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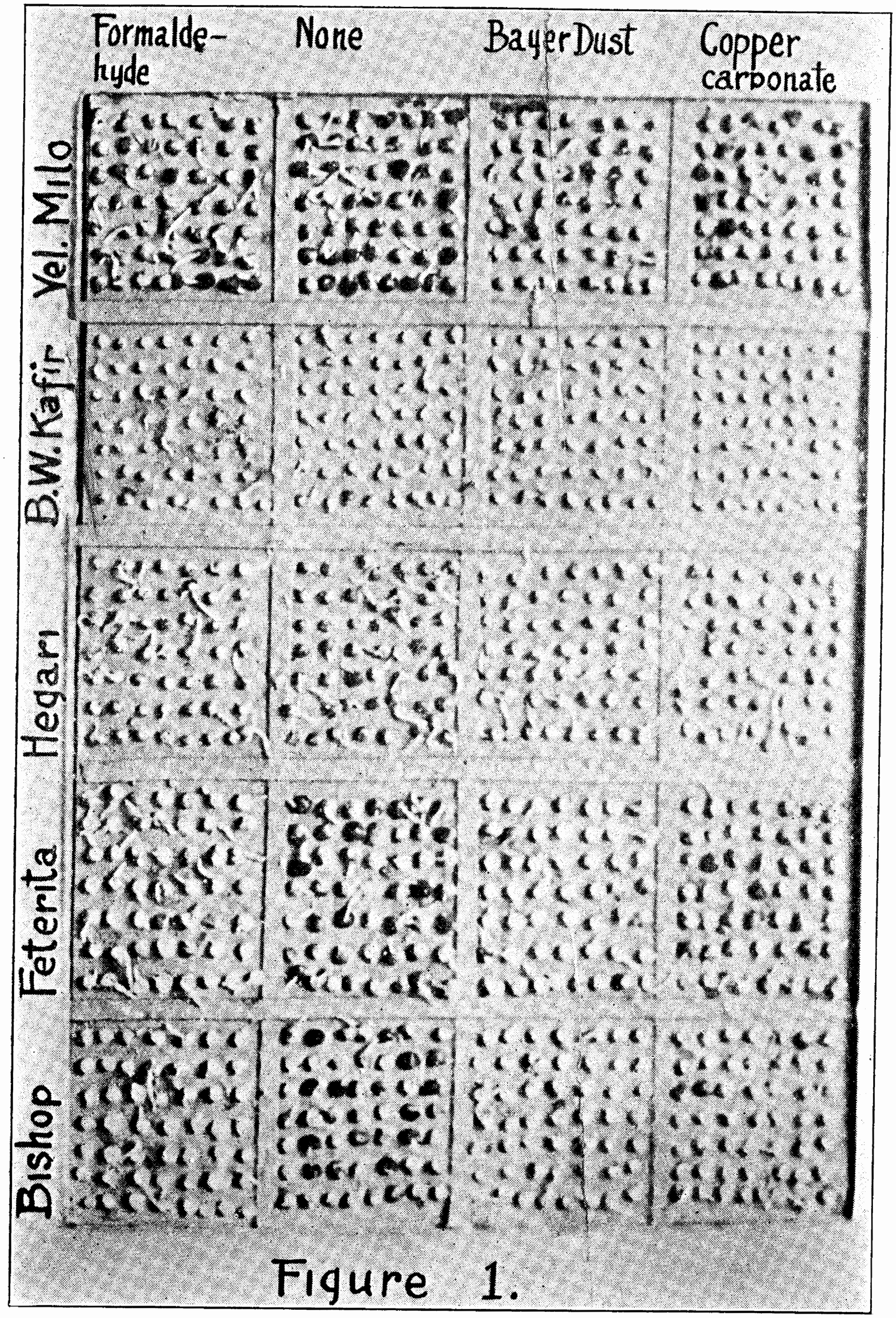

A GERMINATION TRAY ON THE THIRD DAY OF THE TEST

Improving Stands of Grain Sorghums By Seed Treatments

By H. H. FINNELL,
Associate Agronomist in Charge of Panhandle Station, Goodwell, Oklahoma,

PRELIMINARY

The need for methods of improving the stands of certain varieties of grain sorghums has been much felt by the farmers of the plains region of Oklahoma. In fact some varieties which might otherwise be desirable are being avoided quite generally, mainly because of the difficulty of securing a good stand. First among these is Feterita, though Dwarf Hegari, Blackhull White Kafir, and Bishop often require replanting.

The treatment of wheat seed for stinking smut prevention by various methods has led to the observation of consistent differences in stands due to treatment. Formaldehyde decreased the germination so that more seed per acre was required. Where 25 pounds of untreated seed had been sufficient for a full stand a 30 to 40 pound rate became necessary. On the other hand equivalent stands were secured with the dust disinfectants used by sowing 19 to 20 pounds per acre. Table 1 gives a summary of these data.

Table 1. Effective Germination of Hard Winter Wheat

Average of all plots in 1924 and 1925.

Variety	Number of Plots	Seed Treatment	Percent Effective Germination
Kanred	34	None	41.2
Kanred	10	Formaldehyde, .5% solution, 10 mins.	20.4
Kanred	14	Copper carbonate dust	51.5
Kanred	4	Bayer dust	66.7

Effective germination is defined as the percentage of plants produced from the calculated number of viable seed sown. The number of viable seed per plot is calculated from the germination test, blotter method, temperature 80° F. and the average seed delivery of the drill used. The same drill was used for sowing all plots.

Commercial grade formaldehyde was used. Copper carbonate was not of the kind sold under special brands but the regular powdered form prepared for dusting seed. Bayer dust used is a preparation of an organic disinfectant said by the Bayer Company to contain nitrophenol-mercury as an active principle. The same stock of disinfectants has been used on all the seed treatment experiments outlined herein.

All plots included in the above averages were sown on the same type of soil and at the same date in the respective years.

This experience with wheat suggested the possibility of employing Bayer Dust of copper carbonate as a means of protecting grain sorghum seed from seedbed decay and thus being made useful to secure better stands, especially under adverse germination conditions.

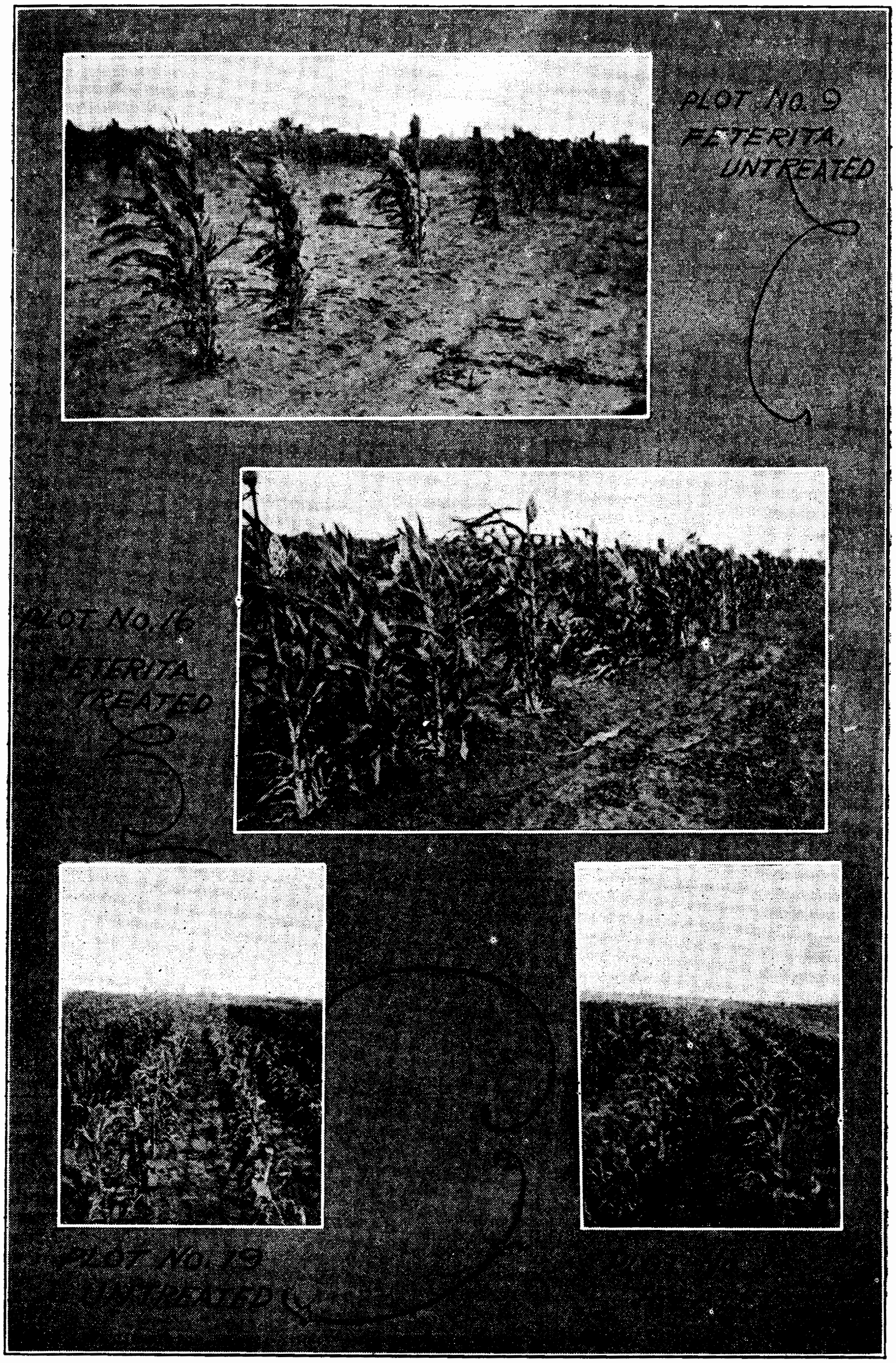
PLOT NO. 9
FETERITA,
UNTREATED
PLOT NO. 16
FETERITA
TREATED
PLOT NO. 19
UNTREATED

FIGURE 2

Since kernel smut is prevalent in B. W. Kafir and several of the sweet sorghums it was considered desirable to limit the investigation to treatments available and recommended for smut, so that if found effective in improving stands they might be known to serve a double purpose. However, the problem of smut control will not be touched on in this discussion.

Because the poorer stands are usually secured from early plantings when soil temperature is low or when the soil is too wet or both, the experiments following were planned to learn the behavior of the protective dust treatments under the most severe conditions.

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GERMINATION TESTS, INCUBATOR

Feterita, Dwarf Hegari, Blackhull White Kafir, Bishop, and Yellow Milo were selected to represent the most commonly grown types of grain sorghums in the Panhandle territory.

Germination tests were made in an incubator badly infected with molds to note the effect of the different treatments on the protection of the seed from molds and what bearing it might have on the percent of germination. Proper moisture was provided in the germinator but the temperature was maintained about 15 degrees lower than that necessary for prompt sprouting of the seed. The germination period was thereby extended through about six days. Fig. 1 shows a section of one of these tests on the 3rd day.

FIGURE 3—PLOT NO. 10, B. W. KAFIR UNTREATED

A noticeable growth of mold appeared on the untreated seed the second day. The Copper carbonate section showed considerable infection by the third and fourth days. The Formaldehyde treated seed resisted the mold until the fifth day, but was quickly overgrown with it immediately thereafter. The Bayer Dust treated seed persisted free from molds until after the germination was complete. The seeds in these tests were not flooded with water during the test and did not come in contact with anything but the blotter on which they lay. Table 2 gives the details of the incubator results.

Table 2. Incubator Tests With Grain Sorghums

Variety	Test No.	Untreated Percentage		Formaldehyde Percentage		Bayer Dust Percentage		Copper Carbonate Percentage	
		Germination	Molded	Germination	Molded	Germination	Molded	Germination	Molded
Feterita	1	98	100	98	94	100	30	98	96
Feterita	2	92	96	86	.88	92	8	82	86
Hegari	1	80	100	80	100	82	4	82	100
Hegari	2	76	98	60	70	68	0	68	78
(Average of chalk white seed group)		86.5	98.5	81.0	88.0	85.5	10.5	82.5	90.0
B. W. Kafir	2	81	82	60	68	92	0	90	22
Bishop	1	86	94	83	74	96	10	88	58
Bishop	2	80	86	66	82	90	4	92	40
Average of ivory white seed group		82.3	87.3	69.6	74.6	92.6	4.6	90.0	40.0
Yellow Milo	2	94	90	86	68	92	14	86	62
Average of all varieties		85.87	93.25	77.37	80.57	89.00	8.75	85.70	67.75

Tests Nos. 1 and 2 were run at different times but under uniform conditions. Stock seed used in this and all other phases of this investigation was prepared as follows:

Formaldehyde.—Seed wet for ten minutes with .5% solution and dried on disinfected table in thin layer.

Copper Carbonate and Bayer Dust.—Seed dusted by rotation in air-tight container with dust at the rate of 4 ounces per 60 lbs. seed.

The blotters on which both tests were made had been thoroughly infected by previous use with grain sorghums and was carefully swabbed over with wet cotton to insure distribution of spores. Seeds with hulls on and those broken or cracked were excluded by hand. They were spaced on moist blotter with no two seeds in contact and left uncovered in saturated atmosphere at a mean temperature of 65° F. for Test No. 1 and 64.5° F. for Test No. 2. Count for germination and molding of seeds was made at 96 hours for Test No. 1 and 120 hours for Test No. 2.

The lower germination of the Formaldehyde treated seed is attributed to the direct injury of the germ by the disinfectant. Copper carbonate gave approximately the same germination as the untreated seed. The final percentage of mold infection for these two treatments was not much less than that of the untreated seed. The Bayer Dust treatment resulted in 91.25% of seeds mold-free, the Formaldehyde 19.43% mold-free, and the Copper Carbonate 32.25% mold-free.

A gain of 3.13% average germination for Bayer Dust treated seed appears to be due to the effective control of mold infection continuing through the germination period.

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SOIL USED FOR FIELD TESTS

The soil is typical of the type classified by the U. S. Bureau of Soils as Amarillo Silty clay loam and described in Field Operations of the Bureau of Soils—1910. "Reconnoissance Soil Survey of the Panhandle Region of Texas," pp. 37-41, in part as follows:

"The surface soil consists of a light brown or chocolate brown silty loam, having in places a slight reddish tinge. The depth . . . . ." etc.

"Mechanical Analysis of Amarillo silty clay loam

No.	Description	Fine Gravel	Coarse Sand	Med. Sand	Fine Sand	Very Fine Sand	Silt	Clay
20862, 20880, 23749	Soil	0.0	0.4	0.8	6.3	23.6	52.4	16.3
	Subsoil	omitted						

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FIELD TESTS, HAND PLANTED

These plantings are in effect a duplication of the germination tests made under field conditions. No. 1 was planted before the regular planting season opens when the soil temperature averaged 58.5° F. while No. 2 came later in the season at 10 degrees higher temperature. In addition to a cool seedbed an attempt was made to keep the soil nearly waterlogged by irrigation while the seed were germinating. It is thought these conditions are more severe than will ordinarily be found in farm practice.

Table 3. Field Tests With Grain Sorghums, Hand Planted.

Variety	Test No.	Vitality	Untreated Percentage		Formaldehyde Percentage		Bayer Dust Percentage		Cop. Carbonate Percentage	
			Stand	Possible Germin-ation	Stand	Possible Germin-ation	Stand	Possible Germin-ation	Stand	Possible Germin-ation
Feterita	1	95	2	2.1	0	0	8	8.4	16	16.8
Feterita	2	95	18	18.9	2	2.1	24	25.2	46	48.4
Hegari	1	78	2	2.5	0	0	8	10.2	16	20.5
Hegari	2	78	12	15.3	0	0	26	33.3	40	51.2
Average of chalk whie seed group	....	....	8.5	9.7	.5	.5	16.5	19.5	29.5	34.2
B. W. Kafir	1	81	0	0	0	0	22	27.2	38	47.0
B. W. Kafir	2	81	14	17.3	0	0	34	42.0	52	64.2
Bishop	1	83	6	7.2	0	2.4	14	16.8	52	62.6
Bishop	2	83	16	19.2	2	0	36	43.3	60	72.2
Average of ivory white seed group	....	....	9.0	10.9	.5	.6	26.5	32.3	50.5	61.5
Yel. Milo	1	94	22	23.4	10	10.6	56	59.5	64	68.1
Yel. Milo	2	94	52	55.3	2	2.1	74	78.7	46	48.9
Average of yellow seed group			37.0	39.3	6.0	6.3	65.0	69.1	55.0	58.5
Average of all varieties	....	....	....	16.10	....	1.72	....	34.46	....	49.99

Seed used in hand planted field tests were selected against hulls and cracked kernels as in the incubator tests. Tests Nos. 1 and 2 were planted in the same soil under same moisture conditions but at different soil temperatures. See Table 4. Each plot consisted of 50 hills, 1 seed per hill. Spacing board was used in dropping seeds and the drills were accurately graded to permit the even flooding with irrigation water. In both tests the soil was kept saturated by daily applications of water until the first shoots were about to emerge when all drills were mulched with pulverized moist soil. Final counts of stand are represented in above table. The vitality of seed is taken as the average germination of untreated seed in incubator tests.

Table 4 compares the varieties and seed color groups in the two plantings.

Table 4. Variety Reaction to Soil Temperature.

Test No.	Av. Soil Temp., °F.	Moisture Content	First Plants Emerged	Percentage of possible germination effective. Average all plots of treated and untreated seeds							
				Feterita	Hegari	Group Av.	Kafir	Bishop	Group Av.	Milo	All Varieties
1	58.5	26.5	8 Da.	6.82	8.30	7.56	18.55	22.27	20.41	40.40	19.26
2	68.5	26.3	5 Da.	23.65	24.95	24.30	30.87	33.67	32.27	46.25	31.87

Data of Table 3 are here averaged by varieties and conditions of the two tests in hand planted field plots. Soil temperatures were taken daily at 8 a. m. and 6 p. m. during germination. Water was applied in mornings in sufficient quantity to require about 3 hours to soak in. Moisture samples were taken late in afternoon and percentage determined by oven drying at 110° F. and calculation on moisture free basis. Test No. 1 was counted at the end of 16 days and No. 2 at the end of 12 days. No other plants came up after these counts, checks being made at the end of 30 days.

FIELD TESTS, MACHINE PLANTED

Further plantings of Feterita and Kafir on later dates afford a practical confirmation of the foregoing results. These plots were planted under actual farm conditions, soil prepared in the regular way and a lister planter used. The results are substantially the same as given by the hand planted plots. See Table 5.

Table 5. Field Tests With Feterita and Kafir, Machine Planted.

Plot No.	Date of Planting	Soil Temp. °F.	Moisture Content	Treat- ment	No. Hills	Percent of Stand	No. of Plants	No. of Stalks	Stalks Per Hill	Viable Seed Sown	% Possible Germination Effective
Feterita											
1	May 14	61	12.56	None	2	1.22	2	4	2.00	404	.49
7	May 14	61	12.56	Bayer Dust	5	3.03	5	11	2.20	404	1.23
9	June 22	73	15.13	None	64	38.78	80	170	2.65	404	19.72
16	June 22	73	15.13	Bayer Dust	118	71.50	260	327	2.76	404	64.10
19	July 10	82	12.24	None	96	58.22	159	201	2.09	404	39.10
25	July 10	82	12.24	Bayer Dust	135	81.78	291	348	2.58	404	71.80
Blackhull White Kafir											
10	June 22	73	15.13	None	72	43.60	167	185	2.57	708	23.60
11	June 22	73	15.13	Copper Carb.	135	81.75	526	609	4.50	708	74.20
18	June 22	73	15.13	Bayer Dust	125	75.80	388	428	3.42	708	54.75

This series of plots was planted on a similar type of soil to that of the hand planted tests. The lister planter used dropped an average of 2.58 kernels of Feterita per hill and 5.30 kernels of Kafir per hill. Hills averaged 2.36 feet apart. The above plots consisted of 165 hills, approximately 426 and 875 kernels of Feterita and Kafir being planted per plot. Soil temperature in each case represents an average of several readings taken the day following planting in the drill row. Moisture determinations were made from a composite of 8 to 10 samples from drill row 3 inches deep, vertical sections, taken immediately following the planter. All hills were counted which contained one or more plants and the percent of stand calculated on a basis of 165 hills. Numbers of stalks were counted and check made on plants when crop was nearly mature. Viable seed sown per plot is estimated from germination test and drill delivery.

In Table 6 is given the relation of the heat and moisture conditions of the seedbed to the germination of Feterita. This shows plainly the importance of these factors regardless of treatments and method of planting.

Table 6. Feterita Reaction to Seedbed Conditions

Plot No.	Test No.	Soil Temp. °F.	Moisture Content Seedbed	Date of Planting	Percentage Possible Germination Effective. Av. all Plots Treated and Untreated
	1	58.5	26.5%	May 5	6.82
1-7		61.0	12.56%	May 14	.86
	2	68.5	26.30%	May 27	23.65
9-16		73.0	15.13%	June 22	41.91
19-25		82.0	12.24%	July 10	55.45

All dates of planting and all feterita plots are included in Table 6. Tests 1 and 2 were hand planted while plots were machine planted. See Table 5.

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GENERAL DISCUSSION

The similarity of results with Feterita and Dwarf Hegari and again with Blackhull White Kafir and Bishop, especially in the field tests, bring out a definite relation of color of the seedcoat to the sensitiveness of the seed to attacks of decay organisms and a corresponding response to protective treatments. The germinating efficiency of the chalk white varieties when germination is delayed is distinctly lower that that of the ivory white varieties, but both are far behind the yellow seeded milo.

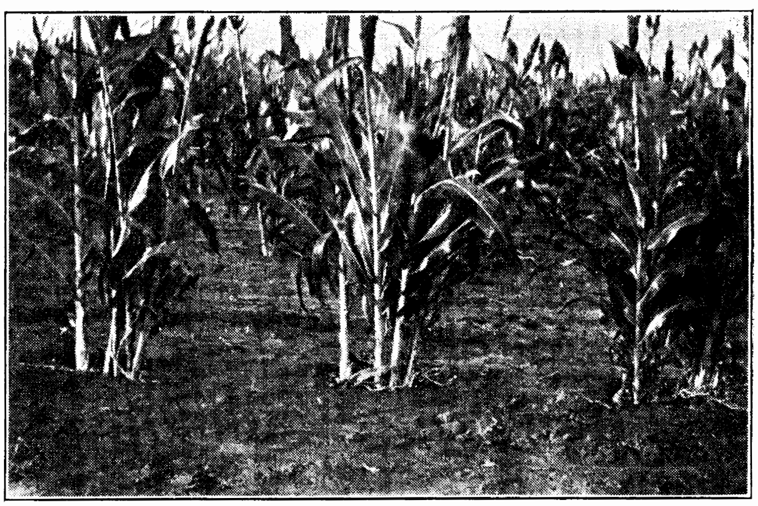

FIGURE 4—PLOT NO. 11, B. W. KAFIR COPPER CARBONATE TREATED

The effect of low temperature is practically to prolong the time required for germination and thereby allow the attack of soil organisms to become destructive of the undeveloped or slowly developing embryo. There is no doubt from the results of the date tests (see Tables 4, 5 and 6) that the protective effect of treatment slowly wears off. Whether this is due to chemical reaction with soil ingredients, dissipation by absorption, some other cause or combination of causes is not brought out in these tests. The efficient disinfectant must keep off the molds long enough to give the seed a chance at life. If it does this much it has served a useful purpose. There is no evidence in these tests for the idea that treatment stimulates the growth. The fertilizing or amending effect on the soil would be negligible considering only one-fifth ounce of dust per acre is used for sorghum seed. It was thought, therefore, that stimulation would be immediate and discernible in the seeding if it occurred at all. Twelve hour observations show, however, that the first plants came up at the same time on treated and untreated plots. The only differences in vigor which could be detected were the stooling of Feterita plants in the untreated field plots to occupy additional space afforded by the poor stands.

Reference to Table 4 will show the Yellow Milo better able to withstand a prolonged germination period than any of the other four varieties. The stand from plantings that took 8 days to emerge was eight-ninths of that from plantings that took only 5 days to emerge. Since Milo stools freely this small difference would make little if any variation in yield of grain. Just

FIGURE 5—PLOT NO. 9. FETERITA UNTREATED

two-thirds as many plants came through on the Kafir and Bishop plots planted early as on those planted later. Feterita and Hegari suffered most from early planting, producing only one-third as many plants as on the later planting. There was twenty-two days difference in dates of planting and ten degrees difference in soil temperature.

Milo, Hegari, Feterita, and Bishop have a greater tendency to stool out when not crowded than does Blackhull White Kafir. A comparison is made in Table 5 between Feterita and Kafir. It will be noted that the Feterita tends to equalize the stand in regard to size of hill in spite of variation in number of plants per hill. This is not the case with Kafir and it is therefore necessary to give closer attention to regulating the planter drop as well as protecting the germination by a suitable treatment. The illustrations on

Figures 2, 3 and 4 are numbered to correspond with the plots described in Table 5.

It is obvious when seasonal conditions and growing habits are considered that each variety can not be planted on the dates favoring the best germination. The general experience of plains farmers points strongly toward planting as late in the season as possible so long as the ripening grain is not in danger of frost. There are several reasons for this, the more important ones being as follows: (1) The summer rainfall of the high plains constitutes nearly three-fourths of the total annual rainfall, and grain sorghums to take advantage of the whole amount should not mature before or during the late summer rains; (2) Field cultivation to control weeds and thereby save moisture for the oncoming crop is more efficiently done before planting than after; (3) A fast growing crop coming to maturity in the shortest possible time makes a more economical use of the soil resources than one which lingers through idle periods of cool or dry weather in the growing period.

This means the varieties are grouped in respect to time of maturity when it comes to selecting the planting dates. Blackhull White Kafir and Bishop fall together and must be planted fairly early in spite of the chance of getting a poor stand, because they take longer to mature. Yellow Milo, Feterita, and Hegari are grouped together for later planting.

Since Milo has the best average chance when planted in June and is also highly resistant to seedbed decay it can be dismissed from further discussion as not requiring seed treatment ordinarily for the purpose of protecting the germination.

Kafir and Bishop should be planted before the soil warms up to its full summer temperature and being fairly easy to rot can be very profitably treated with a proper dust disinfectant.

Feterita, though it may be planted later than Kafir or Bishop, is shown by these experiments to be very sensitive to adverse conditions. The effective germination was improved materially by appropriate seed treatment, even on plantings made too late in the season to perimt maturity.

CHOICE OF TREATMENT

The two treatments from which we have secured favorable results are Copper Carbonate and Bayer Dust. The Bayer Dust seems to have been more effective in the case of incubator tests and with Wheat and Yellow Milo. The Copper Carbonate has shown an advantage in the cases of the white seeded grain sorghums. We do not consider these results taken as a whole to indicate a great preference for either disinfectant. The cost of material and availability should probably determine which to use. There are yet some questions of technical nature regarding the physical and chemical processes involved in the protection of the seed under soil conditions, which if investigated should throw some light on the apparent adaptation of each treatment to particular conditions and varieties. For practical purposes both treatments have proved worthy of recommendation.

It should be pointed out in this connection that the method of measuring the results of field plantings by the effective germination gives a lower figure than would be had by using the effective stand (see Table 5) but is more accurate and less complicated. It often happens that in farm practice a satisfactory stand is secured with a 25 to 50 percent effective germination. In the case of grain sorghums where a small amount of seed per acre is used the advantage of treatment is not so much from the saving of seed as from the assurance of a workable stand under adverse planting conditions. The saving achieved is in avoiding as often as possible, the necessity of replanting. This is not only an important factor from a labor standpoint, but in northwestern Oklahoma the shortness of the season demands a greater certainty of results than might be permissable elsewhere.

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METHOD OF TREATMENT

It has been found that the amount of dust required depends a little on the quality of the seed. Seed containing much dirt, trash, hulls, or cracked kernels takes more dust to provide each kernel with all that will adhere to it than does bright clean seed. Four ounces per bushel has ordinarily sufficed to cover grain sorghum seed with a small surplus to spare.

Any closed container that can be rotated will serve to apply the dust treatment. A small quantity of seed can be handily treated in a closed can shaken by hand, but for larger amounts of seed a barrel mounted as a barrel churn with a crank and handy opening for filling and discharging is almost a necessity.

To avoid the sickening effect of inhaling the dust a moist cloth or aspirator must be worn over the mouth and nostrils.

Treated seed may be stored in the bin immediately and indefinitely.

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COST OF TREATMENT

Since one bushel of sorghum seed will plant from 10 to 30 acres depending on the size of seed and the spacing, the main cost is the labor of applying the treatment. Rating the material at 50 cents a pound, which is well above the cost at the time of writing, the cash outlay averages about 2 cents per acre.

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CONCLUSIONS

1. Feterita, Dwarf Hegari, Blackhull White Kafir, and Bishop are subject to serious losses of stand by seed rot when germination is delayed due to adverse seedbed conditions.

2. Profitable increases of stand were secured by treating the seed of

the above named varieties with Bayer Dust or with Copper Carbonate at the rate of 4 ounces per bushel.

3. Results of treatment were consistent in all plantings of each variety under soil temperatures ranging from 58.5° to 82° F.

4. As good a stand was had of Feterita with dust disinfectation when the soil temperature was 68° as with untreated seed at a temperature of 82° in silty clay loam soil.

5. The chalk-white seeded varieties of grain sorghums do not resist decay as well as the ivory white, nor the ivory white as well as the yellow.

6. Yellow Milo does not require treatment for germination protection under average field conditions.

7. The treatment of white seeded varieties by either of the dust disinfectants described gave them seedbed protection practically equal to that naturally possessed by Yellow Milo.

8. The earlier the planting is made the more urgent is the necessity of treating the seed for improving the stand.

9. The protective effect of treatment gradually disappears in incubator and soil.

10. Treatment prolongs the resistance to decay from three to five days.