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ABSTRACT — Germination of sorghum seed did not appear to be affected by spraying the plants with Maneb or with a chemical defoliant before harvest. Mechanical threshing greatly reduced germination of most but not all lots; this injury is thought to be related to the maturity and/or moisture content of the seed when threshed, although other varietal differences may be important. At any given time there were large differences in moisture content between seeds of different hybrids, different plants of any one hybrid, and between different parts of the same panicle.

In winter of 1961-62 a firm producing hybrid sorghum seed provided a number of lots of seed with low germinability for testing. The seed had been grown in Nebraska. Microscopic examination of the embryos of the kernels revealed no obvious mechanical injury.

Kernels of all lots were surface disinfected by shaking for 1 minute in 2 per cent sodium hypochlorite, then were rinsed in sterile water and cultured on agar media designed to reveal the presence of field fungi and storage fungi. No storage fungi were found, but kernels of some lots yielded a variety of field fungi, principally *Alternaria, Cladosporium, Fusarium*, and *Helminthosporium*. It was thought that one or more of these fungi might have been partly responsible for the low germination of the seed. Just before harvest, a defoliant had been applied to the plants from which the seed came, and it was thought also that this might have injured the seeds. Another possibility was that the seeds had suffered mechanical injury during threshing. To test these ideas, the work here described was undertaken.

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Materials and methods of planting

Seeds of several hybrids of sorghum were planted June 12, 1963, in rows 132 feet long, the rows 3 feet apart, with two border rows on each side, on the research field of the Institute of Agriculture at the St. Paul campus of the University of Minnesota. The plants were irrigated by overhead sprinklers several times during the very dry period of midsummer. Plants developed well, and headed about August 1. In late August cages of chickenwire, each cage 4 feet wide, 10 feet long, and 6 feet high were erected over the plants to protect them from birds. The plants in one cage were sprayed with Maneb (Dithane M-22), 3 lbs/199 gal of water, plus 1.5 ml of Triton B-1956/gal as a sticker-spreader on 8/19, 8/26, 9/5, 9/12, 9/19, and 10/2/63. The aim of this spraying schedule was to reduce infection of the seeds by field fungi. The fungicide Maneb was chosen as a result of previous tests of a number of fungicides on barley, in which Maneb seemed to be about the most effective for this purpose.

The plants in one cage were sprayed with normal strength DEFOLATE when the moisture content of the seeds average 40 per cent. DEFOLATE is the trade name of a defoliant consisting of 41.5 per cent sodium chlorate and 58.5 per cent magnesium chloride. The directions with this material specified an application of 20 lbs./acre applied as a spray of 30 gallons/acre. The amount necessary to apply to the plants in each cage was calculated, and this amount applied with a hand sprayer. It is believed that the amounts applied agreed fairly closely with those specified dosages.

The directions also specified that the defoliant should not be applied until the moisture content of the seeds was about 30 per cent, since with a higher moisture content, some damage to the seeds might result. The purpose in applying DEFOLATE to plants whose seeds averaged 40 per cent moisture content was to evaluate such possible damage.

When the seeds reached an average moisture content of 30 per cent, plants in one cage were sprayed with double strength DEFOLATE, those in another cage with normal strength, and those in a third cage with half strength, to test the effect of different concentrations on subsequent germination of the seed.

Moisture checked after harvest

Moisture contents of seeds were determined several times by the two stage air, oven method (American Association of Cereal Chemists) before DEFOLATE was applied, and also several times afterwards, to determine the effect of DEFOLATE upon rapidity of drying of the seeds in heads on the plants. All were harvested on October 23, and at that time moisture contents were determined by Radson, Motomco, and Steinlite meters as well as by oven drying. In nearly all of these tests, seeds were collected from the tops of heads and from the bottom of the same heads and tested separately for moisture content, since observation indicated that the moisture content of seeds in the bottom portion of the heads might be considerably higher than the moisture content in seeds from the tops. If injury were expected from aplication of DEFOLATE to plants whose seeds had more than 30

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TABLE 1. Moisture content of sorghum seeds collected from top and bottom of plants at time of first application of DEFOLATE. 10/3/63.

Hybrid	Plant	Portion of head from which seed was collected	Moisture content	Average
			%	
GS-60	1	top	41.6	
		bottom	47.1	
	2	top	32.3	
		bottom	42.8	
		Average	41.0	
GS-70	1	top	35.2	
		bottom	47.9	
	2	top	39.0	
		bottom	44.6	
		Average	41.7	
RS-608	1	top	24.2	
		bottom	38.3	
	2	top	32.7	
		bottom	41.1	
		Average	24.1	39.2
		Range in moisture content		
		Within one hybrid (RS-608)	Among hybrids	
		24.2–41.1	24.2–47.1	

per cent moisture, the variation in moisture content between seeds in different portions of the heads presumably could be important.

The weather during the three weeks before harvest was consistently clear and warm, excellent for maturation of the seed. There was no frost up to October 23. At harvest the tops of all plants within the cages were cut off. A portion of the seed was removed by hand from the top and bottom of the heads, and seeds were removed from the top and bottom of heads by a small machine thresher. The seeds were stored dry in the laboratory, and the germination percentage tested after approximately one month.

In the germination tests the seeds were placed on moist towels. These were incubated in the refrigerator for five days, then incubated in the laboratory at room temperature. The number of germinated seeds was counted at intervals of three, five, seven, and ten days. Additional germination tests were made approximately two months later.

Differences related to moisture content

Moisture contents of the samples of sorghum seed are summarized in Tables 1-3. In all cases there was a great difference in moisture content between seeds from the tops of the heads and those from the bottom (Table 1). This difference was larger when the moisture content of the seeds averaged 30 to 40 per cent, than at harvest, when the moisture content averaged about 17 to 22 per cent. Even at harvest, however, the moisture content in seeds from the bottom of the heads was as much as 6 per cent higher than the moisture content in the seeds from the top of the same heads (Table 3).

Obviously, an "average" moisture content in sorghum

TABLE 2. Moisture content of sorghum seeds collected from top and bottom of heads of one hybrid. GS-60, after first application of DEFOLATE.

Date of seed collection	Plant number	Plants sprayed with DEFOLATE			Plants not sprayed with DEFOLATE		
		Top of head	Bottom of head	Aver.	Top of head	Bottom of head	Aver.
10/6/63	1	22.2	37.2		15.8	36.7	
	2	21.2	38.5		18.7	33.3	
	Average	21.7	37.9	29.8	17.3	30.3	26.3
10/8/63	1	21.6	32.6		19.2	41.7	
	2	17.4	33.4		16.4	34.9	
	Average	19.5	33.0	26.3	17.8	38.3	28.1
10/9/63	1	26.8			22.2		
	2	16.0			15.8		
	3	20.6			22.4		
	4	19.9			23.7		
	Average	20.8		20.8	21.0		21.0
10/11/63 (light rain previous	1	24.9	35.3		35.9	38.2	
	2	22.8	36.6		26.0	36.4	
evening)	Average	23.9	36.0	30.0	31.0	37.3	34.1
10/14/63	1	21.9	33.7		17.3	34.5	
	2	19.6	28.0		16.7	31.1	
	Average	20.7	30.8	25.8	17.0	32.8	24.9
10/16/63 (very light rain previous evening)	1	14.2	25.3		16.0	36.1	
	2	15.1	24.8		16.6	33.8	
	Average	14.7	25.0	19.9	16.3	35.0	25.6

seed may at times be a rather misleading figure. The Radson meter gave readings consistently lower than those obtained by oven drying Table 3). In one case (seeds from the bottom of the heads of plants to which no DEFOLATE had been applied) the moisture content as

TABLE 3. Moisture content of sorghum seeds collected from top and bottom of heads of plants of hybrid GS-60, 13 days after plants had been sprayed with DEFOLATE.

Treatment	Portion of head from which seed was taken	Per cent moisture content as determined by:			
		Radson	Motomco	Steinlite	Oven
No DEFOLATE	top	17.4	19.1	18.2	19.4
	bottom	21.5	over 24	24.9	25.4
	Average	19.4		21.5	22.4
DEFOLATE, double strength	top	15.6	17.4	16.6	16.9
	bottom	20.2	22.1	21.7	22.0
	Average	17.9	19.7	19.1	19.5
DEFOLATE, normal strength	top	15.0	17.5	16.7	17.0
	bottom	20.1	22.0	21.9	22.1
	Average	17.5	19.7	19.3	19.5
DEFOLATE, half strength	top	17.1	18.5	18.4	18.4
	bottom	21.1	23.8	22.9	23.4
	Average	19.1	21.1	20.6	20.9

TABLE 4. Germination percentage of sorghum seeds from plants sprayed with a fungicide and with DEFOLATE.

Treatment	Portion of head from which seed was collected	Germination percent after 7 days HYBRID RS-608	GS-60	GS-70	RS-501
Hand Threshed					
Maneb fungicide	top	83	94	86	94
	bottom	87	96	84	85
DEFOLATE applied 10/3	top	81	78	75	
	bottom	73	95	88	
DEFOLATE applied 10/9, normal strength	top	67	70	79	
	bottom	72	92	89	
Machine Threshed — only seeds appearing sound were selected for germination test.					
DEFOLATE, normal strength applied 10/9	top	53	50	54	
	bottom	42	39	45	
DEFOLATE, half strength applied 10/9	top	57	52	35	
	bottom	42	43	42	
DEFOLATE, double strength applied 10/9	top	62	44	45	
	bottom	50	42	45	
No treatment	top	43			
	bottom	36			

determined by Radson meter was 3 per cent lower than the moisture content as determined by oven drying. Moisture contents as determined by the Motomco and Steinlite meters were in fairly close agreement with readings determined by oven drying, and the agreement between the Motomco meter and oven drying was especially close.

Application of DEFOLATE did not result in much reduction in moisture content within 10 days (Table 2), but did result in somewhat lower moisture contents later (Tables 2 and 3). Other researchers have reported an increase in the rate of drying if desiccants are applied when the moisture content is 40-50 per cent, but when applied at moisture contents of less than 30 per cent, desiccants had little effect on the rate of drying (Alvey and Pendleton, and Bovey and McCarty).

The germination tests (Tables 4 and 5) suggest that

TABLE 5. Germination percentage of sorghum seeds from plants sprayed and not sprayed with a fungicide and with a defoliant and threshed.

Treatment and mode of threshing	Germination HYBRID GS-70	GS-60	RS-501
Hand Threshed	%	%	%
Maneb	91	94	
Defolate, normal strength 10/3	97	93	
Defolate, normal strength 10/9	93	91	
Defolate, half strength 10/3	91	89	
Defolate, double strength 10/3	94	85	
Control, no spray	95	99	99
Machine Threshed			
Defolate, half strength 10/3	59	63	
Defolate, double strength 10/3	60	69	
Defolate, normal strength 10/10	63	78	
Control, no spray	68	53	98

application of DEFOLATE may have slightly reduced the germination percentage of some samples, but not others. Bovey and McCarty reported that desiccation treatments did not appear to affect germination. Machine threshing greatly reduced the germination percentages of all but one of the lots. This single exception was seed from the hybrid RS-501, used as border rows. Moisture content of the seeds of this variety was not determined at the time of harvest, but the seeds appeared to be more mature and drier than those of the other lots, and this is probably the reason they were not damaged by mechanical threshing. Subsequent experience by the firm concerned indicates that hybrid sorghum seed produced in Texas, where the seeds mature well and are of low moisture content at harvest, are of uniformly high germination even when mechanically threshed.

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