12-1-1942

A Comparision of Dosages of Copper Carbonate and Ethyl Mercuric Phosphate with Chloranil and Sulfur as Sorghum Seed Treatments

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Progress Report, Project 110
Agricultural Experiment Station
South Dakota State College
Brookings, South Dakota

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The present military emergency threatens the supply of copper and mercury for fungicidal use. Copper carbonate and organic mercury compounds, notably ethyl mercuric phosphate, are the active ingredients of standard dust fungicides used in treating sorghum seed for protection of the germinating seed from soil and seedborne, seed-rotting fungi and for covered smut control. (2,4).

In the event of enforced restriction of manufacture and sale of copper and mercuric fungicidal materials, two alternatives may confront the grower who nevertheless wishes to treat his sorghum seed. They are: reduce the dosage of copper or mercury, or, use a substitute material which is available. Chloranil and sulfur have been suggested as such substitute materials (1,3). The effectiveness of both for smut control is established (2,3).

During the 1942 season, a comparison of various dosages of copper carbonate and ethyl mercuric phosphate with chloranil and sulfur as sorghum seed treatments was undertaken at the South Dakota Agricultural Experiment Station. The results of that attempt are herein presented. Two striking phenomena were apparent, namely, the effectiveness of copper carbonate at all dosages tried and the apparent toxicity of sulfur to the germinating seed.

Experimental Procedure

Relatively smut spore-free seed lots of the varieties, Sooner Milo, a grain sorghum, and 39-30-S, a black amber forage sorghum, were used. The lots germinated 73.5 and 92 percent normal, respectively, by blotter test. Germinated lots of the Sooner Milo seed contained an additional 12 percent of abnormally germinating seeds. From each variety lot were weighed four sub-lots, to which were added smut spores* by weight, as follows: none, 1 to 5000, 4 to 5000 and 16 to 5000. The smut spores were applied by shaking vigorously, in a can for one minute, each sub-lot plus its respective smut spore addition. The 16 to 1000 smut spore load appeared to be heavier than usually occurs on sorghum seed planted in South Dakota.

Equal parts of each sub-lot were treated with dust fungicides as follows: Copper carbonate, 18 percent, at 3/4, 1 1/2, 3 and 6 ounces per bushel, ethyl mercuric phosphate, 5 percent, at 1/8, 1/4, 1/2, and 1 ounce per bushel, ethyl mercuric phosphate, 1 percent, at 5/8, 1 1/4, 2 1/2 and 5 ounces per bushel, chloranil and sulfur at 3 ounces per bushel, and two lots with not any, to serve as checks.

Copper carbonate, 18 percent, at 3 ounces per bushel and ethyl mercuric phosphate, 5 percent, at 1 1/2 ounce per bushel were considered to be standard treatments. Ethyl mercuric phosphate was applied in equal amounts at one and five percent concentrations because it is available on the market at these concentrations. Such an arrangement might allow also the measurement of dilution and dispersal effects, especially with very light dosages. All dust

*Smut spore additions were of race 2 to Sooner Milo and race 1 to 39-30-S. These spores were kindly furnished by Dr. L.E. Melchers of the Kansas Agricultural Experiment Station.

fungicides were applied by vigorously shaking the seed plus treatment material in a tough paper bag for one minute. A separate bag was used for each treatment dosage, and the lightest spore load was treated first, the heaviest spore load last. Separate series of treatment bags were used for the two varieties. Sixteen lots of 50 seeds were counted from each treatment dosage lot. The counted lots were left in small paper bags in the laboratory at room temperature for three weeks prior to planting.

Each treatment dosage lot of 50 seeds was planted in a rod row with a continuous belt drop planter, in such a manner as to remain within the rod row and yet distribute the 50 seeds over the entire row length. Treatment dosages were randomized within each spore load range. Spore load ranges were randomized within each replicate of four spore load ranges. There were four replicates in each variety block and the two variety blocks were adjacent to each other, end to end.

Seedlings were counted when germination was obviously completed. Healthy and smutted heads and culms were counted in mid-September. Both varieties were badly frozen September 24 and 28. As a result, the Sooner Milo was virtually a crop failure, but healthy heads were cut and weighed as such in mid-October. The forage variety was harvested as quickly as possible after it was frozen. No moisture determinations were made or incorporated into the data. However, harvesting of unit replications was always begun and completed on the same day. With only one grain and sorghum variety and other moisture factors balanced out, no moisture determinations were necessary to assure the validity of the desired comparisons.

The dates of the operations enumerated above are as follows: planting, June 15, 16; seedling count, June 27, 29, 30; head, culm, and smut counts, September 14 to 19; harvest 39-30-S, October 2, 6, 7; Sooner Milo, October 13, 14, 15.

Results

The results are for the most part readily separable into two categories, namely, smut control and seed and seedling protective effects. Yield probably embodies both. For the sake of simplicity of presentation, therefore, results are presented in two tables, smut control in table 1 and seed and seedling protective effects in table 2. In all cases the data are in actual numbers per rod row of 50 seeds planted, the unit plot of the experiment. Percentages have not been calculated because in some cases percentages are not calculable and in others might unduly magnify differences.

Smut control

Covered smut is such a common and destructive disease of both grain and forage sorghum in South Dakota that the major consideration in seed treatment at present probably is smut control. Purely on the basis of smut control, sulfur was the most effective treatment compound, although it was virtually on a par with copper carbonate at 6 ounces per bushel, which is double the standard dosage, and with chloranil, which is the other suggested substitute material. These three treatments accomplished nearly perfect smut control, even at the highest smut spore loads.

Copper carbonate was uniformly effective at all dosages on all spore loads. The possible exception was the one-fourth standard dosage (3/4 ounce

Table 1. Average number of smutted heads or culms on plants of Sooner Milo grain and 39-30-S forage sorghum grown from smutted and non-smutted seeds, untreated or treated with chloranil, sulfur and various dosages of copper carbonate and ethyl mercuric phosphate.

	Smutted heads of Sooner Milo (Applied smut spore load by weight)					Smutted culms of 39-30-S (Applied smut spore load by weight)				
Treatment	0	1-5000	4-5000	16-5000	Average	0	1-5000	4-5000	16-5000	Average
Check	0	2.7*	11.2	21.5	8.9	2.7	5.0	14.7	16.5	9.7
Cu CO3, 18%, 3/4 oz.	0	0	0	3.2	0.8	1.0	0	0	4.5	1.4
" 1 1/2 oz.	0	0	0	0.2	0.1	0	0	2.2	2.2	1.1
" 3 oz.	0	0	0	1.2	0.3	0	0.7	0	2.0	0.7
" 6 oz.	0	0	0	0	0	0	0	0	1.0	0.25
Chloranil ("Spergon") 3 oz	0	0	0	0	0	1.0	0	0	0.2	0.3
Flowers of sulfur, 3 oz.	0	0	0	0	0	0	0	0.7	0	0.2
Check	1.5	3.0	17.7	13.7	9.0	1.2	6.7	19.7	17.7	11.4
5% Ethyl Hg PO4 1/8 oz.	0	1.5	5.0	15.2	5.4	0.7	4.5	6.0	17.5	7.2
(New Imp. Ceresan), 1/4 oz.	0	0.7	0	12.7	3.2	0	2.0	8.0	7.2	4.3
" , 1/2 oz.	0.5	0	1.0	4.5	1.4	0	0	3.5	0.7	1.1
" , 1 oz.	0	0	0.2	1.2	0.4	0	0	1.0	0.2	0.3
1% Ethyl Hg PO_4, 5/8 oz.	0.5	0	2.0	17.0	4.9	0.5	0.7	5.5	4.0	2.7
(New Imp. Sem. Jr.) 1 1/4 oz.	0	0	2.5	9.5	3.0	1.7	0.5	4.7	6.0	3.2
" 2 1/2 oz.	0	0.5	2.5	6.7	2.4	0	1.2	0.7	0.2	0.6
" 5 oz.	1.0	0	1.0	3.5	1.4	0	0	0	3.5	0.9

* Average of 4 rod rows, 50 seeds per row.

Table 2. Average number of seedlings and total, smutted and healthy heads or culms and yield of Sooner Milo grain and 39-30-S forage sorghum grown from seed not treated or treated with chloranil, sulfur and various dosages of copper carbonate and ethyl mercuric phosphate

Treatment	Sooner Milo: Seedlings	Sooner Milo: All Heads	Sooner Milo: Smutted Heads	Sooner Milo: Healthy Heads	Sooner Milo: Lbs. Healthy Heads	39-30-S: Seedlings	39-30-S: All Culms	39-30-S: Smutted Culms	39-30-S: Healthy Culms	39-30-S: Lbs. Fodder
Check	26.9*	62.7	8.9	53.8	1.72	35.8	84.1	9.7	74.4	20.8
Cu CO_3, 18%, 3/4 oz.	32.3	68.7	0.8	67.9	2.04	37.2	85.0	1.4	83.6	22.6
" 1 1/2 oz.	34.7	65.8	0.1	65.7	2.10	34.8	82.0	1.1	80.9	22.1
" 3 oz.	37.25	71.1	0.3	70.8	2.20	36.9	85.9	0.7	85.2	22.0
" 6 oz.	37.3	73.6	0	73.6	2.35	37.9	87.6	0.25	87.35	23.3
Chloranil ("Spergon") 3 oz.	37.3	66.6	0	66.6	2.08	37.6	85.3	0.3	85.0	22.5
Flowers of sulfur, 3 oz.	24.5	54.7	0	54.7	1.79	33.8	83.7	0.2	83.5	21.7
Check	28.1	59.4	9.0	50.4	1.80	35.5	86.2	11.4	74.8	21.0
5% Ethyl Hg PO_4, 1/8 oz.	26.3	61.3	5.4	55.9	1.83	34.8	86.1	7.2	78.9	21.[illegible]
(New Imp. Ceresan), 1/4 oz.	25.9	55.6	3.2	52.4	1.65	34.9	84.9	4.3	80.6	21.1
" , 1/2 oz.	29.3	60.5	1.4	59.1	1.90	38.9	86.7	1.1	85.6	22.4
" , 1 oz.	32.6	65.1	0.4	64.7	2.01	39.2	85.1	0.3	84.8	22.2
1% Ethyl Hg PO_4, , 5/8 oz.	26.5	58.1	4.9	53.2	1.77	35.6	81.6	2.7	78.9	21.2
(New Imp. Sem. Jr.), 1 1/4 oz.	26.4	58.3	3.0	55.3	1.79	34.7	83.5	3.2	80.3	21.2
" , 2 1/2 oz.	30.1	62.7	2.4	60.3	1.92	38.2	84.1	0.6	83.5	22.6
" , 5 oz.	26.3	56.6	1.4	55.2	1.74	39.2	86.9	0.9	86.0	23.0

* All the numbers are averages from 16 rod rows, 50 seeds per row.

per bushel) on the heaviest spore load. Even there, 85 and 73 percent control resulted on Sooner Milo and 39-30-S, respectively.

Although the results are somewhat erratic at lower smut spore loads on Sooner Milo, in general, ethyl mercuric phosphate was ineffective at less than the standard dosages. In fact, with the heaviest spore load, ethyl mercuric phosphate at any dosage in either concentration was not as effective as copper carbonate at all but the lowest dosage, or sulfur or chloranil.

On the basis of smut control, sulfur and chloranil were effective at the one dosage used, copper carbonate was effective at all dosages used and ethyl mercuric phosphate was effective at dosages of standard or more.

Seed and seedling protection and yield effects

Seed-borne fungi capable of interrupting germination and similar soil-borne fungi may both be in conflict with the germinating seed and its protecting fungicide. The fungicide itself, because of its possible toxicity to the seed, may further complicate germination and thus affect the number and vigor of plants in a so-called "stand."

The seed of the 39-30-S variety was relatively free of fungi. The laboratory-germinated seed of Sooner Milo was covered by a species of Rhizopus. In laboratory germinations, the naked seeds of grain varieties are more often covered with molds than the glume-covered seeds of forage varieties. Plantings were made in mid-June when the temperature was moderate and soil moisture adequate. The Barnes sandy loam on which the experiment occured is not given to unusual packing and crusting. The 60 to 70 percent stands of Sooner Milo and 70 to 80 percent stands of 39-30-S indicate that conditions generally were favorable to germination and that seed protective effects were not unusually and consistently large, and less so with 39-30-S than with Sooner Milo.

In view of these circumstances, perhaps the most significant fact is that sulfur-treated seed yielded the poorest stands of all the treatments, less even than from untreated seed (24.5 seedlings per 50 seeds planted as compared to 26.9 and 28.1 from untreated seed of Sooner Milo; 33.8 as against 35.5 and 35.8 of 39-30-S). In 13 of 16 replications of Sooner Milo, stands from sulfur-treated seed were below the average of the two checks; in 5 of 16 replications, stands from sulfur-treated seed were the lowest in the replication. In contrast, Sooner Milo seed treated with three-fourths ounces of copper carbonate, in 13 of 16 replications, yielded stands better than the average of the checks, in 15 of 16 replications better than sulfur-treated seed; in the sixteenth replication stands from the two were identical.

The poor stand of Sooner Milo from sulfur-treated seed was reflected in the number of heads at harvest time and in yield of healthy heads, which was no better than from untreated seed, despite smut control. With 39-30-S, the stand from sulfur-treated seed, although the lowest, was not so much lower than the general average and the effect at harvest time not so evident, although "all culms" from sulfur-treated seed was fourth from low and yield of fodder was below average. Smutted culms were included in "lbs fodder" of 39-30-S.

There are probably no other differences worthy of mention in the stands and yields of 39-30-S. With Sooner Milo, for the most part, the somewhat better seedling stands resulting from the copper carbonate, chloranil and ethyl mercuric phosphate treatments are reflected in the number of heads produced and in yield, provided failure of smut control by small dosages of ethyl mercuric phosphate is taken into account. The satisfactory performance, in all respects, of copper carbonate is apparent here as in the smut control data.

On the basis of seed protective and subsequent yield effects as indicated in these data, copper carbonate at all dosages used, chloranil at the one dosage used and ethyl mercuric phosphate at all dosages used were satisfactory seed treatments, probably in the order named. Sulfur was unsatisfactory by virtue of its apparent toxicity to the germinating seed.

Summary and Conclusions

Copper carbonate (18%) at one-fourth, one-half, standard and double standard dosages and ethyl mercuric phosphate at the same four dosages for one and 5 percent concentrations were compared with chloranil and sulfur at 3 ounces per bushel as seed treatments for Sooner Milo grain and 39-30-S forage sorghum.

For smut control, copper carbonate at all four dosages, chloranil and sulfur were satisfactory. Ethyl mercuric phosphate accomplished only partial control at below standard dosages, particularly at high smut spore loads, but control was satisfactory at standard dosages or above against all but the heaviest spore loads.

For seed protection and subsequent yield effects, copper carbonate at all dosages, chloranil, and ethyl mercuric phosphate at all dosages were satisfactory, probably in the order named. Sulfur was unsatisfactory because of its apparent toxicity to the germinating seed, as expressed by seedling stands poorer than from all other seed lots, treated or untreated, both varieties, and likewise poorer yields, particularly of Sooner Milo.

In the light of possible economy in the use of copper, mercury or other materials for sorghum seed treatment, the following statements are ventured on the basis of the above results: (1) A reduction in dosage of ethyl mercuric phosphate may result in partial failure of smut control, particularly with heavy spore loads. (2) Sulfur is excellent for smut control but is toxic to the germinating seed. (3) Chloranil at 3 ounces per bushel is satisfactory for smut control and seed protection. (4) Copper carbonate is effective for smut control and seed protection at dosages as low as one-fourth of standard. Of the four materials tested, copper carbonate is probably the best seed treatment available to growers.

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