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The Effects of Carbon Disulphide Upon Germination and Baking Quality of Wheat

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INTRODUCTION

A sample of excellent appearing Turkey wheat was entered at the Enid Wheat Show in 1941 and was placed first in competition with other samples of this variety on the basis of external appearance. However, when the sample was milled and baked, a very poor loaf of bread was obtained. In talking with the owner of the wheat it was learned that a rather heavy treatment of carbon disulphide had been applied to control weevil.

This fumigant is being used extensively in Oklahoma for controlling insects in stored wheat. It can be obtained in most communities for about one dollar per gallon as indicated by Fenton[1], and is an excellent fumigant if precautions are taken against fire hazards. The present study was made to determine the concentration and length of treatment which would affect seed germination and baking quality.

REVIEW OF THE LITERATURE

Dean and Swanson[2] studied the effects of carbon disulphide upon both hard and soft wheat flours. Three grades of hard winter wheat flour consisting of a patent, a straight, and a low grade were used. Two sets of 10-12 pound samples were treated. Treatment was made at the rate of one pound of carbon disulphide to 500 cubic feet of space in an airtight chamber for 12 hours at 90° F. Samples were baked immediately after fumigation, 2-3 days later, 30 days and 60 days after treatment. No significant differences were obtained between treated and untreated samples.

* The authors wish to express their appreciation to the Crops Products Control Department of General Mills, Oklahoma City, for milling, baking, and scoring the wheat samples, and to Sgt. A. J. Cross, Military Department, Oklahoma Agricultural and Mechanical College, for taking and developing the greenhouse pictures.

[1] Fenton, F. A. *Protecting stored wheat against insects.* Oklahoma Agricultural Experiment Station Circular C-95. 1941.

[2] Dean, George A., and Swanson, C. O. *Effect of common mill fumigants on the baking qualities of wheat flour.* Kansas Agricultural Experiment Station Bulletin 178. 1911.

The rate of treatment in the above-mentioned study was approximately one quart per 1000 bushels of wheat. Farrar, Winburn, and Flint[3], and Fenton[4] recommended 3-4 gallons per 1000 bushels of grain, or about twelve times the rate used by Dean and Swanson for adequate control of weevil in stored grain.

MATERIALS AND METHODS

A set of 32 wide-mouthed glass jars each having a capacity of approximately five pounds of wheat was used. The lids were loose enough to allow some exchange of air. Four pounds of Turkey wheat of approximately 14% protein was weighed and placed in each jar. Each treatment was applied for one, two, three, and four days. The jars were arranged at random on a table under room temperature conditions. The various rates of application, interpreted in gallons per 1000 bushels, are given in Table I.

TABLE I.—Rates of Treatment Used (cc. per Lb.) and Equivalents in Gallons per Bushel.

cc per Lb.	Gals. per 1,000 Bu.
Untreated	0
.25	4*
.50	8
1.00	16
2.50	40
5.00	80
7.50	120
10.00	160

* Recommended rate for quantities less than 500 bushels.

The carbon disulphide was measured by means of a burette and poured on blotting paper placed inside the jars on top of the grain. Sufficient paper was used in all jars to absorb the liquid carbon disulphide which was added. This provided a means of obtaining an even distribution of the gas through the sample.

As soon as a specific treatment had been made for a particular length of time, the blotting paper was removed and samples of wheat were obtained from each of four different depths. Four sets of 100 sound seeds each were counted out.

[3] Farrar, M. D., Winburn, T. F., and Flint, W. P. *How to know and control stored grain insects.* Illinois Agricultural Extension Circular 512. 1941.

[4] *Op. cit.*

Each set included 25 seeds from each of the four levels in the jar. The remaining wheat was thoroughly mixed by pouring through a Boerner sampler and then spread in front of an electric fan and allowed to aerate for 24 hours, after which it was sacked and stored.

Two of the 100-seed samples from each treatment were planted at random in a sand culture in the greenhouse in rows one inch apart. Two rows were sown for each treatment, each having 50 seeds spaced .7 inch apart and planted one-half inch deep. The sand was kept moist by sprinkling each day. The two remaining samples for each treatment were placed in petri dishes each containing two pieces of No. 3 filter paper. Sufficient moisture for germination was added each day to the various samples. The dishes were arranged at random in a germinator with temperature control set at 86° F. for a period of 15 days. Germination counts were made at 3, 6, 9, 12, and 15 days after treatment for samples in both greenhouse and germinator.

Eight samples from the 32 treated lots of seed were selected for milling and baking tests. It was not possible with the equipment and time available to bake all of the samples treated.

Milling of the samples was done on an experimental Allis-Chalmers Mill. Two hundred grams of unbleached flour from each sample were used for baking duplicate loaves. Bromate (2 mgs.) was added, also 2½% sugar, 1% salt, 3% yeast, 2% shortening and enough water to make the dough of the right consistency. The dough was mixed two minutes at medium speed with a Hobart Mixer. The fermentation time was 2 hours and 40 minutes, with proof to ⅜ inches above the top of the pan. The dough was baked 25 minutes at 446° F. with top heat on low. Scoring of the bread was done the day after baking.

Results

Figures 1, 2, 3, and 4 are pictures taken in the greenhouse 15 days after the treatments were made. The seed was treated for 1, 2, 3, and 4 days respectively. Concentrations are shown by lettering above the two stakes marking the two rows devoted to each treatment.

Table II and Figure 5 present the results of the germination tests. Table III gives the data obtained from baking tests, and the test loaves are pictured in Fig. 6.

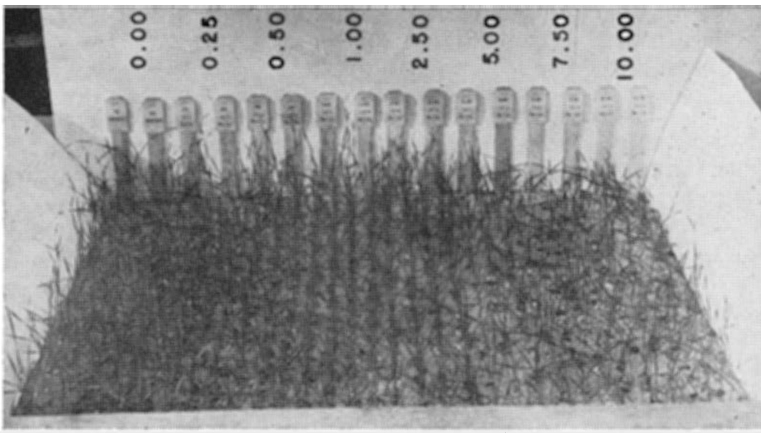

Figure 1.—Germination 15 days after one-day treatment.

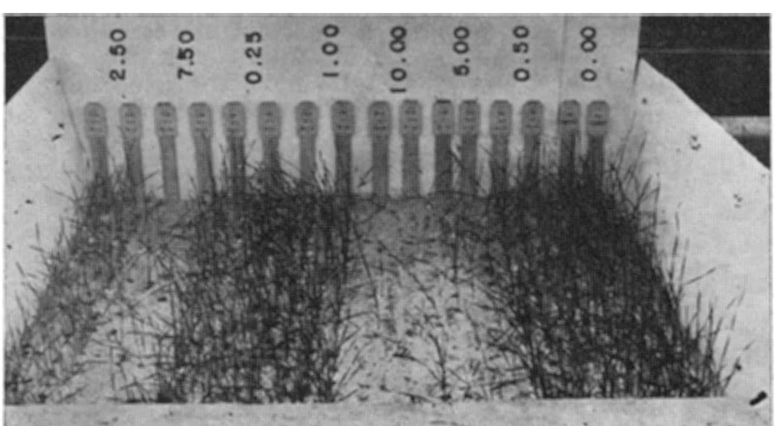

Figure 2.—Germination 15 days after two-day treatment.

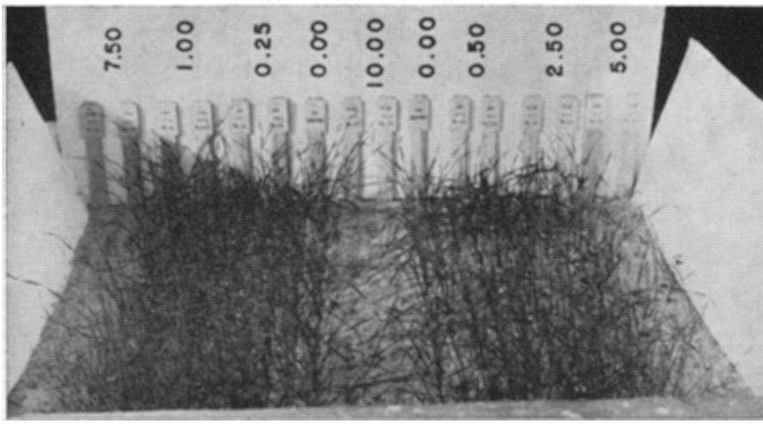

Figure 4.—Germination 15 days after four-day treatment.

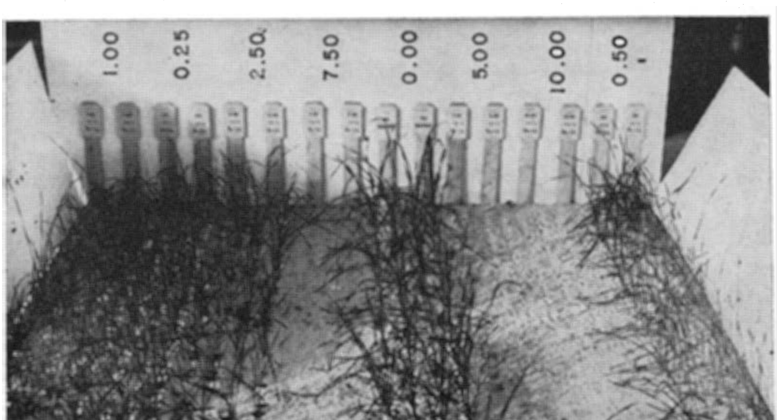

Figure 3.—Germination 15 days after three-day treatment.

*TABLE II.—Germination Percentage of Wheat Samples 15 Days After Treatment with Carbon Disulphide.**

Concentration (cc per Lb.)	Method of Testing	GERMINATION Length of Treatment (Days): 1	2	3	4	Ave.
	Germinator	96.0	91.5	93.0	93.5	93.5
Untreated	Greenhouse	91.0	89.0	91.5	93.5	91.3
	Average	93.5	90.3	92.3	93.5	92.4
	Germinator	96.0	94.0	95.5	90.5	94.0
.25	Greenhouse	94.5	93.0	93.5	88.5	92.4
	Average	95.3	93.5	94.5	89.5	93.2
	Germinator	96.5	88.0	93.5	88.0	91.5
.50	Greenhouse	94.0	91.5	92.0	93.5	92.8
	Average	95.3	89.8	92.8	90.8	92.3
	Germinator	92.0	89.5	83.5	81.5	86.6
1.00	Greenhouse	91.5	91.5	90.5	88.0	90.4
	Average	91.8	90.5	87.0	84.5	88.5
	Germinator	67.0	39.0	48.0	11.5	41.4
2.50	Greenhouse	78.5	72.5	84.0	68.5	75.9
	Average	72.8	55.8	66.0	40.0	58.7
	Germinator	9.0	0.0	1.0	0.0	2.5
5.00	Greenhouse	55.5	20.5	9.0	1.0	21.5
	Average	32.3	10.3	5.0	0.5	12.0
	Germinator	15.0	0.5	0.0	1.0	4.1
7.50	Greenhouse	58.0	11.5	0.0	0.5	17.5
	Average	36.5	6.0	0.0	0.8	10.8
	Germinator	4.5	0.0	0.0	0.0	1.1
10.00	Greenhouse	58.5	3.5	1.0	0.0	15.8
	Average	31.5	1.8	0.5	0.0	8.5
Average, all concentrations		68.6	54.7	54.7	49.9	

* Average of two replications in greenhouse, and two in germinator.

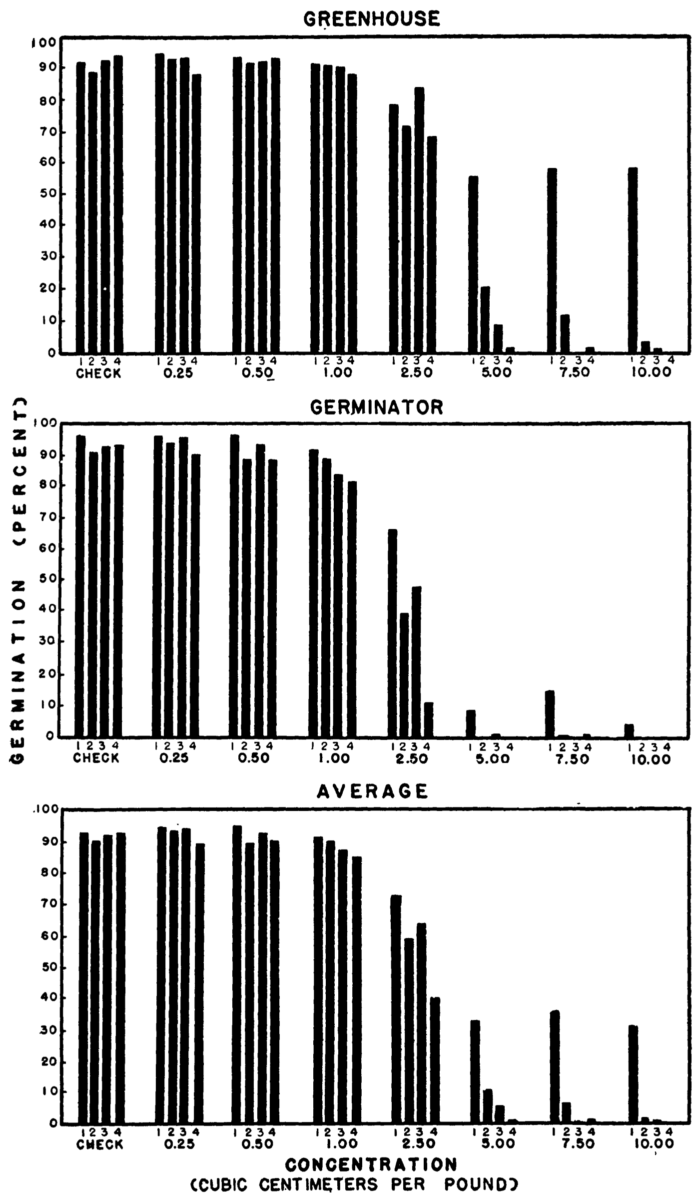

Figure 5.—Percentage of germination of wheat as affected by various concentrations of carbon disulphide applied for periods of 1, 2, 3 and 4 days.

TABLE III.—Results of Baking Tests of Wheat Treated with Carbon Disulphide.

Sample No.	Length of treatment (days)	Concen- tration (cc per Lb.)	Absorp- tion	Character of dough	CRUST		CRUMB		Voume (2-loaf average)	Proof (Minutes)
					Color	Char- acter	Color	Grain		
1.	1	Un- treated	65	DFVP	5+	5	9	10 Sl. open	710	55
2.	2	.25	64	DFP	5	5	9	10	695	55
3.	4	.50	64	DFP	5	4	9	10	630	55
4.	2	1.00	64	VP	5	4	9	10	615	55
5.	4	2.50	64	Sl. dead plastic Sl. sticky	3	No	8D*	None	505	60
6.	2	5.00	64	Plastic dead Sl. sticky	3	No	8D*	None	505	60
7.	4	7.50	64	Plastic dead Sl. sticky	2½	No	8D*	None	485	60
8.	2	10.00	64	Plastic dead Sl. sticky	3	No	8D*	None	515	60

D=dry.
F=firm.
V=very.
P=pliable.
*=dark.

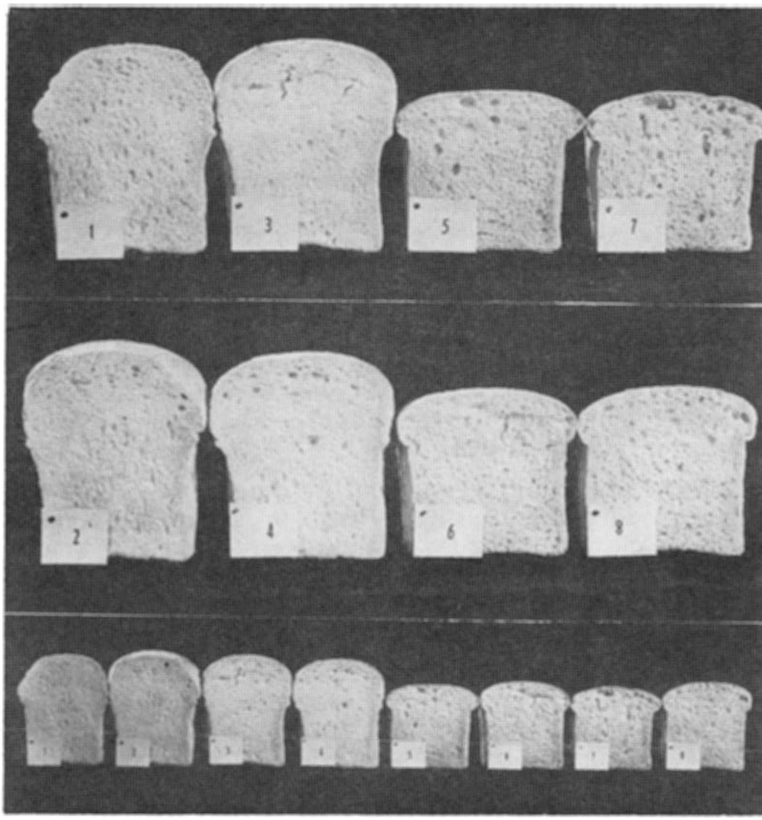

Figure 6.—Effect of carbon disulphide treatment of wheat upon baking quality.

Top: After treatment for four days. (1) Untreated. (3) 0.5 cc per lb. (5) 2.5 cc per lb. (7) 7.5 cc per lb.

Center: After treatment for two days. (2) 0.25 cc per lb. (4) 1.0 cc per lb. (6) 5.0 cc per lb. (8) 10.0 cc per lb.

Bottom: Loaves arranged from left to right in order of increasing concentrations as shown in Table III. E.g., loaf on left is from untreated wheat, the next from wheat treated with 0.25 cc per lb., etc.

Discussion

In these studies, no significant effect upon germination or baking quality was noted until concentrations exceeding four times the recommended rate of approximately 4 gallons per 1,000 bushels were used. The number of ungerminated seeds increased sharply when amounts of the fumigant equal to 20 times the recommended rate were used. When larger applications than this were made, there was no significant increase in ungerminated seeds.

A marked diference was noted in the vigor of seedlings and the rapidity with which germination occurred both in the germinator and in the greenhouse. With concentrations of 40 gallons or more per 1,000 bushels plumules emerged and grew slowly and most of the seeds could not be considered as germinated until 12 to 15 days after treatment. The germs of the seed which failed to sprout turned black before the 15-day germination period expired.

No differences due to length of treatment were noted until sufficient concentrations were used to affect germination. After this point was reached, a significant difference was obtained between 1- and 2-day periods of application. There was no significant difference between 2, 3, and 4 days treatment.

It will be noted from Fig. 5 that the germination in the greenhouse, particularly after heavy treatments, was higher than for corresponding samples tested in the germinator. This difference is significant. It is logical to believe that greenhouse conditions were more favorable than those in the germinator. It also seems reasonable that any remaining carbon disulphide on the seed would be more readily absorbed by the moist sand and thus be more rapidly eliminated as a factor affecting germination.

Treatment with concentrations heavy enough to affect germination also reduced loaf volume and changed the character of the dough. Crust color, grain, and texture were all scored low after heavy applications. It would have been desirable to mill and bake the entire set of samples but since commercial equipment and time was limited this was not done, therefore, definite conclusions cannot be drawn regarding baking quality of samples treated for 1 or 3 days time.

Summary

Samples of wheat were treated with varying amounts of carbon disulphide for different lengths of time to study its effects upon germination and baking quality.

No significant differences in germination were obtained until concentrations greater than four times the rate recommended for insect control were applied. A rapid decrease in percentage of germination occurred when amounts equal to 20 times the normal rate were used.

Effects due to length of treatment did not become apparent until concentrations heavy enough to affect germination were used. A significant difference was obtained between 1 and 2 days treatment. Longer periods of treatment did not result in significantly lower germination.

When the higher concentrations were applied, germination in the greenhouse was significantly higher than in the germinator.

Baking quality was reduced at the same concentration which significantly lowered germination. Applications which decreased the percentage of germination all had adverse effects upon loaf volume, dough character, crust color, grain, and texture.