8	76	92	70.3	91.1	41.9	50.9	23.3	52
Water	8	86	92	85.3	79.7	48.9	51.2	51.2	51.8
Sodium Nitrate	3	65	97	53	97	73	75.5	60	78.5
Rodent Poison	7	82.3	88.5	59.1	92	57.5	59	48.4	53.5
Rat Embalmer	5	81.6	94.8	53.8	91	39	47	14.8	45.6
Sodium Fluosilicate	5	70	90.8	28.8	80	37	47	29	45.6
Sodium Bicarbonate	2	85	91.2	86.2	91.5	36	52.5	32	48
Copper Carbonate	7	80.2	92.2	86.5	90.7	66.2	53.7	55.8	55
Korn Protector	5	82.6	92.6	73.6	90.6	56.2	59.2	55.4	57
Paradichlorobenzene	2	88	95.5	82	88.5	65.5	75	75	78.5
Creosote	2	61.5	95.5	79.5	88.5	53	75	20	78.5
Sodium Arsenite	4	0	92.7	0	91.7	2	64.5	0	63.2
Sulphur	2	88.5	95.5	94.3	88.5	71.5	75	82	78.5
Soap Solution	2	50	91	59.7	87	48	61	66	66.6

TABLE XI. THE EFFECTS OF CHEMICALS ON CORN AND KAFIR SEEDS CONT'D

Chemical	No. TTS	Corn				Kafir			
		Dipped		Soaked		Dipped		Soaked	
		TTD	CK	TTD	CK	TTD	CK	TTD	CK
Black Leaf 40 (5 percent)	3	89	91	90	88	72	61	66.3	65
Black Leaf 40 (15 percent)	3	80.9	91	84.7	88	61	61	61	66.3
Black Leaf 40 (25 percent)	3	71	91	53	88	57	61	37	66.3
Black Leaf 40 (Straight)	3	72	91	29	90	66	61	45.7	65
Copper Sulphate	8	82.6	93.5	78.2	91.3	52.4	50.6	40.1	51.5
Kerosene	4	61	85.1	69.7	90.1	33.4	42.9	28.2	43
Carbon Bisulphide	2	87.5	92.8	0	84	40.3	40.3	15	41.7

Lemon Oil

This material was not diluted. The soaked seeds had an orange color, the dipped had a yellowish color. Probably a weaker solution would be just as effective and not so injurious to the germination of the soaked seeds. Forbes suggests the use of alcohol to dilute lemon oil. The seeds had a sticky covering even after 30 hours of drying. It did not retard germination nor injure the plant growth.

Corona Copper Carb

A 5 percent solution of this material was used. The soaked seeds had a bluish color, and were easily handled. The dipped seeds were not colored. It decreased the germination of the corn about 4 percent, but increased the kafir about 15 percent. It hastened the rate of germination and did not have any injurious effect upon the plant growth.

Mercuric Chloride

This material was diluted to a 5 percent solution. The soaked seeds were a light blue color after treatment. The treatment reduced the percent of germination of both the soaked and dipped seeds, and retarded the rate of

appearance above ground.

Lime Sulphur Solution

The material was not diluted. It has an offensive odor and might prove to be a good repellent on kafir. It injures germination of corn, however. The soaked seeds after 30 hours of drying had an orange color; the dipped were yellow. It had no effect upon rate of germination or subsequent plant growth.

Derresite

Using a full strength solution gave a very offensive odor. The seeds had a dirty white appearance for both dipped and soaked treatment. It seriously injured the germinating power of the soaked seeds as can be seen from Table II.

Cresol U. S. P.

This material is a creosote compound, and was not diluted. The seeds were very oily after drying for 30 hours. The seeds after treatment were very dark in color, indicating that the material had entered the seed. The rate of germination of corn was very greatly retarded, and there was no plant growth, while with the kafir no serious injury was done except to germination.

Sunoco Emulsion

A commercial product put out by the Sunoco Oil Company. The seeds after treatment were yellow and oily. It did not decrease to any great extent the rate of germination.

Stove Polish

A 5 percent solution was used. The seeds turned black but the percent of germination was not reduced, except in the case of the soaked kafir seeds.

Arsenic

A 5 percent solution had no effect on the color of the seeds, but the rate of germination was cut down in nearly every test.

Nico Fume

The effect of this material using a 5 percent solution was that it decreased the rate of germination in every case. It had no effect upon the color of the seeds.

Seed Protecto

The rate of germination was not cut down very much using a 5 percent solution. The color of the seeds was

very dark.

Kerosene Emulsion

This material was used at full strength. The seeds had a natural color and were easy to handle after drying 30 hours. The rate of germination was very much retarded and the plant growth was smaller at the end of the test than the average growth of other tests.

Copper Sulphate Emulsion

This material was not diluted and the seeds after treatment and drying had a bluish color. The rate of germination was decreased, but at the finish of the test the rate of growth was above average. There was no great injury to the treated seeds, except the dipped kafir.

Paris Green

Five grams of Paris green were used with water in solution. The seeds had a more or less greenish tinge to them, but this was only on the outside. The material had not entered the seed. The rate of appearance was hastened and the subsequent growth was not harmed.

Water

Seeds treated with water had a very good rate of germination. The plant growth was normal and there was no changing in color of the seeds. The water was of ordinary room temperature.

Sodium Nitrate

Using a 5 percent solution the rate of germination was reduced, the seeds retained their natural color, the rate of germination was retarded, and the subsequent plant growth was stunted.

Rodent Poison

The germination was injured, especially with soaked corn, using five grams of this material in solution with water. The rate of germination was not slowed up, but the plant growth was very pale, and in a number of cases the plants did not make a good growth. They appeared to have very little strength as the leaves would all fall away as soon as the plant appeared above the ground.

Rat Embalmer

The seeds had an orange color after treatment. The germination of the soaked seeds was cut down. The rate of

appearance and the height of the plants were normal, however. The solution was five grams in water.

Sodium Fluosilicate

This solution was five ounces of material dissolved in water. The seeds after treatment were dry and of a natural color. The rate of germination was retarded, especially in the soaked seeds. The height of the plants was less than the average.

Sodium Bicarbonate

The percent of germination was reduced in both dipped and soaked seeds. Five grams of material were dissolved in water. The rate of germination was hastened very much, and the plants were above the average in height.

Copper Carbonate

The germination was increased, especially in the kafir seeds. The rate of germination was also stimulated; seeds treated with this material were usually the first to appear above the ground. The subsequent plant growth was of average height. Five grams of the material were dissolved in water. The seeds had a bluish color after having dried.

Korn Protector

A 5 percent solution of this material was used. The seeds were very dark in color when dry. They were only coated, however. Korn Protector seemed to stimulate the rate of germination as the seeds treated with this material were the first to appear above ground. The plants at the end of the test were of average height.

Paradichlorobensene

This material would not go into solution very well, so the writer used soapy water, five grams of the material was used. The seeds had a natural color, but the rate of appearance was cut down very much. The plant growth was normal.

Creosote

This material, although injurious to germination, has a repellent action on certain insects, and it is probable that a repellent may be found in the creosote group. It did not slow up the rate of germination of the seeds nor did it affect the subsequent plant growth.

Sodium Arsenite

Using a 5 percent solution, no germination took place.

Sulphur

The seeds treated with sulphur showed injury to germination, to rate of appearance, and to plant growth, but the sulphur did not stick to the seeds, so could not do injury or be beneficial either.

Soap Solution

The soap solution had very little effect on germination of kafir seeds, but it did injure the corn seeds. The rate of appearance was normal as was the plant growth.

Black Leaf 40 (Five Percent)

Germination was not injured, seeds were more or less natural color when dry. The plant growth was not injured.

Black Leaf 40 (Fifteen Percent)

Germination retarded only slightly, the treated seeds were a little darker than those treated with 5 percent. The rate of germination was normal, and the plant growth was above average.

Black Leaf 40 (Twenty-five Percent)

The germination of the seeds was injured, especially in the corn. The rate of germination was very much retarded, but the height of the subsequent growth was about average.

Black Leaf 40 (Full Strength)

The germination was decreased in both corn and kafir, especially the soaked seeds. The seeds were very dark in color when dry. Plant growth was not injured, but the rate of germination was very slow.

Copper Sulphate

A saturated solution was used and the treated seeds had a decided bluish color. The rate of germination was very high; they came through the ground nearly as quickly as the copper carbonate treated seeds. The plant growth was above the average.

Kerosene

This material was not diluted, and in every case injured the germination of the seeds. The treated seeds had a dull color; it was evident that the kerosene had gone into the seed. This was ascertained by opening some of

them. Seeds treated with kerosene were very slow in making their appearance above ground.

Carbon Bisulphide

This material used full strength had a very offending odor and proved to be detrimental to germination, especially the soaked seeds. The rate of germination was more or less retarded, and the subsequent plant growth was under the average.

SUMMARY

1. The dipped seeds had a higher rate of germination than the soaked seeds, because the soaked seeds were exposed to the material longer which in several cases proved to have a harmful effect upon germination.

2. Corn seeds had a higher rate of germination than the kafir seeds, due mainly to the difference in the seed coats.

3. The following materials were found to have no deleterious effect upon the rate of seed germination. Bordeaux mixture 4-5-50, Bordeaux water, copper carbonate, "Corona Copper Carb", "Seed Protecto", lemon oil, water, Black Leaf 40, copper sulphate, tobacco dust, stove polish, "Korn Protector", Rodent poison, paradichlorobenzene and sulphur.

4. Those which had a very detrimental effect upon the rate of germination were: Aniline, oil of cloves, naphthaline in alcohol, fish oil, formalin, Hess' Stock Dip, crude carbolic acid, sodium arsenite, mercuric chloride, and nitrobenzene.

5. The tests on kafir ant using camphor, kerosene and turpentine appear to be very promising, but more work should be done before making any recommendation.

6. The data on hand show that it is very likely that the best repellent will be found in the creosote group. The majority of the creosotes leave the seed in a condition that it may be handled if allowed to dry. Since it is known that creososte is a repellent to certain insects, it is not at all unlikely that a good repellent may possibly be found in this group which will not injure the germinating seeds.

7. More materials should be used in germination tests and their repellent action on insects determined. Varieties of wheat should be added to these tests because there are insects that might be controlled by repellents that attack wheat.

8. The writer feels that should a good repellent be found, it would facilitate in the control of some of our underground insects.

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