

EXPERIMENT STATION
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BOTANICAL DEPARTMENT.

W. A. KELLERMAN, PH.D., BOTANIST.

I.- EXPERIMENTS WITH SORGHUM SMUTS.

In Kansas, two species of smuts have been found (*Ustilago Sorghi* and *Ustilago Reiliana*) infecting sorghum. One of these attacks the individual grains of the head or panicle of sorghum, and, therefore, may be called *grain* smut, and the other attacks the whole head, converting it into a large, black mass, which at maturity resembles corn smut in appearance; this form will be called the *head* smut.

THE GRAIN SMUT OF SORGHUM.

This species is found only in the individual grains of the sorghum head or panicle, which become, in consequence of the attack, considerably elongated, and usually somewhat increased in diameter. Plate II, figures 3 and 8, show attacked grains, and figures 2 and 7 show sound ones from the same heads. The plate also shows, in figures 1, 4, and 6, the appearance of the attacked panicle. It does not differ from the normal in size and shape, but the elongated grains, whose membranous covering is quite white upon its first appearance, are very conspicuous. Upon maturity of the cane the smutted grains become of a grayish color, and the membrane more or less broken when exposed all winter.

This smut seems to attack only the varieties of sorghum that are grown from imported seed. As to its distribution, the following was published in

the Proceedings of the Kansas Academy of Science, 23d Annual Meeting, p. 158,* (1890.)

"USTILAGO SORGHI (Link.?) Passerini, in Thum. Herb. myc. oec. n. 63. (? *Sporisorium Sorghi* Link. Sp. Pl. II, p. 86.)

"This species, which has been reported from Washington, D. C.,¹ Madison, Wis.,¹ New York,¹ and Lincoln, Neb.,² on sorghum grown from imported seed, was found by Mr. H. M. Cottrell on the College Farm, Manhattan, Kas., in small quantities, on sorghum raised from seed received from the U. S. Department of Agriculture. The seed had been obtained through the U. S. Consul at Calcutta. It was found later by Prof. G. H. Failyer, on sorghum grown by the Chemical Department on a different part of the College Farm, from seed received from Dr. Peter Collier. The seed in this case had been imported from Africa and not previously grown in this country. One variety grown by the Chemical Department that was attacked was received under the name of *Huansa Byn*, and the others (designated by numbers) were *Rangoon* varieties. Many of these were badly attacked, and in some cases as many as one-fourth the heads were smutted. The smutted varieties grown by the Farm Department were very unlike the preceding. Of these there were three numbers quite similar in appearance, and they may have been one and the same variety.

"Mr. A. A. Denton, of the Sterling Syrup Works, Sterling, Ka, has sent us a specimen of this smut. He says that in some lots about half of the seed heads were affected. Several varieties of sorghum (*vulgare?*) were attacked, but all were grown from foreign seed."

THE HEAD SMUT OF SORGHUM.

Plates III and IV show the general appearance of the head smut. The whole head (usually) is converted into a large, continuous or lobulated mass, covered with a white membrane. The latter soon ruptures and exposes the black, powdery mass of spores. A short time afterward, if the head is not protected from exposure, nothing remains but black threads, which represent the fibro-vascular bundles and dried remains of the panicle branches. Rarely, as shown in plate IV, figure 5, only a portion of the head is attacked. The following account was published in the Transactions of the Kansas Academy of Science, 1. c.--to which may be added that Prof. B. D. Halsted, the same season, sent us specimens of this species of smut from New Jersey, where it was reported for the first time; it was said to be abundant, and on sorghum from home-grown seed (Amber):

"USTILAGO REILIANA, Kuhn, in Rabenhorst, Fungi europaei exsiccati, cent. XX (Dresden, 1875) No. 1988.

"This species was found by Mr. J. T. Willard, early in September of this year (1890), in a sorghum plant grown by the Chemical Department. The variety of sorghum (*S. vulgare*) was known as Red Liberian, the seed of which was obtained from the Sterling Syrup Works in 1888. It had been grown at Manhattan continuously since that time, but no smutted heads had, in the meantime, been observed. Only one stalk in the plot was found smutted this year. The uppermost panicle was not smutted, but it produced no seed. The uppermost lateral heads ripened their smut

*Notes on sorghum smuts, by W. A. Kellerman and W. T. Swingle.
1 William Trelease, Preliminary List of the Parasitic Fungi of Wisconsin, p. 34.
2 H. J. Webber, Rusts and Smuts of Nebraska. Bulletin of the Agr. Exp. Sta. Nebr., No. II, p. 69; also Catalogue of the Flora of Nebraska, in Report of the Botanist, p. 74, Extr. from Report Nebr. State Bd. Agr. for 1889.

early in September. Other lateral branches were produced until killed by frost. There were in all seven smutted heads produced; four of these, together with the non-smutted panicle, are reproduced in the plate. It can be seen that each of the smutted heads there shown is formed of several lobes, or parts, more or less distinct from each other. In case of each of the last two lateral heads produced (not shown in the plate) there was but one continuous mass of spores, inclosed by a smooth, white membrane. This species has not hitherto been reported in the United States, though it occurs in Egypt on *Sorghum vulgare*, and in Europe on *Sorghum vulgare* and *S. saccharatum* (on the latter by artificial inoculation), and on the male inflorescence (tassel) of maize.

"Mr. A. A. Denton reports it at Sterling, Kansas, as the following letter shows:

"STERLING, KANSAS, November 16, 1890.

"Prof. W.A. Kellerman, Manhattan, Kansas--DEAR SIR: I have to-day hunted over the experimental field for smutted cane-tops, without success. The canes were all cut some time ago, and most have been hauled away, but few remaining in shock upon the land.

"I had noticed the two kinds of smut during the season. The five smutted heads, as shown in the larger photograph* which you sent, I had repeatedly noticed. It is not usual, except in one variety, for a cane to have five seed-tops; and the fact that all the heads on one cane were smutted, made the case more noticeable.

"The other case, in which the grain only was attacked, I had also noticed. In two or three lots many of the seed-heads were thus affected; the berry or the kernel had an unnatural appearance - a whitish color--though the interior of each grain was powdery smut.

"Both kinds were, so far as observed, found only in seeds of foreign growth.

"I believe that the black, powdery seed-heads, in which the entire seed-head is a mass of smut similar to the smut found on corn, is occasionally found, or something similar, each year in cane. It was, however, singular that when rank growth was prevented by drouth, five seed-heads on one cane and all of them smutted, should have been noticed only in foreign canes.

Respectfully,
A. A. DENTON.

"An account of both of the species here recorded is given by Prof. J. Kuhn, Die Brandformen der Sorghum-Arten in Mittheilungen des Vereins für Erdkunde 1877, reviewed in Botanischer Jahresbericht V. Jahrg. (1877) S. 117. Prof. O. Brefeld gives a description of the germination of the spores of *Ustilago Reiliana* in Die Brandpilze, I., S. 94-5 Taf. XI, figs. 3-7."

Further investigations of the species of sorghum smuts have not been completed, and are temporarily interrupted by the resignation of the author as botanist to this Station, to accept the professorship of botany in the Ohio State University, Columbus, Ohio.

PRELIMINARY TEST IN GREENHOUSE.

A preliminary test was begun in the greenhouse November 29, 1890, with the view of determining the possibility of infecting sorghum plants by using seed to which smut spores might be adhering.

VARIETIES USED.

For this purpose the following varieties of sorghum were selected: Red Liberian and Rangoon (seed grown by the Chemical Department in 1890), Early Amber, White Kaffir Corn, and a variety from Calcutta (seed grown by the Farm Department 1890).

MODE OF PLANTING AND GROWTH.

The seed was planted in small pots placed in the greenhouse. They were attended to as ordinarily done in such case, and the plants made a

*Reproduced in Plate III.

growth much less, of course, than if in the open field in proper season; yet, under the circumstances, satisfactory. Many seeds were planted in each pot, but the plants were reduced to a few (usually three) when well established. They were re-potted from time to time as needed.

The temperature varied from 50 deg. F. (at night) to 78 deg. F.

PREVIOUS TREATMENT OF SEED.

All the seed was immersed for 15 minutes in water raised to a temperature between 134 and 135 deg. F., and immediately cooled in water of ordinary temperature at that season. The object of this treatment was to kill, absolutely, any spores of smut that might be adhering to the seed, since the infected seed would vitiate the control plants. Immediately after this treatment the seed was planted as indicated elsewhere.

NUMBER AND RECORD OF THE POTS.

The treated seed was planted in the several pots, with or without further treatment, as follows:

- Pot 1. Red Liberian; dry spores of *Ustilago Sorghi* mixed with the seed.
- Pot 2. Red Liberian; dry spores of *Ustilago Reiliana* mixed with the seed.
- Pot 3. Red Liberian; seed free from smut.
- Pot 4. Red Liberian; seed free from smut.
- Pot 5. Red Liberian; seed previously germinated in tester, to which germinated spores (in water) of *Ustilago Sorghi* were applied with a camel's-hair brush and by direct pouring of the liquid.
- Pot 6. Red Liberian; seed previously germinated in tester; germinated spores of *Ustilago Reiliana* added.
- Pot 7. Rangoon; dry spores of *Ustilago Sorghi* mixed with the seed.
- Pot 8. Rangoon; dry spores of *Ustilago Reiliana* mixed with the seed.
- Pot 9. Rangoon; seed free from smut.
- Pot 10. Rangoon; seed free from smut.
- Pot 11. Rangoon; to the previously-germinated seed, germinated spores of *Ustilago Sorghi* added.
- Pot 12. Rangoon; to the previously-germinated seed, germinated spores of *Ustilago Reiliana* added.
- Pot 13. Early Amber; dry spores of *Ustilago Sorghi* mixed with the seed.
- Pot 14. Early Amber; dry spores of *Ustilago Reiliana* mixed with the seed.
- Pot 16. Early Amber; seed free from smut.
- Pot 16. Early Amber; seed free from smut.
- Pot 17. Early Amber; to the previously-germinated seed, germinated spores of *Ustilago Sorghi* added.
- Pot 18. Early Amber; to the previously-germinated seed, germinated spores of *Ustilago Reiliana* added.
- Pot 19. White Kaffir Corn; dry spores of *Ustilago Sorghi* mixed with the seed.
- Pot 20. White Kaffir Corn; dry spores of *Ustilago Reiliana* mixed with the seed.
- Pot 21. White Kaffir Corn; seed free from smut.
- Pot 22. White Kaffir Corn; seed free from smut.
- Pot 23. White Kaffir Corn; to the previously-germinated seed, germinated spores of *Ustilago Sorghi* added.
- Pot 24. White Kaffir Corn; to the previously-germinated seed, germinated spores of *Ustilago Reiliana* added.

- Pot 25. India var.; dry spores of *Ustilago Sorghi* mixed with the seed.
 Pot 26. India var.; dry spores of *Ustilago Reiliana* mixed with the seed.
 Pot 27. India var.; seed free from smut.
 Pot 28. India var.; seed free from smut.
 Pot 29. India var.; to seed previously germinated, germinated spores of *Ustilago Sorghi* added.
 Pot 30. India var.; to seed previously germinated, germinated spores of *Ustilago Reiliana* added.

RESULTS OF THE ATTEMPTED INFECTION IN THE GREENHOUSE.

The plants in five of the pots (12, 13, 15, 26, and 30) died.

Of the remaining twenty-five pots, nine contained seed free from smut. When the plants were mature, examination showed that not a single one was infected with smut.

Fifteen of the twenty-five pots were planted with seed that was infected; the plants of nine (1, 2, 5, 7, 11, 14, 17, 18, and 23) of them (*or 60 per cent.*) produced smutted heads. In seven (1, 5, 7, 11, 14,* 17, and 23) cases the result was *Ustilago Sorghi*, and in two cases *Ustilago Reiliana* appeared. (In some manner not evident, there was contamination of the seed with *Ustilago Sorghi* in case of pot 14, which should have given *Ustilago Reiliana*.)

To the germinated seed, in case of five of the pots (5, 11, 17, 18, and 23), germinated spores of the smut were added, and to the remaining four (1, 2, 7, and 14) dry spores were added to the seed.

Suffice to say, in conclusion, that it was evident that infection of the sorghum plants could be induced by infection of the seed, and accordingly a field experiment was carried out, as follows:

FIELD EXPERIMENTS WITH SORGHUM SMUT.

Seed from a plot of the Farm Department was selected which contained some smutted heads (grain smut - *Ustilago Sorghi*) the preceding year. Seed from the Chemical Department, similarly affected, was also used. Spores of the head smut (*Ustilago Reiliana*) obtained from Sterling, Kansas, and also from the Chemical Department were used. The ground was "second bench," adjacent to the plots used in spraying to prevent rust. (Bulletin 22.)

TREATMENT OF THE SEED.

To insure infection, there was added to the seed a quantity of more or less broken smutted grains, and the whole was thoroughly mixed. A portion of this seed was then used in planting the untreated plots. With the other portion the following treatments were made. Seed was treated similarly with the head smut (*Ustilago Reiliana*) for plots 18 and 19. The arrangement and numbering of the plots is also indicated:

* Evident contamination with *Ustilago Sorghi*, since *Ustilago Reiliana* should have, according to the label, appeared.

(*Ustilago Sorghi.*)

1. Untreated.
2. Potassium sulphide, 2 per cent. solution, 4 hours.
3. Potassium sulphide, 2 per cent. solution, 18 hours.
4. Potassium sulphide, 1 per cent. solution, 4 hours.
5. Potassium sulphide, 1 per cent. solution, 18 hours.
6. Potassium sulphide, 1/2 per cent. solution, 4 hours.
7. Potassium sulphide, 1/2 per cent. solution, 18 hours.
8. Untreated.
9. Chloride of iron, 2 per cent. solution, 4 hours.
10. Chloride of iron, 2 per cent. solution, 18 hours.
11. Chloride of iron, 1 per cent. solution, 4 hours.
12. Chloride of iron, 1 per cent. solution, 18 hours.
13. Chloride of iron, 1/2 per cent. solution, 4 hours.
14. Chloride of iron, 1/2 per cent. solution, 18 hours.
15. Untreated.
16. Hot water, 131 deg. F., 8 minutes.
17. Hot water, 131 deg. F., 15 minutes.

(*Ustilago Reiliana.*)

18. Dry spores of *Ustilago Reiliana* mixed with common seed.
19. Wet spores of *Ustilago Reiliana* mixed with common seed.

RESULTS OF THE FIELD EXPERIMENT.

At or about the time of maturity of the sorghum (Aug. 31), a careful examination of all the stalks was made. The table below shows the number of stalks in the several rows, and the number and per cent. of stalks affected with smut:

	<i>Treatment.</i>	<i>Length of row, in feet.</i>	<i>Total number of stalks.</i>	<i>No. of smutted stalks.</i>	<i>Per cent. of smutted stalks.</i>
1	Untreated	200	414	4	.97
2	Potassium sulphide, 2 per cent. sol., 4 hrs. . . .	100	97	0	0
3	Potassium sulphide, 2 per cent. sol., 18 hrs. . . .	100	148	0	0
4	Potassium sulphide, 1 per cent. sol., 4 hrs. . . .	100	46	0	0
5	Potassium sulphide, 1 per cent. sol., 18 hrs. . . .	100	87	0	0
6	Potassium sulphide, 1/2 per cent. sol., 4 hrs. . . .	100	131	0	0
7	Potassium sulphide, 1/2 per cent. sol., 18 hrs. . . .	100	145	0	0
8	Untreated	200	357	8	2.24
9	Chloride of iron, 2 per cent. sol., 4 hrs.	100	161	2	1.24
10	Chloride of iron, 2 per cent. sol., 18 hrs.	100	248	0	0
11	Chloride of iron, 1 per cent. sol., 4 hrs.	100	111	4	3.60
12	Chloride of iron, 1 per cent. sol., 18 hrs.	100	235	0	0
13	Chloride of iron, 1/2 per cent. sol., 4 hrs.	100	131	2	1.53
14	Chloride of iron, 1/2 per cent. sol., 18 hrs.	100	197	0	0

Plot.....	Treatment.	Length of row, in feet.	Total number of stalks.	No. of smutted stalks.	Per cent. of smutted stalks.
15	Untreated	200	270	9	3.33 $\frac{1}{3}$
16	Hot water, 131 deg. F., 8 min.....	100	154	0	0
17	Hot water, 131 deg. F., 15 min.....	100	269	0	0
18	Dry spores of <i>Ustilago Reiliana</i> mixed with } common seed.....	100	247	2	.81
19	Wet spores of <i>Ustilago Reiliana</i> mixed with } common seed.....	100	337	0	0

CONCLUSION.

The results, as shown in the above tabulation, are not of a decisive character, and therefore a conclusion as to the value of the treatment of the seed with the three fungicides used, must be withheld. The untreated plots gave from 1 to 3 1/3 per cent. of smutted heads, and the majority of treated plots were free from smut, yet one of the latter (No. 11) produced a higher percentage (3.60) of smutted stalks than any of the untreated plots. The artificial infection of the seed does not seem to be successful; but if seed from fields where the percentage of smut is very high could be used, a repetition of the experiment would likely furnish decisive results.

II.-CORN SMUT.

While carrying on the preliminary test in the greenhouse with sorghum smuts (p. 97), a few trials were made at the same time to infect maize with corn smut (*Ustilago Zeae-Mays*) and also with the head smut of sorghum. The seed was infected with smut in a manner that will be sufficiently understood by perusal of the test with sorghum smuts, just mentioned. The seed used was a yellow variety of dent (Pride of the North), and pop-corn.

NUMBER AND RECORD OF THE POTS.

31. **Pride of the North; seed mixed with dry spores of corn smut (*Ustilago Zeae-Mays*).**
32. **Pride of the North; seed mixed with dry spores of sorghum smut (*Ustilago Reiliana*).**
33. **Pride of the North; seed free from smut.**
34. **Pride of the North; seed free from smut.**
35. **Pride of the North; to the previously-germinated seed, germinated spores of *Ustilago Reiliana* added.**
37. **Pop-corn; seed mixed with dry spores of corn smut (*Ustilago Zeae-Mays*).**
38. **Pop-corn; seed mixed with dry spores of sorghum smut (*Ustilago Reiliana*).**
39. **Pop-corn; seed free from smut.**

40. Pop-corn; seed free from smut.

41. Pop-corn; to the previously-germinated seed, germinated spores of *Ustilago Reiliana* added.

RESULT OF THE GREENHOUSE EXPERIMENT.

In all of the pots the corn germinated, and the plants, though small, grew as well as could be expected under the circumstances. But the most careful search failed to reveal the least trace of smut on any part of any of the stalks. It has been already noticed that in case of similar experiments with sorghum smuts, 60 per cent. of the pots produced plants with smutted heads.

Although this trial gave no evidence of possible infection through the seed, yet a field experiment on a small scale was determined upon.

FIELD EXPERIMENT WITH CORN SMUT.

The object of the field experiment was simply to test under normal conditions the possibility of infecting the corn through the seed. For this purpose several rows were planted adjacent to the rows of sorghum in the preceding account. A white variety (St. Charles) and pop-corn were used. The following paragraph shows the arrangement of the plots and the mode of infecting the seed:

NUMBER AND RECORD OF THE PLOTS.

- 20. St. Charles; dry seed rolled in dry smut (*Ustilago Zeae-Mays*).
- 21. St. Charles; seed wetted and rolled in smut.
- 22. Pop-corn; dry seed rolled in dry smut.
- 23. Pop-corn; seed wetted and rolled in smut.
- 24. St. Charles; seed not artificially infected with smut, as above.
- 25. Pop-corn; seed not artificially infected with smut, as above.
- 26. St. Charles; dry seed rolled in dry smut.
- 27. St. Charles; seed wetted and rolled in smut.
- 28. Pop-corn; dry seed rolled in dry smut.
- 29. Pop-corn; seed wetted and rolled in smut.
- 30. St. Charles; seed not artificially infected with smut, as above.
- 31. Pop-corn; seed not artificially infected with smut, as above.

The following diagram shows the arrangement of the plots:

31	29	25	23
	28		22
30	27	24	21
	26		20

RESULT OF THE EXPERIMENT.

A careful examination was made for smut when the corn was nearly mature, with the following result:

Plot	Treatment.	Length in feet.	Total number of stalks.	No. of smutted stalks	% Smutted stalks
20	St. Charles; dry seed rolled in dry smut (<i>Us-tilago Zeae-Mays</i>). }	50	55	1	1.82
21	St. Charles; seed wetted and rolled in smut. . .	50	38	2	5.26
22	Pop-corn; dry seed rolled in dry smut.	50	55	2	3.64
23	Pop-corn; seed wetted and rolled in smut. . . .	50	88	4	4.55
24	St. Charles; seed not artificially infected with smut, as above.	100	107	3	2.80
25	Pop-corn; seed not artificially infected with smut, as above.	100	136	4	2.94
26	St. Charles; dry seed rolled in dry smut.	50	58	0	0
27	St. Charles; seed wetted and rolled in smut. . .	50	80	1	1.25
28	Pop-corn; dry seed rolled in dry smut.	50	61	2	3.28
29	Pop-corn; seed wetted and rolled in smut. . . .	50	99	3	3.03
30	St. Charles; seed not artificially infected with smut, as above.	100	97	11	11.34
31	Pop-corn; seed not artificially infected with smut, as above. }	100	216	4	1.85

SPRAYING EXPERIMENT FOR CORN SMUT

Two rows of corn adjacent to the rows of barley, etc., that were sprayed to prevent rust (see Bulletin No. 22), were sprayed in a similar manner and with the same fungicides as were used in the experiment just referred to. The seed (Leaming) of east row was not artificially smutted, and that of the west row was rolled in dry smut. Each plot was twenty feet in length, and each alternate plot was not treated.

FUNGICIDES USED.

The fungicides used were Bordeaux mixture, chloride of iron, one-half ounce in three gallons of water, and potassium sulphide (liver of sulphur), one ounce in three gallons of water. The spraying was begun about three days after the plants appeared above ground, and continued till the corn was out in tassel and silk.

TIME OF EACH SPRAYING.

- 1.--May 19, 1891.
- 2.--May 26; rain almost daily since last spraying.
- 3.--June 2; rain almost daily since last spraying.
- 4.--June 10; rains numerous, and plants wet almost all the time since the last spraying.
- 6.--June 20; rain June 16 (when plots should have been sprayed), and each day since.

- 6.--June 27; rains June 25 and 26.
- 7.--July 2; rain previous night.
- 8.--1 July 9.

RESULT OF THE EXPERIMENT.

The following table shows the result of the examination made the last day of August; it also indicates the arrangement of the plots:

TREATMENT.	EAST ROW—Seed not smutted.			WEST ROW—Seed smutted.		
	Total number of stalks.	Number of smutted stalks.	Per cent. of smutted stalks.	Total number of stalks.	Number of smutted stalks.	Per cent. of smutted stalks.
Untreated	13	1	7.69	10	1	10
Potassium sulphide	21	0	0	22	5	22.73
Untreated	16	3	18.75	19	3	15.69
Chloride of iron.....	14	0	0	10	0	0
Untreated	13	1	7.69	12	0	0
Bordeaux mixture....	8	0	0	11	1	9.09
Untreated	18	1	5.63	16	3	18.75

This tabulation shows that (artificial) infection of the seed does not increase the amount of smut. Farther investigation is necessary in order to determine the mode of infection--a point that must be settled before we can hope to employ rational methods for the prevention of this annoying and destructive pest.

SUMMARY OF THE BULLETIN.

Two different smuts affect sorghum--*grain smut (Ustilago Sorghi)*, infesting the individual grains, and *head smut (Ustilago Reiliana)*, converting the whole panicle or head of sorghum into a large, black mass, covered in the earlier stages with a white membrane.

The smuts so far as heretofore reported attack only those varieties raised from foreign seed, or seed recently imported. They have not been very abundant as yet in Kansas. The *head smut* was first reported in this country in 1891, though known for several years previous in Europe and Africa.

A preliminary test in the greenhouse, in the winter of 1890-91, showed that it was possible to infect the plants by infecting the seeds with the spores of the smut.

Treating the infected seed with three fungicides, namely, liver of sulphur, chloride of iron, and hot water, did not result in decisive evidence as to the actual value of the fungicides.

Attempts, both in the greenhouse and in the field, to infect maize by adding a quantity of the spores of corn smut to the seed were unsuccessful.

Spraying corn with Bordeaux mixture, with chloride of iron, and with potassium sulphide solution, did not prove efficient in the attempted prevention of the corn smut.

EXPLANATION OF PLATES.

PLATE II. GRAIN SMUT OF SORGHUM (*Ustilago Sorghi*).

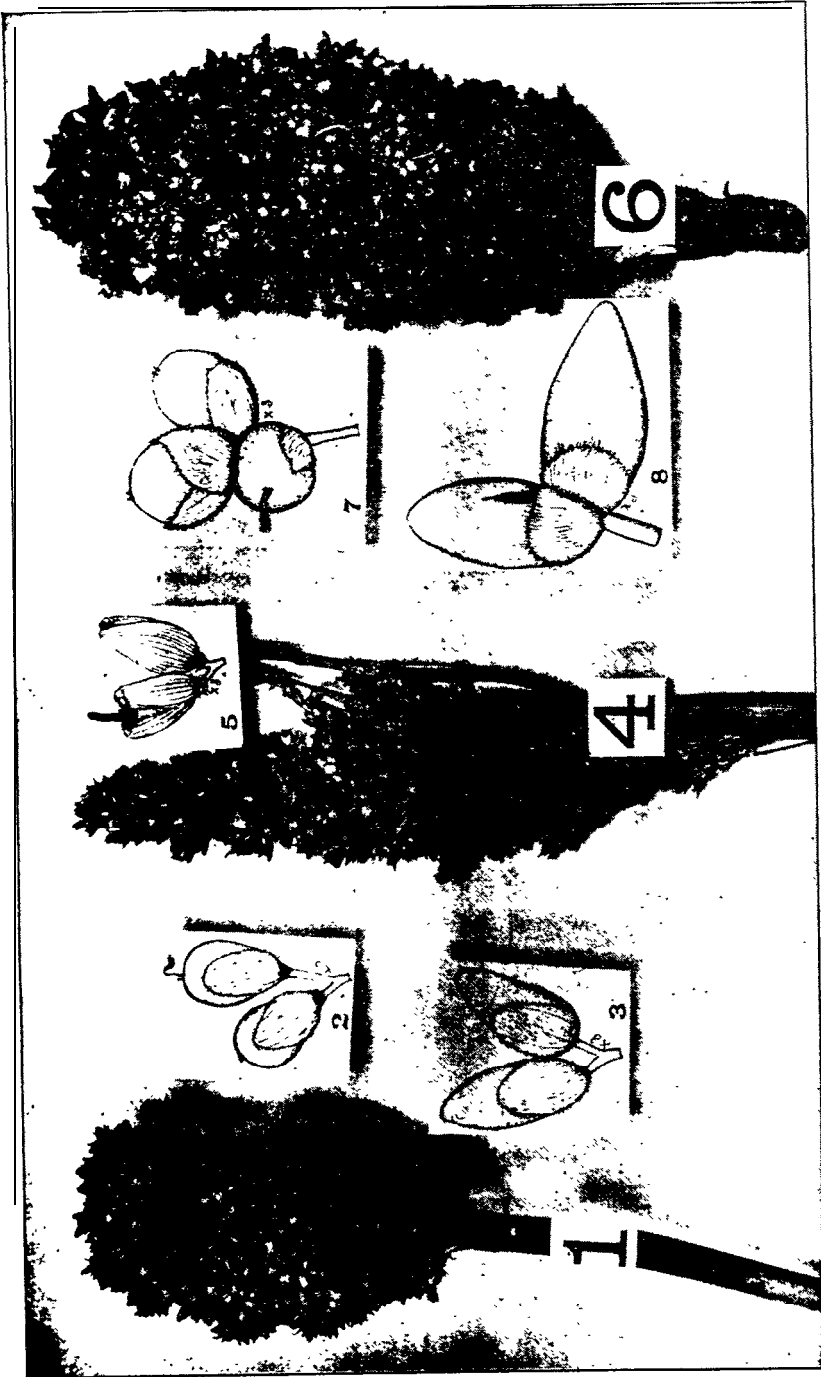
1. Smutted head; one-half natural size.
2. Sound grains from head 1; magnified three diameters.
3. Smutted grains from head 1; magnified three diameters.
4. Smutted head; one-half natural size.
5. Smutted grains from head 4; magnified two diameters.
6. Smutted head; one half natural size.
7. Sound grains from head 6; magnified three diameters.
8. Smutted grains from head 6; magnified three diameters.

PLATE III. HEAD SMUT OF SORGHUM (*Ustilago Reiliana*).

- A. Uppermost head or panicle of sorghum, sound.
- B, C, D, E. Lateral heads from same stalk, smutted.

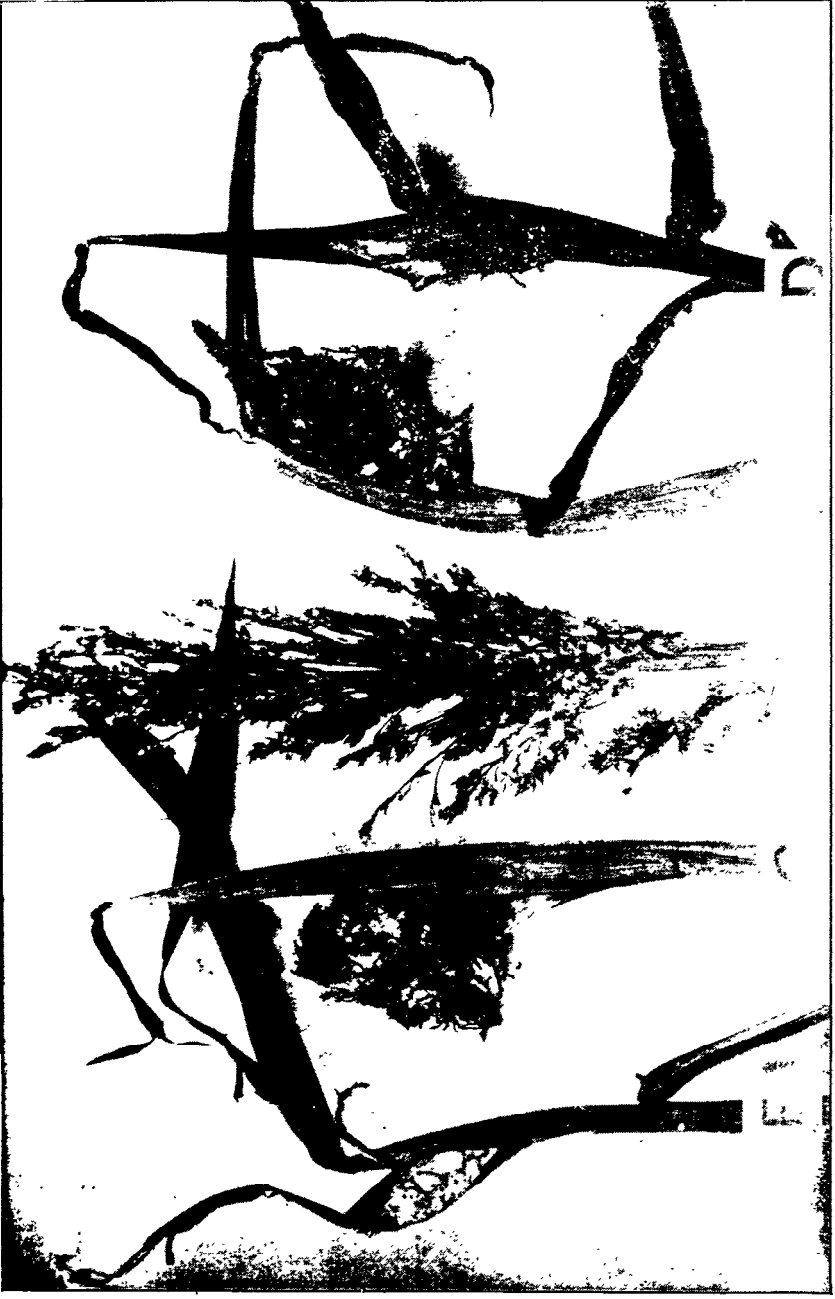
PLATE IV. HEAD SMUT OF SORGHUM (*Ustilago Reiliana*).

1. Smutted head still inclosed by leaf sheaths.
2. Smutted head yet inclosed, but showing smut on the edge of leaf sheaths.
3. Smutted head breaking through the sheaths.
4. Smutted head exposed by cutting away sheaths.
5. Head smutted only at base.
6. Head smutted and considerably weathered.



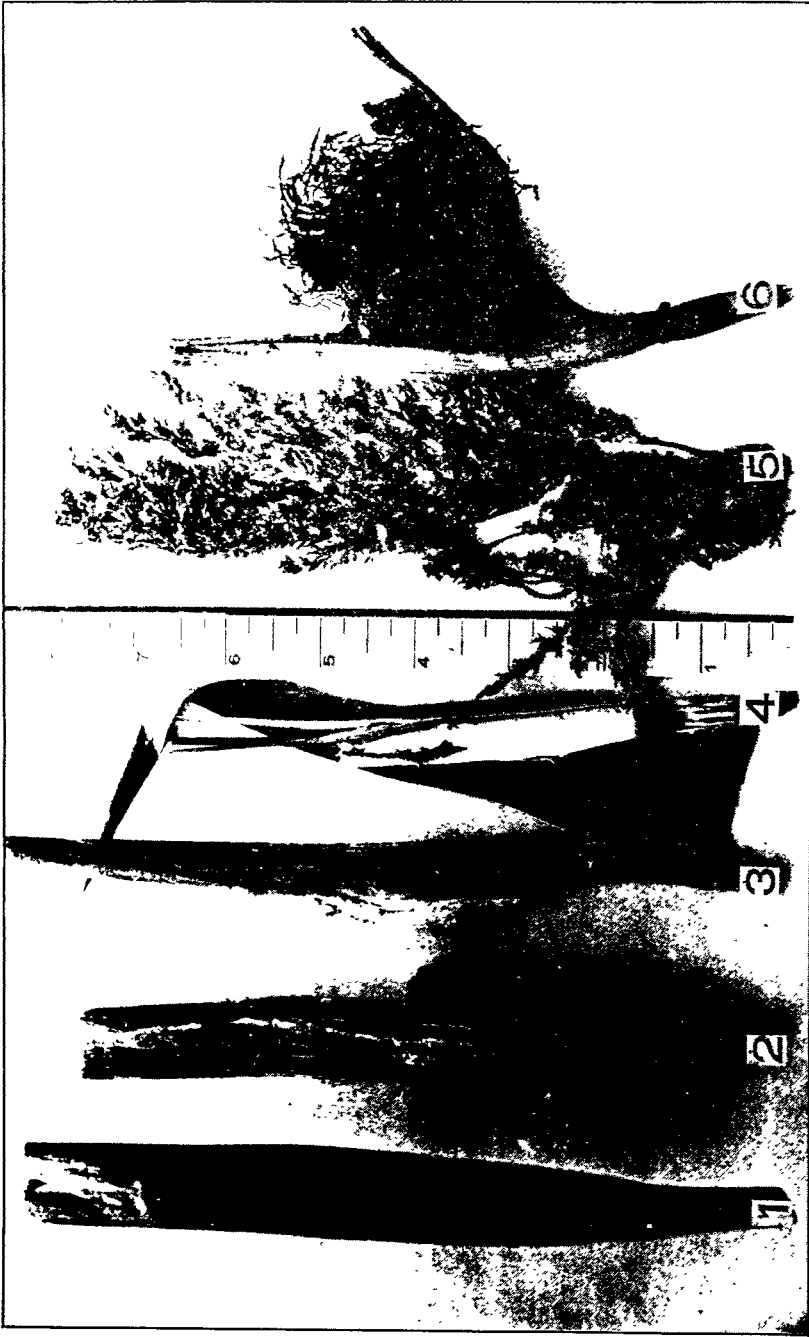
GRAIN-SMUT OF SORGHUM (*Ustilago Sorgheti*).

Photographed by W. A. Kellerman.



HEAD-SMUT OF SORGHUM (*Ustilago zeae*).

Photographed by Kellerman and Swingle.



HEAD-SMUT OF SORGHUM (*Usittago Kelliana*).