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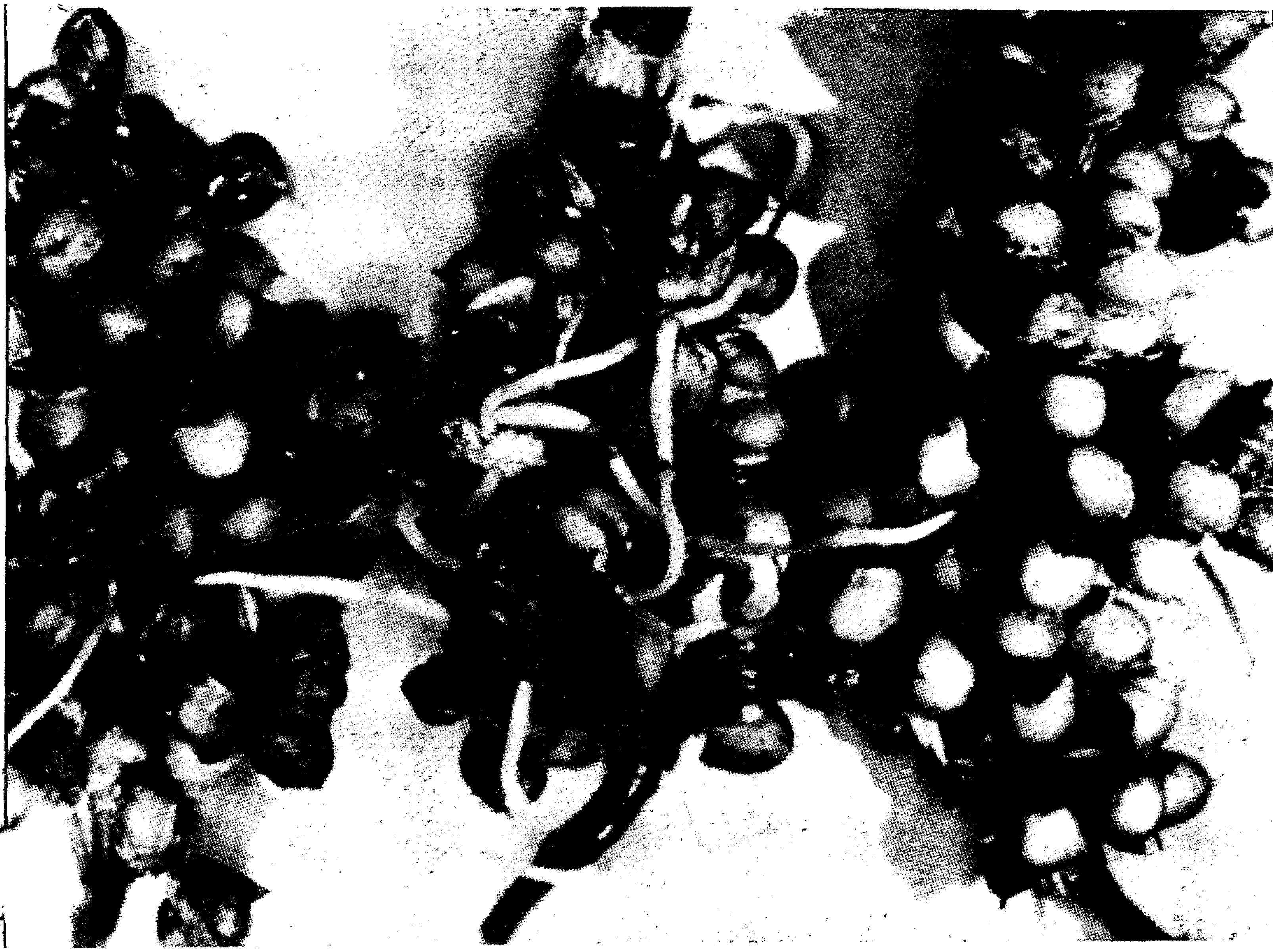
Weathered Sorghum Grain



The Texas Agricultural Experiment Station, Neville P. Clarke, Director
The Texas A&M University System, College Station, Texas

INTRODUCTION

Grain sorghum was first grown conunerc ia lly in the Coastal Bend area of Texas in the 1940's, and by the late 1960's it was the principal crop of South Texas. Planting exceeded 1.25 million acres in 1976, as sorghum was considered a secure row crop for the Coastal Bend area. If planted in late February or early March, it could be harvested before the sununer rainy season. Delayed planting for any reason increases the risk of preharvest weather losses.

In 1976, planting of many fields was delayed due to poor moisture. Soil moisture stress limited early growth, and below normal seasonal temperatures in May and June delayed grain sorghum maturity. Consequently, when heavy rains (12 to 16 inches) started in early July, 70 to 80 percent of the crop remained to be harvested.

Some earlier maturing hybrids were harvested before the sununer rains. But, unharvested grain was mostly hybrids susceptible to weather damage. Predominant damage was due to kernels sprouting in the seedhead and subsequently dropping to the ground. Following several days of dry weather, the kernel sprouts shriveled and became inconspicuous except upon close inspection. Some kernels mildewed and became discolored; however, only a small fraction was affected by mold to the extent that they rotted.

The quality of grain harvested after the extended torrential rains was questioned. Somewhat similar situations occurred in the sununers of 1968 and 1973 when about 25 percent of the crop was still unharvested.

However, the extent of sprouted grain was substantially less in those years than in 1976. The effect of periodic and long duration rains on quality of sorghum grain had not been investigated.

The Texas Agricultural Experiment Station and the Texas Agricultural Extension Service responded immediately by providing the best technical guidance that was available for producers and the grain industry. As a follow-up for many unanswered questions, Station scientists conducted laboratory studies and numerous feeding trials with poultry, dairy and beef animals, and swine. Research was conducted under a "crash program" at the Corpus Christi Center and by many scientists at the Main Station. The program received the support and backing of the grain industry and others who helped make these studies possible.

While preliminary research results were previously returned on an informal basis, this report was prepared to document the results and evaluations of weather-affected sorghum.

Neville P. Clarke
Director, The Texas
Agricultural Experiment
Station

RAINFALL RECORDS IN THE COASTAL BEND

Lucas Reyes

Normal distribution of the 28-inch annual rainfall (Table 1) favors grain sorghum production. The pattern of light rains during winter and early spring, normally 2 to 5 inches, provides good conditions for preparing the land, planting and establishing the crop. Heavier rainfall (4 to 6 inches) during late spring (May) and early summer (June) generally ensures maturity of a good crop. Harvesting takes place in the normally hot, dry month of July when only 1 to 2 inches is expected. However, wide deviations from the normal pattern sometimes occur as in 1976 (Table 1). During January, February and March there was no effective rain and farmers held off planting later than usual. During April and May rainfall was 73 and 81 percent, respectively, above average, but fell 38 percent below average in June. Then nearly seven times the average monthly total fell from July 5 to July 17 when three-fourths of the grain was still in the field.

Table 1. RAINFALL DISTRIBUTION AT CORPUS CHRISTI, TEXAS

Month	Average 1941-70	1976	Deviation from average in 1976	
	in.	in.	in.	%
January	1.58	0.13	-1.45	-92
February	1.95	T	-1.95	-100
March	1.10	0.07	-1.03	-94
April	2.15	3.73	+1.58	+73
May	3.17	5.73	+2.56	+81
June	2.67	1.02	-1.65	-38
July	1.88	12.98	+11.10	+590
August	3.20	0.79	-2.41	-75
September	4.90	5.67	+0.77	+16
October	2.77	6.09	+3.32	+120
November	1.63	3.85	+2.22	+136
December	1.53	2.90	+1.37	+90
TOTAL	28.53	42.96	+14.43	+51

Summary

Prolonged and excessive rainy weather at grain sorghum harvest time may not affect the feed quality of the grain harvested, but yield losses due to shattering and low grades and bushel weights will be sustained in varying degrees by the different genotypes. This was determined from a date of planting test and a performance test with 96 hybrids, both conducted in the Coastal Bend area in 1976 when a 12- to 20-inch, 3 week rainy spell occurred just as the grain sorghum crop was ready to be harvested. The adverse weather allowed plant breeders and plant pathologists an opportunity to observe and select breeding material with higher degrees of weathering and disease resistance.

EFFECT OF WEATHERING ON YIELD, GRADE AND PRICE OF GRAIN

Lucas Reyes and J. E. Matocha

The effects of weathering on acre yield and certain grain quality characteristics are shown in Table 2 for six selections planted at Corpus Christi in February and March and harvested before and after the severe weather period in 1976.

Weathering reduced the yield an average of 925 pounds per acre, or 25 percent for the February planting, and 532 pounds, or 14 percent, for the March planting. Considerable variation was observed among the selections, the percentage of loss ranging from 11 to 41 percent in the early planted and 3 to 21 percent in the late planted grain.

Since virtually no kernel damage and not more than 4.8 percent broken kernels were found in the grain harvested before the rains and bushel weight ranged from 56 to 60 pounds, all the grain graded No. 1 or No. 2 and was valued at $4.45 per cwt. Grain harvested after the rains contained from 9 to 85 percent damaged kernels with 4 to 27 percent broken kernels, and all except three samples showed test weights less than 55 pounds per bushel. Average reduction in test weight of the early planted grain was 5.3 pounds; that of the later planted was 6.4 pounds. All the weathered grain was "Sample" grade.

Counting all deductions for damaged kernels, broken kernels and reduced bushel weight, the reduction in grade brought the average price of February planted grain to $3.87 per cwt. and to $4.11 for the March planted grain. Losses to farmers were therefore considerably greater for the grain planted early ($57.04 per acre) than for that planted later ($34.44 per acre). Assuming a 50-50 ratio of early and late planted grain of these six selections in the million acres subjected to the severe weather period, the loss to producers was nearly 46 million dollars.

Although this was a staggering economic loss to the area, it could have been far greater had it not been for the high level of disease resistance possessed by the commercial plant materials as a result of earlier work by TAES plant breeders and plant pathologists. Anthracnose alone would have caused such a lodging problem that much of the crop could not have been harvested at all; however, due to breeding for good standability the crop was harvested. Individual producers reported 20 to 50 percent losses in yield from grain shattering and reduced test weight from kernels sprouting and molding in the seed head and additional losses due to the markedly lower price caused by lower grade. Test weights as low as 42 pounds per bushel and kernel damage as high as 94 percent were recorded.

Table 2. EFFECT OF WEATHERING ON YIELD, PRICE AND GRAIN CHARACTERISTICS AT CORPUS CHRISTI, 1976

Variety or selection	Av. acre yield, lbs.	Weathering loss, %	Price cwt.[1]	Grade	Damage kernel %	Broken kernel %	Bushel weight, lbs.
February planting harvested before rains:							
RS-626	3260		$4.45	No. 2	0	4.6	56.0
NK-266A	4200		4.45	No. 2	0	4.8	58.5
P-8311	3885		4.45	No. 1	0	3.7	58.0
G-577	3350		4.45	No. 1	0	3.0	58.0
TAM-680	3500		4.45	No. 1	0	2.8	58.5
WAC-692R	3785		4.45	No. 2	0	4.2	58.5
Av.	3663		$4.45				57.9
February planting harvested after rains:							
RS-626	2225	32	$3.77	Sample	30.0	27.0	47.0
NK-266A	3300	21	4.22	Sample	18.0	9.3	53.5
P-8311	3460	11	4.09	Sample	22.0	8.6	55.5
G-577	1975	41	3.19	Sample	85.0	4.7	51.5
TAM-680	2710	23	4.23	Sample	21.5	4.0	56.5
WAC-692R	2760	27	3.74	Sample	34.0	13.0	51.5
Av.	2738	25	$3.87				52.6
March planting harvested before rains:							
RS-626	3460		$4.45	No. 2	0	3.8	56.5
NK-266A	2775		4.45	No. 2	0	2.0	59.0
P-8311	3610		4.45	No. 2	0	2.0	59.0
G-577	3725		4.45	No. 2	0	3.0	59.0
TAM-680	3950		4.45	No. 2	1.0	2.0	60.0
WAC-692R	4625		4.45	No. 2	0	1.5	59.5
Av.	3690		$4.45				58.8
March planting harvested after rains:							
RS-626	2735	21	$3.33	Sample	78.4	6.0	49.0
NK-266A	2690	3	4.14	Sample	28.0	14.0	51.5
P-8311	3175	12	4.30	Sample	15.0	6.9	55.5
G-577	3260	12	4.25	Sample	18.0	8.4	53.0
TAM-680	3360	15	4.33	Sample	9.0	17.0	51.5
WAC-692R	3725	19	4.32	Sample	12.0	9.4	54.0
Av.	3158	14	$4.11				52.4

[1] Deductions: 1¢ for each lb. less than 55 lb. bushel wt. and 1¢ for each percent up to 50 percent damaged grain and 2¢ for each percent thereafter.

Summary

The grain of weathered sorghum has a dark, discolored external appearance and a dark, discolored germ. The protein matrix and starch granules inside the kernel are partially hydrolyzed by the enzymes of microorganisms and the grain itself. The extent of hydrolysis depends on the severity of weathering. The kernels are soft, weak and easily break into pieces during harvesting and subsequent handling. Cross sections of weathered kernels have a soft, floury appearance. Weathered kernels have decreased hardness, density, test weight and germination. The processing properties, handling characteristics and storage properties are altered. Provided the problem of feeding a dusty ration is avoided, the actual digestibility of weathered grain might be slightly enhanced because in a sense it is "pre-digested" in the field.

Genetic differences in resistance to weathering exist among sorghum lines. Research to develop nonbrown sorghums with resistance to field deterioration has identified lines with resistance, developed an understanding of possible mechanisms of resistance and led to the development of possible laboratory screening methods.

PHYSICAL AND STRUCTURAL PROPERTIES OF WEATHERED SORGHUM GRAIN

J. A. Glueck, L.W. Rooney, D.T. Rosenow, F.R. Miller and R. E. Lichtenwalner

Throughout the world sorghum grain frequently deteriorates in the ~field. The term "weathering" has been used to refer to this phenomenon in the United States whereas "seed molding" is often used in other areas of the world. "Field deterioration" may be a more appropriate term since both environmental and microorganism effects are involved.

Both sprouting and microorganism invasion result in breakdown of seed components. Deterioration is caused by the interaction of environment, microorganisms, enzymatic activity prior to and during germination, and characteristics of the grain and/or plant. Prolonged rainfall, high humidity, high temperature and alternate periods of wetting and drying, before and after physiological maturity of the grain, all favor deterioration. The kind of microorganisms and their growth rat~ as well as the initiation of kernel germination, are affected by environmental conditions. Significant losses from weatherin&which occurred on the High Plains of Texas in 1974,were caused primarily by invasion of the kernels by microorganisms while those in South Texas in 1976 were due to the combined effects of sprouting and microorganisms. High temperature during an extended period of rainfall accelerated the deterioration process in South Texas.

Sorghums are very diverse genetically. Certain plant and kernel characteristics provide resistance to field deterioration. These characteristics include:

1) open heads with the seed completely enclosed with long papery glumes (Murthy, 1975),

2) brown seed with high tannin content and a pigmented testa (Ellis, 1972; Harris and Burns, 1973; Murthy, 1975),

3) seed with thin, smooth, translucent pericarp (Leukel and Martin, 1943 and Ellis, 1972); and

4). corneous endosperm texture with normal endosperm type (Clark and Ellis, 1973).

Some of these characteristics are undesirable from either an agronomic or a quality standpoint. For example, brown sorghums resist deterioration but their high tannin content reduces digestibility and feed efficiency of the grain by livestock and produces undesirable color in food products. The open headed, long glume characteristic seems negatively related to grain yield, so it may not be useful in imparting resistance to the grain.

This report summarizes information concerning physical and structural changes that occur during deterioration. In addition, it documents that some sorghum lines with nonbrown pericarp, no seedcoat (testa) and normal endosperm are resistant to field deterioration.

CHANGES IN PHYSICAL PROPERTIES OF GRAIN

Grain weathering tests were conducted on a statewide basis in Texas during 1975 and 1976. The data in Table 3, taken from these tests in 1975, show typical changes that occur as grain deteriorates in the field.

Deterioration results from physical, physiological and chemical changes in the kernel causing breakdown of kernel structure and eventual loss of viability. Deteriorated grain is usually dark and discolored in external appearance, has a dark, discolored germ, and the inside of the kernel is chalky in appearance due to partial hydrolysis of starch and protein (Figure 1). When environmental conditions are favorable, sprout-

Table 3. MEAN AND RANGE OF MEASUREMENTS OF THE EFFECT OF DETERIORATION ON PHYSICAL PROPERTIES OF GRAIN FROM 25 SORGHUM LINES

	Test Weight,[1] lb/bu			1,000 K. Wt. g.			Density g/cc			Hardness[2]			Germination %		
	Lub	CS1	CS2	Lub	CS1	CS2	Lub	CS1	CS2	Lub	CS1	CS2	Lub	CS1	CS2
mean	62.6	58.6	55.5	27.8	25.7	25.0	1.36	1.36	1.35	22.9	22.3	20.0	94.6	78.2	32.0
minimum	56.3	51.9	47.3	20.3	19.3	17.9	1.27	1.29	1.29	0.5	1.8	2.7	86.5	33.0	2.3
maximum	65.0	62.2	58.5	37.8	32.8	33.5	1.39	1.39	1.37	33.7	34.9	30.6	98.5	93.0	75.3

[1] All lines were grown at Lubbock and College Station. Lubbock grain was essentially free of deterioration while grain from CS1 and CS2 had moderate to severe deterioration, respectively. No sprouting was observed.

[2] Hardness was determined by a standardized pearling procedure. The highest values have the greatest resistance to pearling which is an index of hardness.

ing may occur as in South Texas ih,,1976 (Figure 1, C and D). Among fifteen selections grown in the Corpus Christi test nursery and harvested after the l2-day rainy period, sprout damage was extensive in all; ranging from 38 to 100 percent (Table 4). In general} grains with highest sprout damage also had more mold damage and greater discoloration. Bushel weight of the line which showed the greatest degree of weathering was 42 pounds. Grain of the same line grown at a different location and harvested without weathering weighed 58 pounds. Although the percent of trash is regulated by combine conditions, weathered grain tends to be more "trashy", perhaps as a result of attempting to maximize the amount of grain harvested. The percentage of fines and broken kernels was also higher in the weathered grain.

	Nonweathered grain	Weathered grain
Bushel weight, lb.	58.0	42.0
Trash, percent	1.3	7.2
Fines, percent		3.8

Physical, physiological and chemical changes result in loss of dry matter and decreased test weight, 1,000 kernel weight, density and hardness of the grain (Table 3). Changes in physical properties can be explained by comparing scanning electron micrographs of ~ndamaged and deteriorated sorghum kernels (Figures 2 and 3). The endosperm is composed of starch granules surrounded by a matrix of protein and protein bodies. Starch and protein are closely associated especially in the outer layers of the endopserm, i.e. the peripherial and corneous endosperm area (Figure 2). Undamaged starch granules are spherical and have a smooth surface. In contrast, starch granules ofdeterio.rated grain ,show considerable pitting on the surface resulting from enzyme attack (Figure 3 D), and the protein matrix is weakened and partially hydrolyzed (compare Figure 3 Band C with Figure 2 B and C). The fungus mycelium, which appears as a

TABLE 4. VISUAL CHARACTERISTICS OF WEATHERED GRAIN

Grain #	Sprout damage[a] (1)	(2)	Total	Mold	Discolored
	%	%	%	%	%
1	50	8	58	5	75
2	40	12	52	15	50
3	80	20	100	35	75
4	70	15	85	35	75
5	90	10	100	15	75
6	40	20	60	5	25
7	45	55	100	25	75
8	40	20	60	15	50
9	85	15	100	45	45
10	80	20	100	85	100
11	60	40	100	25	50
12	50	20	70	15	25
13	60	20	80	20	25
14	70	25	95	20	50
15	30	8	38	5	25

[a] Sprout damage: 1) seed coat broken or sprout extended less than 1/8 inch; 2) sprout extended 1/8 inch or more. Total percent sprout damage is the sum of 1 and 2.

threadlike network, penetrated through the endosperm and partially hydrolyzed the protein and starch (Figure 3 B and C). Other enzymes are produced by the kernel itself during the initial stages of germination. The individual or combined action of the fungal and/or grain enzymes produces a softer kernel which may break when handled and produce fine particles when ground, micronized or rolled.

Chemical composition of weathered grain was not greatly different from that of nonweathered grain as indicated by average values for 12 lines grown at Corpus Christi and harvested before and after the deluge in 1976 (Table 5). Weathering decreased the proportion of crude protein and fat and increased crude fiber and ash; however, only the difference in ash was significant, and the variability among lines was quite great as indicated by the standard deviations. Nitrogen-free extract (NFE) and starch content were not affected. Other data have shown slight decreases in NFE and slight increases in protein, fat, ash and fiber as compared to nonweathered grain. In the latter case, it is felt that a portion of the soluble carbohydrates is utilized to provide energy for growth and development of the fungi and respiration of the grain so is lost as carbon dioxide and water. The protein may be partially hydrolyzed and used in synthesis of fungal protein thus remaining in the grain. Seed protein used in production of protein in the sprout mayor may not remain with the grain depending upon whether or not it dries, breaks off and falls or is blown away during harvest and cleaning operations. Slight losses of NFE relative to other grain components could explain the increased percentages of protein, ash, fat and fiber. It seems quite evident that the degree of weathering ranging from surface discoloration caused by microorganisms to extensive growth of mold and the penetration of the seed by mycelia accompanied by sprouting may have quite variable effects on composition.

TABLE 5. EFFECT OF WEATHERING ON CHEMICAL COMPOSITION OF SORGHID1 GRAIN

Grain[1]	Moisture	Nutrient, % Protein	Fat	Fiber	Ash	NFE
Nonweathered	13.9	10.7	3.1	2.3	1.7	82.3
Weathered	12.5	10.5	3.0	2.4	1.9	82.4
Weathered as percent of nonweathered						
Percent	89.9	98.1	%.8	104.4	111.8	100.1
Std. deviation	9.2	6.8	11.0	13.4	9.6	1.2

[1]Average of 12 lines grown at Corpus Christi.

It is possible that grain deterioration has a desirable affect on digestibility since endosperm components are partially hydrolyzed and therefore are more accessible to digestive fluids and enzymes. Reconstitution, a method of grain processing, is based on controlled autolysis of the grain prior to grinding which improves feed efficiency significantly. During reconstitution, oxygen is excluded and little dry matter is lost. In weather deterioration, reactions occur similar to those in reconstitution; however, since oxygen is present, dry matter is lost in the deteriorated grain.

SeZection of Sorghum Lines ,with Resistance to Deterioration

Although sorghums have been selected for improved resistance to grain weathering for several years, a formal, statewide testing program was initiated in 1975. Both resistant and susceptible lines, varieties and hybrids are included in the test which has the objectives of identifying weather resistant nonbrown sorghums and of determining why they are resistant.

Evaluating resistanc~ to grain deterioration depends upon conducive environmental conditions and may be confounded by differences in maturity and interactions of disease and insects. For example, some late planted or late maturing sorghum hybrids did not weather and sprout as severely as others in South Texas in 1976. They may not be genetically resistant, but merely escaped extensive deterioration because they were less mature and not exposed to the adverse environment for as long. Maturity must be considered in evaluating each line, or variety, for resistance to deterioration. Therefore, the grains in the weathering test are grown at a number of locations in Texas and are left in the field for extended periods to allow sufficient deterioration to permit selection.

Differences in ability of sorghum lines or varieties to resist field deterioration of the grain were apparent (Table 6). The susceptible checks, Tx2536 and SC414-12E, showed the greatest deterioration at most locations, whereas SC279-14, SC748-5, 74PR759, SC566-14, BTX-398, and SCI03-12 were consistently ranked as the more resistant lines. The locations presented in Table 6 provide a comparison of relatively undamaged grain (Lubbock) with moderately (CSI) and severely (CS2) damaged grain at College Station.

In general, subjective field ratings provide a reliable index of deteripration although the Lubbock samples were ranked too high relative to those at College Station. This probably occurred because some staining detracted from the appearance of the Lubbock samples, but little deterioration occurred in test weight, germination or kernel structure. Considerable deterioration undoubtedly occurs prior to physiological maturity. Grain of College Station first harvest showed lower germination, test weight and subjective field ratings than the graln harvested at Lubbock. Plants at College Station were tagged at mid-bloom, and physiologically mature grain was harvested at time of black layer formation (35-40 days past 50% bloom).

By 30-45 days after physiological maturity, the susceptible checks were severely deteriorated and vast differences existed among the other lines. For instance, only BTX398 and the brown seeded SCl03-l2 had greater than 50% germination. The brown grain contained high levels of tannins which undoubtedly contributed to the resistance of SCI03-12. BTx-398, however, has a reddish-brown pericarp and is not extremely high in tannins. Careful interpretation of these data reemphasizes the_multiplicity of factors affecting grain deterioration and that all grains will deteriorate with prolonged exposure to inclement environment.

Table 6. THE EXTENT OF GRAIN DETERIORATION AMONG DIFFERENT SORGHUM LINES AND VARIETIES1)

Line	Test Wt.2:./ lb/bu			Field Rating3/			Germination4/ %			Conductivity5/ uMohs/g			H2O UPtake~/ g/g		
	Lub.	CSI	CS2	Lub.	CSI	CS2	Lub.	CSI	CS2	Lub.	CSI	CS2	Lub.	CSI	CS2
SC748-5	64	59	56	1.4	1.5	1.6	97	81	32	9	12	19	.14	.14	.24
TAM428	65	60	55	2.1	1.8	3.8	95	57	13	10	19	27	.13	,.15	.24
SC279-l4	64	60	57	1.2	1.1	1.2	96	93	30	10	8	15	.10	.11	.17
SC566-l4	64	60	56	1.4	1.5	2.2	94	78	32	12	16	17	.11	.13	.20
74PR759	61	58	56	1.7	1.4	1.7	95	81	39	11	21	22	.12	.14	.20
SC97-l4	64	60	56	1.5	1.7	2.5	95	79	17	11	10	18	.12	.12	.22
SC283-l4	65	62	58	1.5	1.8	2.5	95	88	36	8	8	11	.10	.10	.15
SCI03-l2	56	57	54	1.2	1.0	1.4	90	89	75	19	15	18	.20	.18	.24
BTx398	64	60	57	2.2	1.8	2.6	97	86	60	7	9	12	.11	.11	.17
NK233	64	61	59	1.6	1.4	2.2	98	92	33	8	10	13	.09	.10	.16
Tx2536	64	52	47	2.6	2.8	5.0	93	33	2	19	33	39	.13	.20	.38
SC4l4-12E	62	59	54	2.9	1.9	4.0	96	83	10	17	26	34	.17	.18	.29

~l/ - Lub.-Lubbock; CSI - College Station harvested at physiological maturity; CS2 - College Station harvested 65-70 days post physiological maturity. The Lubbock grain had very little deterioration whereas CSI and CS2 had moderate and severe deterioration respectively. Days to 50% bloom indicated that any real differences in maturity should have favored the more susceptible lines since they matured later and were subjected to the weather for a shorter time.

l/Test weight was on cleaned grain, free of glumes. Original grain samples (comparable to combine run) were 2-8 lbs/bu less.

l/Subjective field rating of grain - 1.0 no grain discoloration or damage and 5.0 - grain entirely discolored, germ dead, endosperm chalky.

i/Standard germination procedure consisted of 4 reps of 100 seed placed in rolled paper towels for 7 days at alternate 20-30C temperatures.

i/ixpressed as the difference of 60 and 15 minute readings in uMohs/g seed. Measurements are the mean of 2 reps. 100 seed were steeped in 25.0 mI. distilled, deionized water and conductance was meausred with a conductance meter.

~/Grams of water taken up per g. seed at 75 minutes or termination of the seed leachate tests.

A number of mechanisms for resistance are suggested by the reaction of the various lines to similar environments. A key to understanding grain deterioration appears related to the rate of water uptake by the kernel. The primary entry of water and fungus into the kernel appears to be via the black layer (hilum area) with subsequent movement into the grain and endosperm via the cross and the tube cells. Initial colonization of fungus appears primarily in the scutellum area with movement into the adjacent endosperm tissue. Several lines appear to resist the initial attack of the seed by microorganisms, for example SCI03-12 and BTx398. Other lines like SC279-14, SC748-5 and 74PR759 lost viability (low germination) yet the endosperm was not severely damaged. Thus, value of the grain for feed would not be greatly affected. Better measures of grain deterioration than germination are needed.

The rate of water absorption and the conductivity of seed leachates appear to be related to the extent of grain deterioration and may be useful in predicting the inherent ability of a sorghum line to resist grain deterioration. The susceptible lines appear to have more rapid water uptake and higher conductivity of seed leachates than the resistant lines (Table 6) although differences in pericarp thickness, kernel size and other kernel characteristics affect these values. Water absorption and leachate tests may be useful as preliminary screening methods.

Future Developments

Experimental hybrids, using resistant lines as parents, exhibited better resistance to deterioration than commercial hybrids in South Texas in 1976. Nonbrown sorghum lines resistant to molds have been identified by personnel at the International Center for Research in the Semi-Arid Tropics in.India. Several of these lines have been included in the breeding program and will be available for U. S. sorghum improvement.

The ultimate output from this work will be nonbrown sorghum hybrids with much better resistance to field deterioration. Such grain will have optimum digestibility and quality. These new hybrids may not be as resistant as comparable brown hybrids, but they will be better accepted by importers and users of sorghum.

REFERENCES

Clark, L. E. and E. B. Ellis. 1973. Evaluation of selected sorghum lines for weathering resistance. Grain Sorghum Res. Utile CoL Bienn. Program. 8th:66-70.

Ellis, E. B. 1972. Morphological Characteristics in relation to seed deterioration in sorghum. Masters thesis: Texas A&M University, College Station, Texas. 51 pp.

Harris, H. B. and R. E. Burnes. 1973. Relationship between tannin content of sorghum grain and preharvest seed molding. Agron. J. 65(6) 957-959.

Leuke1, R. W. and J. H. Martin. 1943. Seed rot and seedling blight of sorghum. U. S. Dep. Agr. Tech. Bull. 839. 26 p.

Murthy, D. S. 1975. Development of early and mou1dfree grain sorghum. Informal report: International Center for Research in the Semi-arid tropics. April.

Description of Plates:

Figure 1. Light photomicrographs of undamaged and deteriorated sorghum kernels.

A. Undamaged, whole and half kernels with yellow endosperm, intermediate texture. CE, corneous endosperm; FE, floury endosperm; OP, surface of the pericarp. ca. 4.0x.

B. Undamaged, half kernel with yellow endosperm, intermediate texture. S, scutellum; EP, epicotyl, radical and coleorhiza of germ, ca 6.4x.

C. Whole and half kernels with normal, intermediate texture and sprout damage. EP, epicotyl which has emerged from seed; R, elongated radical, ca. 4.0x.

D. Half kernel of grain with sprout and microbial damage. DG, damaged germ. ca. 6.4x.

E. Whole and half kernels with yellow endosperm, intermediate texture and severe damage, ca 4.0x.

F. Half kernel with yellow endosperm, intermediate texture and severe damage ca. 6.4x.

Figure 2. Scanning electron photomicrographs of undamaged yellow endosperm, intermediate texture sorghum kernels.

A. Endosperm cross section: P, pericarp; AL, aleurone cell layer; PE, peripherial endosperm; CE, corneous endosperm. ca. 200x.

B. Corneous endosperm area: SV, starch void; SG, starch granule. ca. 1,000x.

C. Protein and starch of corneous endosperm. PM, protein matrix; PB, protein bodies; SG, starch granule. ca. 2,000x.

D. Starch of floury endosperm. ca. 4,000x.

Figure 3. Scanning electron photomicrographs of deteriorated yellow endosperm, intermediate texture sorghum kernels.

A. Endosperm cross section: P, pericarp; AL, aleurone cell layer; PE, peripheral endosperm; CE, corneous endosperm; FE, floury endosperm. ca. 200x.

B. Corneous endosperm area. PB, protein body; FM, fungus mycelium; SG, starch granule. ca. 1,OOOx.

C. Fungus, protein and starch of corneous endosperm. ca. 2,OOOx.

D. Starch of floury endosperm. ca. 4,OOOx.

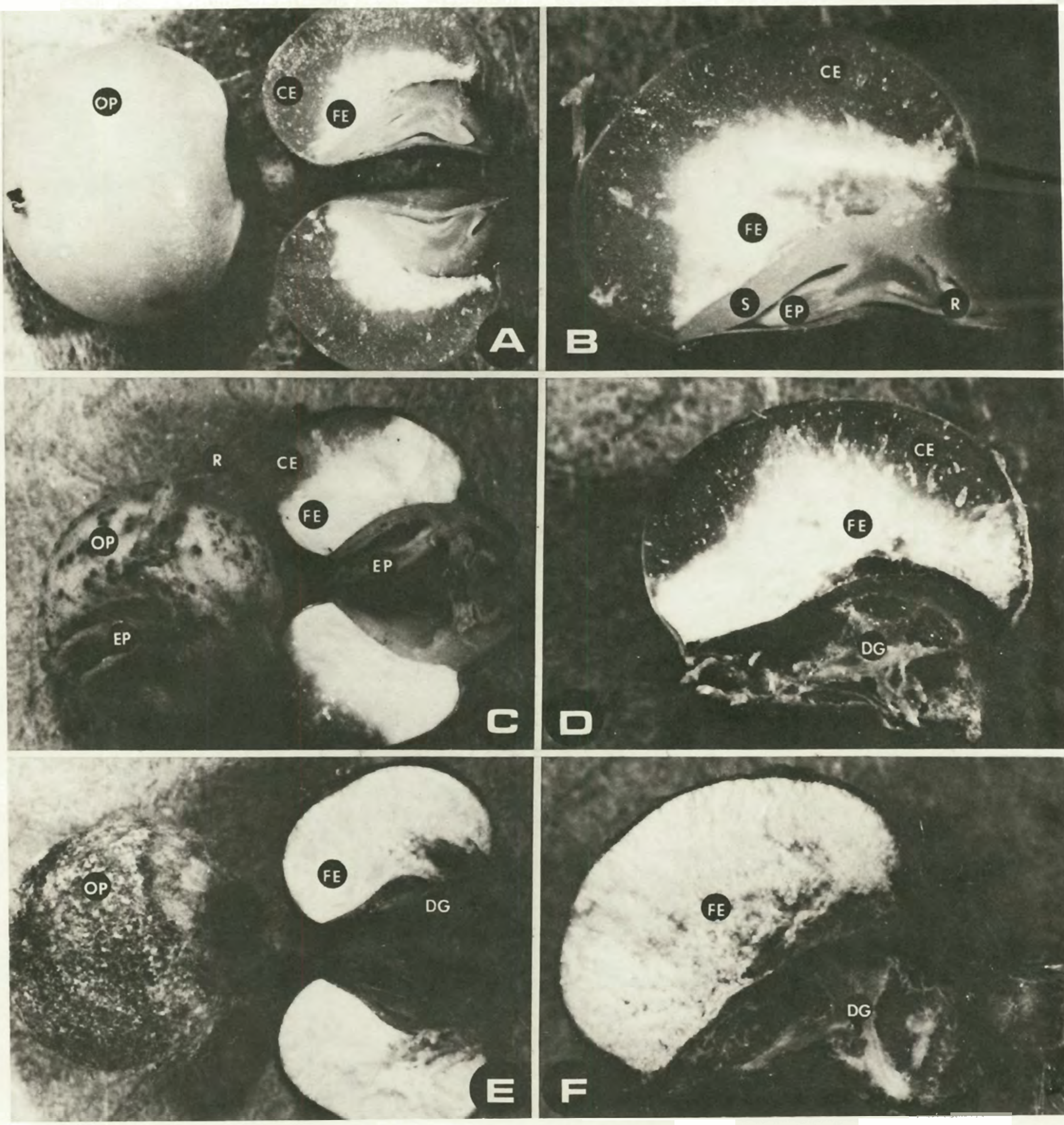


Figure 1. Light photomicrographs of undamaged and deteriorated sorghum kernels.

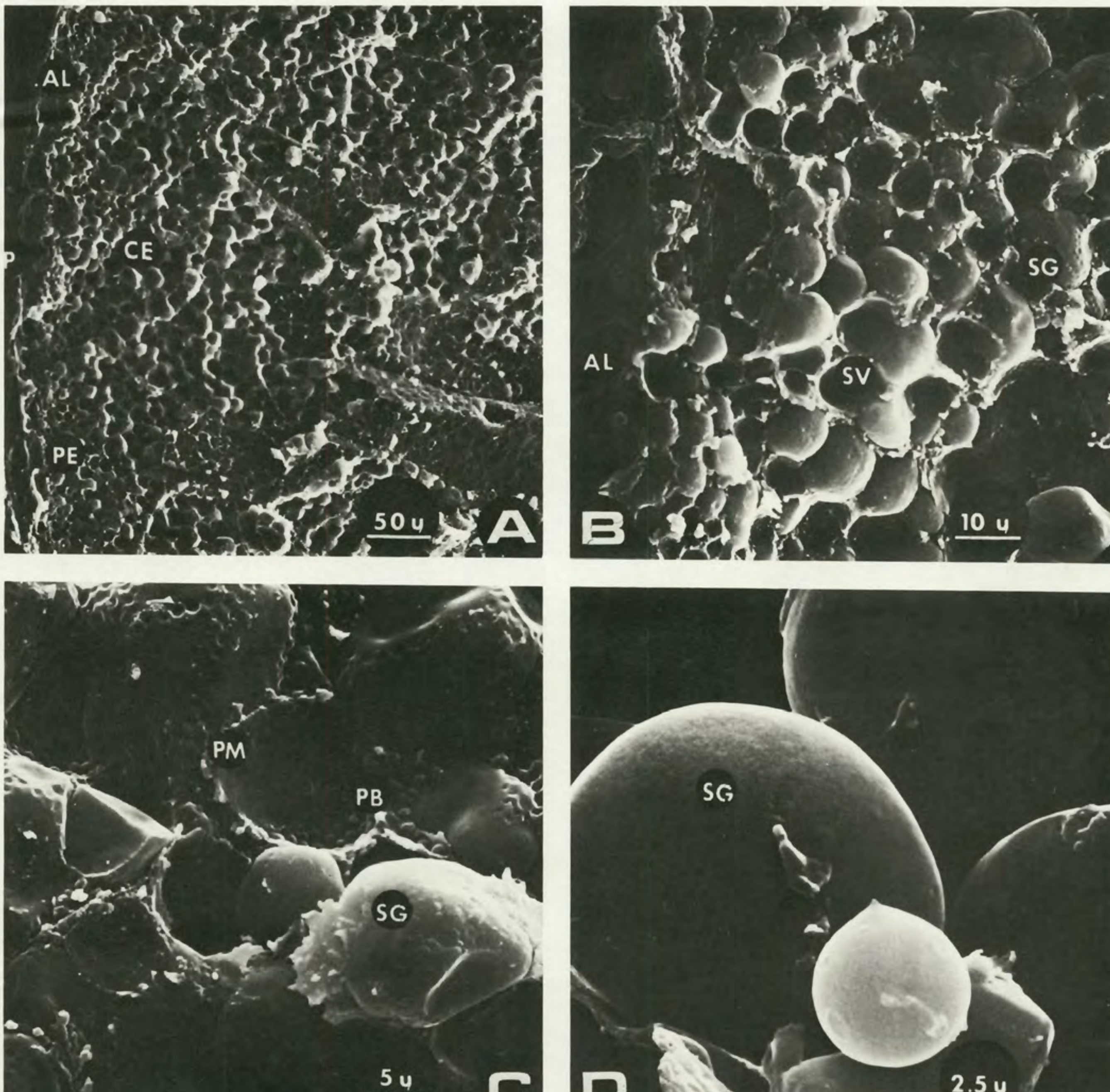


Figure 2. Scanning electron photomicrographs of und[redacted]aged yellow endosperm, intermediate texture sorghum kernels.

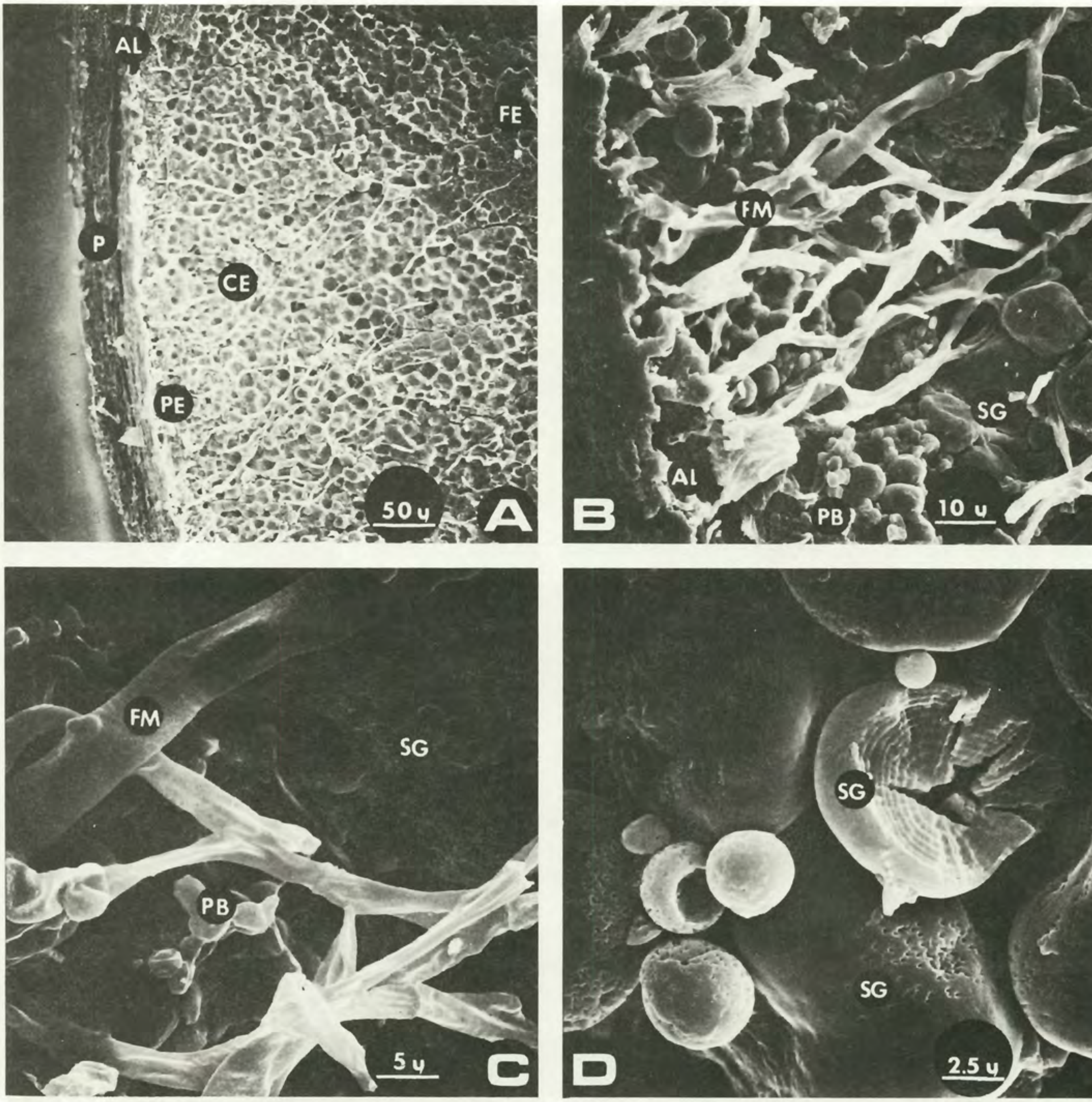


Figure 3. Scanning electron photomicrographs of deteriorated yellow endosperm, intermediate texture sorghum kernels.

Summary

Sorghum seeds from grain elevators in the Beeville - Corpus Christi-adem area, a region of the state where severe mold damage ("weather damage") occurred, were examined for the presence of toxin producing molds. Seeds were surface disinfested and plated on selective nutrient media. The kinds and numbers of molds growing from these seeds were identified and their frequency of occurrence recorded. All seeds examined from the weather damaged sorgh um samples contained one to several di fferent fungi. The most commonly detected fungi were members of the fungal genera Fusarium and Alternaria, which infested up to 60% of the seeds in a given lot. Several of these fungi produce potentially poisonous toxins. The aflatoxin-producing fungus, Aspergillus flavus, was detected in 1 percent of the sorghum seeds. The incidence of Aspergillus flavus in the blended feed used in the poultry study was high. The scope of this project did not include chemical analyses of the grains and mixed feeds for mycotoxins.

An examination of sorghum cultivar seed from research plots harvested before and after the adverse weather revealed that many of the fungi had already become established in the sorghum before the adverse weather. Once warm damp conditions persisted in the field, these fungi became quite active and severely damaged the seeds.

The observations indicate that considerable risk may be involved in using weather-damaged grain sorghum in human or animal foods or feeds.

FUNGI INVOLVED IN THE DETERIORATION OF GRAIN SORGHUM

Robert E. Pettit and Ruth Ann Taber

The role of fungi in the deterioration of grain sorghum has long been observed in the field, within transport containers, and within storage facilities. The discovery of mycotoxins (poisonous metabolites produced by fungi) in grain sorghum has necessitated evaluation of fungal deterioration and possible serious implications. Reports of problems in the growth and reproduction of animals fed moldy grain sorghum and the large volume of damaged grain sorghum harvested in South Texas in 1976 have prompted the following studies.

The extent to which grain sorghum is damaged by fungi and the degree to which these grains are contaminated with mycotoxins are dependent on several factors. Some of these factors are the climatic conditions under which the grain is produced; sorghum variety planted; availability of nutrients for plant growth such as calcium; plant stress during the maturation of the grain; and conditions under which the grain is harvested, transported and stored. One major factor influencing fungal growth in grain sorghum within the field is the moisture content of the heads prior to harvest. Periods of damp or wet weather can provide ideal conditions for the development of the many fungi capable of growlng on the grain. Many different fungi are capable of growing on the grains. The fungal type which is most active at any time is dependent upon the indigenous fungal population, moisture levels of the graln, temperature, atmospheric humidity, and physiological characteristics of the grain.

Procedures

Sorghum seed samples examined during these studies came from two areas of Texas. The initial samples came from grain sorghum used in feeding trials. The damaged sorghum came from grain elevators in the Beeville - Corpus Christi - Odem area. The higher quality grain sorghum, less severely damaged by fungi, was obtained from the fields along the Brazos River near College Station, Texas. In addition, sorghum seeds of 39 different cultivars grown near Corpus Christi were examined in order to determine if significant differences occurred between cultivars. Seed of each cultivar was harvested before and after the adverse weather conditions.

Isolation studies were primarily directed toward determination of the types of fungi present within the seeds and the extent to which anyone type of fungus predominated. Fifty seeds of each seed sample were washed in sterile distilled water to physically remove a major portion of the debris, subjected to a wetting agent, washed in a disinfestant (sodium hypochlorite) for 3 minutes and rinsed in sterile distilled water to terminate the activity of the chlorine. Following disinfestation the seeds were placed on a nutrient medium containing bacterial inhibitors and salts in order to selectively isolate the fungi present. Three or five replicate plates were prepared for each sample. Ten seeds were placed on each plate and the plates incubated at a temperature of from 23 to 27 C for 7 to 10 days. Following incubation, each fungal type observed growing from the individual seeds was identified (Table 7).

In addition to examination of the internal fungal population some efforts were directed toward measuring the fungal population associated with the external portion of the grain and type infestation of bulk feedstuffs following grinding and blending with other ingredients. These platings were made by using the serial dilution technique where the final dilution of 1:100 was mixed in warm nutrient agar immediately following pouring. Again these plates were incubated and the individual type of fungal organism recorded.

Results and Discussion

Isolation studies of the intact seeds used in the feeding studies, both those heavily damaged seeds from South Texas and the less severely damaged seeds from the Brazos bottom, were 100% infested with various fungi. In the case of the heavily damaged seeds, a large percent of these had germinated and were discolored. The discolored seeds from South Texas were obviously heavily damaged by fungi.

A comparison of the fungi present within both the heavily damaged grain and the less heavily damaged control grain revealed that significant differences occurred in the incidence of various fungi and the concentration of certain species. Also it was noted that damaged grain sorghum samples from different elevators in South Central Texas contained fungi of different kinds and concentration. For example, one sample contained seeds with fungi classified within the genera Phoma, Epicoccum, Rhizopus, Helminthosporium and Fusarium moniliforme. None of these fungi occurred in a sample from another area. These results indicate that it would be impossible to generalize about incidence of any kind of fungus in any one sample and the possibility of contamination with certain poisonous mycotoxins. The only way to obtain this information would be to both plate out the seeds on nutrient agar and analyze the grain chemically for the presence of various mycotoxins.

Grain sorghum from the Odem elevator, heavily damaged by fungi, contained a high incidence of Alternaria, Curvularia, Fusarium semitectum and Aspergillus glaucus. The less severely damaged grain from the Brazos bottom contained a significant level of Alternaria, Olpitrichum, Helminthosporium, Fusarium and Phoma. The incidence of Aspergillus flavus in the whole grain samples was quite low, less than 1%; however the incidence of Aspergillus flavus within the blended feed was quite high. Evidently the ingredients used to mix with the grain sorghum contained a significant level of Aspergillus flavus, particularly in the poultry feed sampled. Some of the weathered grain sorghum samples contained a high incidence of Fusarium moniliforme.

Several fungi found within the grain sorghum samples are mycotoxin producers. The most serious of these are Aspergillus flavus, Fusarium moniliforme and Alternaria alternata. The fungus Aspergillus flavus produces one of the most poisonous substances known, aflatoxin, a member of a group of mycotoxins which cause liver cancer and many other problems in animals and man. Fusarium moniliforme is capable of producing several mycotoxins, one of the most serious of which is zearalenone. Zearalenone is an estero genic toxin capable of interfering with the normal reproductive processes in poultry and other farm animals. Alternaria alternata produces a series of toxins called alternariol, altenuene, tentoxin, altenin, alternaric acid, etc. Studies concerning these toxins are relatively new and the extent of damage to animals caused by these chemicals is uncertain at this time. Other fungi isolated from the grain sorghum also produce mycotoxins; however, most of these occurred in lower concentrations. The potential still exists that some of these fungi may be producing potentially serious poisons.

Feeding damaged grain to various animals would only cause obvious external symptoms when the mycotoxin concentration was quite high. Since many of these mycotoxins are transported to the liver, kidneys and other organs of the anima~ it is likely that these animal parts may be contaminated long before other symptoms become obvious. The scope of this proj ect did not include the chemical analyses of the grains and mixed feeds for the presence of all the potential mycotoxins. Such a procedure would have been very expensive and required a chemist with considerable knowledge of the differences between various mycotoxins and the methods to prove their presence. Hopefully within 'the near future such tests can be conducted on grains suspected of containing various mycotoxins. Such efforts would require addition of new staff and additional funding for the facilities needed.

The preferred method for control of the mycotoxin problem is prevention. Once the grain becomes contaminated it is difficult to utilize such material without running some risk. In order to obtain some preliminary information about the presence of fungi within seeds of various cultivars 78 grain samples were examined. Of these samples only 5 contained seeds which were free from fungal infestation. All of these clean seeds occurred within grain samples collected before the adverse weather conditions. The percent clean seeds in each cultivar were as follows: WAC692R Feb (47% clean), G577 Feb (43% clean), TAM680 Feb (40% clean), RS626 Feb (40% clean), and TAM680 Mar (17% clean). All other seeds from each of the cultivars were 100% infested with fungi before and after the adverse weather conditions.

Alternaria was the most common fungus isolated from seeds. Up to 80% of some seed lots contained seeds infested with this fungus (Table 7). In fact, seeds of all cultivars except Pioneer 8311 contained a high incidence of Alternaria before the adverse weather conditions set in. Seeds harvested from the Brazos bottom near College Station also contained a high incidence of Alternaria.

The most significant increase in fungal infestation following the onset of adverse weather conditions was the increased incidence of the Fusarium species. In many cases the isolation frequency of the Fusarium species from weathered seeds was double that from the nonweathered seeds. It should also be noted that some Aspergillus flavus was detected in the grain sorghum seeds harvested before the adverse weather but that none of the severely damaged seeds contained Aspergillus flavus. These observations reveal that the environmental conditions which occurred during the extremely damp weather were unsuitable for the continued development of Aspergillus flavus. This fungus prefers intermediate moisture levels in order to grow and compete with other fungi. Other environmental con-

Table **7.** DEGREE OF FUNGAL INFESTATION WITHIN SEED OF GRAIN SORGHUM CULTIVARS BEFORE AND AFTER ADVERSE WEATHER CONDITIONS IN SOUTH TEXAS DURING 1976

Cultivar	*Fusarium* species %		*Fusarium moniliforme* %		*Alternaria* species %		*Aspergillus flavus* %		*Aspergillus niger* %		*Helminthosporium* group %		*Phoma* species %		*Curvularia* species %		Others %		Germination %	
	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW1	W2
McGregor Big 68	27	60	3	0	53	37	0	0	7	0	3	0	0	0	7	7	6	13	23	63
Oro DR	43	40	6	0	23	0	13	0	20	47	0	0	3	0	7	0	16	0	43	16
NS 8,000 DM	33	47	0	3	53	43	0	0	6	0	3	0	13	6	0	13	10	3	30	53
Grainmaker 200	20	73	0	13	67	0	0	0	0	0	0	37	6	3	7	7	10	0	57	10
NK 262	40	53	0	6	37	57	3	0	3	0	10	0	3	6	7	7	10	6	47	33
G522	63	57	0	10	20	30	6	0	0	0	0	10	10	6	3	10	6	6	30	20
Tx Triumph 2-68D	10	47	3	13	57	57	0	0	6	0	3	0	6	16	7	3	0	6	40	40
TE Hondo	27	63	0	15	60	13	0	0	0	0	0	0	10	6	0	3	0	13	70	63
PAG 662	77	70	0	10	27	-33	3	0	0	0	0	0	0	6	0	0	0	0	10	10
I GSA 1180	0	37	0	0	67	37	0	0	6	3	6	0	0	0	0	0	20	13	47	43
~TE Total	80	33	0	10	6	57	0	0	0	3	10	0	0	0	0	0	13	10	6	23
I Topaz	67	70	0	0	40	30	0	0	0	3	6	0	3	6	0	0	0	13	13	20
AG 616	6	23	0	0	53	80	0	0	0	0	3	0	0	6	10	0	0	10	43	47
WAC 692	23	47	3	10	40	57	0	0	0	0	0	0	6	0	0	0	23	6	10	50
Wilstar 1350 DM	20	70	10	10	53	47	0	0	0	0	0	3	0	3	7	0	16	3	30	63
WAC 694R	10	23	6	0	70	0	0	0	0	0	0	0	10	0	3	13	6	0	53	27
P 8311 (Feb.)	0	10	0	0	80	60	0	0	0	0	0	6	0	16	0	3	0	10	73	43
P 8311 (Mar.)	27	37	0	0	53	53	0	0	0	0	0	6	0	0	0	7	0	10	53	47
G577 (Feb.)	0	43	0	6	37-	43	0	0	0	0	0	6	6	6	3	7	0	6	93	13
G577 (Mar.)	3	27	0	0	40	67	2	0	0	0	0	0	0	3	0	3	3	6	67	60
Tam 680 (Feb.)	0	43	0	6	33	50	0	0	0	0	0	6	3	10	7	10	16	3	73	13
Tam 680 (Mar.)	6	43	0	6	60	57	0	0	0	0	0	6	0	3	0	7	10	0	73	33
WAC 692R (Feb.)	3	63	0	13	30	30	0	0	0	0	3	6	0	6	7	0	16	3	80	20
WAC 692R (Mar.)	27	70	0	0	60	43	0	0	0	0	3	0	0	0	0	0	6	0	70	7

Cultivar	Fusarium species %		Fusarium moniliforme %		Alternaria species %		Aspergillus flavus %		Aspergillus ni~~ %		Helminthosporium group %		Phoma species %		Curvularia species %		Others %		Germination %	
	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
Acco R 1090	27	70	0	16	70	53	0	0	0	0	3	0	0	0	0	6	0	6	30	13
RS 626 (Feb.)	0	70	0	16	27	20	0	0	0	0	13	3	0	16	6	6	10	23	75	10
RS 626 (Mar.)	10	60	3	3	47	37	0	0	0	0	6	0	0	3	3	3	23	0	43	23
DeKalb D42	13	43	3	0	60	67	0	0	0	0	0	3	0	0	6	3	20	6	10	63
Pioneer 846	40	40	0	6	37	70	0	0	0	0	3	0	0	0	0	3	10	0	20	23
Pioneer 8311	10	23	0	3	0	75	10	0	0	0	0	3	3	3	0	6	6	3	53	60
Pioneer 8308B	67	63	0	0	40	50	0	0	0	3	0	0	0	3	0	0	10	6	27	13
NK 266A (Feb.)	3	40	0	3	47	50	6	0	0	0	6	0	0	3	0	3	10	6	87	57
NK 266A (Mar.)	16	43	3	0	75	53	0	0	0	6	0	3	3	3	0	0	0	6	53	37
Tophand	NS	20	NS	6	NS	63	NS	0	NS	3	NS	3	NS	0	NS	0	NS	6	NS	*57
Warner W866	9	NS	0	NS	23	NS	0	NS	0	NS	0	NS	0	NS	0	NS	6	NS	2	NS
McNair 650	NS	87	NS	0	NS	37	NS	0	NS	0	NS	6	NS	3	NS	0	NS	6	NS	6
Funks 589	NS	50	NS	6	NS	40	NS	0	NS	0	NS	0	NS	0	NS	0	NS	b	NS	43
Acco DR 1095	27	NS	6	NS	75	NS	0	NS	0	NS	3	NS	6	NS	0	NS	3	NS	75	NS
DeKalb	NS	53	NS	3	NS	37	NS	0	NS	0	NS	0	NS	23	NS	6	NS	6	NS	40
Average %	24	49	1	5	46	44	1	0	1	2	2	3	3	5	3	4	8	6	46	33

1non-weathered (35 samples)
2weathered (37 samples)
*no sample

ditions could have been more suitable for the growth of Aspergillus flavus and aflatoxin production.

.Several fungal species isolated from the sorghum seeds were classified within the genus Aspergillus.. These were Aspergillus niger, Aspergillus glaucus, Aspergillus flavus, Aspergillus ruber, Aspergillus ochraceus, and Aspergillus chevalieri. Other fungi found within the grain sorghum seeds included species of Curvulvaria, Pennicillium, Cladosporium, Helminthosporium, Cephalosporium, Macrophomina, Phoma, Xylaria, Trichothecium, Rhizopus, Olpitrichum, Epicoccum, Chaetomium, Goatobotryum, Periconia, and Macrophomina.

It was evident that sorghum seeds from some cultivars were less severely damaged by fungi. These data are in agreement with other data reported in other publications. EV1dence has been presented in several publications that grain sorghum seeds can be severely infested with various fungi. Reports from Kansas have revealed that sorghum seeds infested with Alternaria alternata contain the mycotoxin alternariol. The data also revealed that the amounts of alternariol increased in concentration as the degree of mold damage increased.

From the isolation studies conducted on the grain sorghum it is evident that there is a high probability that one to several mycotoxins occur within the grain. When such grain is fed in a ration containing high levels of protein it is possible to overcome some of the poisonous effects of the mycotoxins. Also, when such mold damaged grains make up only 20 to 40% of the diet, the levels of mycotoxins are in levels where it would take l~nger to detect changes in the growth and reproductive processes in animals. It is theorized, on the basis of the isolation frequency of the various fungi, that very little aflatoxin was present within the mold-damaged grain sorghum. It is likely that some of the toxins produced by the _Fusarium_ and _Alternaria_ species may be present within the grain. It should be noted that toxins of these fungi cause less severe damage than aflatoxin in comparative tests using laboratory test animals.

An examination of the blended feeds used in the feeding trials revealed a high incidence of various fungi including _Aspergillus flavus._ These observations indicate that the other feed ingredients could have contained a high incidence of _Aspergillus flavus_ or the mixing equipment was contaminated with a heavy spore load of the fungus. Many reports have indicated that a high buildup of _Aspergillus flavus_ occurs in mixing facilities. Generally such infestations cause minor damage as long as the grain is protected from atmospheric moisture in the form of high relative humidity, wind-blown rain, or leaks in the storage facilities. With such high spore concentration~ it could be possible to have the mixed feed contaminated with aflatoxin even though the mixing ingredients were found to be free from aflatoxin.

In summary it is evident that extreme caution should be used in feeding grains of any type which have become excessively moldy. A mass of data is available to indicate that the chances of mycotoxin contamination are quite high and that high levels of several different mycotoxins can cause abnormal growth and that reproductive processes within the animal can be altered significantly. The severely molded grain harvested in South Texas during the 1976 growing season contained several fungi which are mycotoxin producers. No chemical analyses were made on the grain to determine the presence of the different mycotoxins.

Summary

Diets containing varYlng levels of weather-damaged milo were fed to broilers, turkeys and laying hens. Diets in which 0, 10, 25, 50, and 100 percent weathered milo from two sources (both moldy and sprouted) replaced No. 2 Milo produced no significant adverse effects on body weight or feed conversions of broilers in two experiments. Turkey poults fed diets ln which 0, 33, 67 and 100 percent elevator-run weathered grain sorghum was used to replace No.2 Milo performed equally well, indicating that weathered milo had substantially the same feeding value as No. 2 grade grain sorghum.

Egg production, albumin height, shell thickness, and mortality were not significantly affected during five 28-day feeding periods when laying diets were fed in which 33, 67, and 100 percent of the milo was replaced with elevator run weathered-damaged milo. Slight improvements were noted for albumen height and shell thickness. No differences were noted in relation to mortality. Weathered milo, which was severely sprouted and field damaged, had approximately the same feeding value for poultry as undamaged milo.

WEATHERED SORGHUM FOR POULTRY

L. O. Rowland~ J. E. Plyler and J.. W. Bradley

While published reports indicate that deleterious effects can occur from feeding moldy corn there is little published information on the effects of feeding sprouted or weather damaged grain sorghum. Sanford and Deyoe (1974) fed laying hens 90 percent field sprouted sorghum as the sole grain for layers and showed improvement in egg production, egg weight and feed convers ion.

Sunde *et al.* (1976) reported that low bushel weight corn (34 or 38 1b) reduced the growth rate of chicks and Leeson and Summers (1976) found that this type corn contained approximately 3 percent less metabolizable energy than standard grade corn. Leeson *et al.* (1977) also reported a 12 kca1/kg. decrease in the metabolizable epergy value for immature corn for each 1 percent increase in moisture.

The effect of high levels of af1atoxins and mycotoxins on poultry, particu1ar1y those from *AspergiUus fZavus* and *Fusarium* groups of molds, is well documented. Adams and Tuite (1976) reported that corn damaged by Gibberella was harmful to broilers; however, work by Speers *et al.* (1971) indicated that feeding *Fusarium* contaminated corn to laying hens had little influence on performance. Bacon and Marks (1976) reported no detrimental effects on either quail or broilers which were fed corn infected with *Fusarium (Gibber-e Ua zeae).*

Peck (1946) reported that feeding moldy corn decreased body weights of chicks slightly while field damaged wheat and moldy corn had no adverse effects on hens. Speers *et al.* (1977) reported that feeding 16 ppm T-2 toxin, 25 and 50 p.p.m. monoacetoxyscirpenol reduced feed intake and egg production of laying hens.

Harms and Goff (1957) reported that Sample Grade corn containing up to 30% cracked, 5% weevil damaged, 10% moldy, or 40% sprouted kernels had no significant effect on body weight or feed conversion of broilers.

Two considerations are involved in the quality of weathered grain: 1) nutritional value associated with sprouted and damaged grain and 2) toxic effects due to molds or fungi. Our emphasis was focused on the nutritional aspects of the grain *per se* rather than on the effect of toxins.

EXPERIMENTAL PROCEDURE

Two lots of weather damaged grain were obtained. The first, Pioneer Brand 8308B, was used in the first chick experiment. It was Sample Grade with a bushel weight of 42 lbs. It was completely molded and showed 100 percent sprout damage. The second, from a commercial elevator, was of unknown variety, graded No.4 and had a bushel weight of 53 lbs. It contained 3.5 percent broken kernels and 28.6 percent total damaged kernels. This material was fed in experiments two, three and four. Both lots were dark in color due to mold. The material when ground was very dusty and a darker color than the No. 2 milo which was used as a control. The proximate analyses of the three grains are given in Table 8.

Experiment 1. Three hundred day-old Hubbard broiler chicks were randomly assigned to 60 decks of twelve standard 64 x 58 x 24 cm electrically heated starting batteries. Five replicates of 12 chicks were fed diets in which No. 2 grain was replaced with levels of 0, 10, 25, 50 and 100 percent weathered Pioneer 8308B (Table 9). The diets contained calculated values of 23 percent total phosphorus and 3,187 kcal M.E./kg. Feed and water were supplied *ad libitum* during the three-week feeding period.

TABLE 8. PROXIMATE ANALYSIS OF MILO

	Nonweathered milo, No. 2	Weathered milo, Pioneer 8308Ba	Weathered milo, elevator runa
	%	%	%
Mois ture	12.51	12.36	12.41
Crude protein	9.51	9.11	9.42
Crude fat	2.61	1.93	2.37
Crude fiber	2.04	2.88	2.68
Ash	1.48	1.39-	1.37
Gross energy, kcal/g.	3.98	3.89	3.91

[a] The following Fungi species were identified: *Fusarium oxysporum, Fusarium moniZiforme, Fusarium graminearum, Aspergi Uus niger, Apergillus candidus, Alternaria species, Curvularia species, Periconia species, Cephalosporium species, Cladosporium species, Peniciuium species,* and *Macrophomina species.* Aflatoxins if present were less than 20 ppb.

TABLE 9. BROILER DIETS FED IN EXPERIMENTS 1 fu~D 2

Ingredients	Diets 1	2	3	4	5
	%	%	%	%	%
Nonweathered milo	48.35	43.51	36.26	24.17	a
Weathered milo	O	4.84	12.09	24.18	48.35
Soybean meal (45% protein)	40.36	40.36	40.36	40.36	40.36
Vegetable animal fat	7.62	7.62	7.62	7.62	7.62
Defluorinated phosphate	2.22	2.22	2.22	2.22	2.22
Vitamin mix[a]	.50	.50	.50	.50	.50
Oyster shell flour	.44	.44	.44	.44	.44
Salt	.25	.25	.25	.25	.25
DL-methionine	.21	.21	.21	.21	.21
Manganese oxide	.025	.025	.025	.025	.025
Zinc oxide	.025	.025	.025	.025	.025
	100.00	100.00	100.00	100.00	100.00

[a] Supplied per kg. of finished feed: 5,500 IU vitamin A; 1,650 IU vitamin D3; 2.2 mg menadione sodium bisulfite; 5.5 IU a-tocopherol acetate; 4.4 mg riboflavin; 11 mg D-calcium pantothenate; 27.5 mg niacin; 50 mg choline chloride; 13 mg vitamin B12.

Experiment 2. Five hundred forty day-old Hubbard broiler chicks were randomly assigned and maintained for 21 days on the five diets fed in Experiment **1.** Three replications of 36 chicks each were housed in 3 x 3 meter floor pens and fed elevator run weathered milo. In addition, a coccidiostat (3, 5-dichloro-2, 6-dimethyl-4-pyridinol) was added at the recommended level of 0.0125 percent.

Experiment 3. One hundred ninety two sexed day-old broad white Nicholas turkey poults were fed diets (Table 10) in which 0, 1/3, 2/3, and all of the grain was replaced with elevator run weathered milo. Three replications each containing eight male and eight females were fed for six weeks *ad Zibitum* in 2.4 x 3 meter floor pens. The poults were injected with Gentamicin at one day of age and were given a coccidiostat during the growing period.

Experiment 4. A laying hen experilimentwas conducted utilizing 368 Hyline pullets 24 weeks old housed in single cages. Typical milo-soybean layer diets (Table 11) in which 0, 1/3, 2/3, and all of the grain was replaced with weathered milo were fed for six 28-day periods. Hen-day egg production, mortality, albumen height, and percent shell were calculated for the last 3 days eggs of each period. In addition, eight hens from each diet were sacrificed at the termination of the experiment for histopathological examination of liver and kidney tissue.

Data for all experiments were subjected to analysis of variance as described by Steel and Torrie C196D).

RESULTS AND DISCUSSION

Experiments 1 *and* 2. Body weights and feed conversion at 21 days of age are shown in Table *U.* No statistical differences in body weight or feed conversion were found between groups in experiment 1 even though there was a slight numerical decrease in body weight as the level of weathered milo

TABLE 10. TURKEY DIETS

Ingredients	Diets 1	2	3	4
	%	%	%	%
Nonweathered milo	35.56	23.57	11.79	0
Weathered milo	0	11.79	23.57	35.36
Soybean meal (45% protein)	55.00	55.00	55.00	55.00
Dicalcium phosphate	4.00	4.00	4.00	4.00
Animal fat	4.60	4.60	4.60	4.60
Methionine	.19	.19	.19	.19
Salt	.25	.25	.25	.25
Vitamin mix[a]	.50	.50	.50	.50
Zinc oxide	.025	.025	.025	.025
Manganese oxide	.025	.025	.025	.025
Coccidiostat[b]	.05	.05	.05	.05
	100.00	100.00	100.00	100.00

[a] Supplied per kg. of finished feed: 13,200 IU vitamin A; 4,400 IU vitamin D_3; 11 IU dl-alpha-tocopheryl; 22 mg vitamin B_{12}; 6.6 mg riboflavin; 33 mg niacin; 17.6mg calcium d-pantothenate; 880 mg choline chloride; 7 mg menadione sodium bisulfite complex; 2.2 mg folic acid; 11 mg pyridoxine hydrochloride; 220 mg biotin; 15 mg vitamin B_{12}; ethoxyquin 0.125%.

[b] 0.0125% 1 - (4-amino-2-n-propyl-5-pyrimidinylmethyl)-2-picolinium chloride hydrochloride.

TABLE 11. LAYER DIETS

Ingredient	Diets 1	2	3	4
	%	%	%	%
Weathered milo	0	21.5	43.00	64.5
No.2 milo	64.5	43.00	21.50	0
Soybean meal (45% protein)	23.00	23.00	23.00	23.00
Alfalfa (17% protein)	3.50	3.50	3.50	3.50
Defluorinated phosphate	2.20	2.20	2.20	2.20
Oyster shell flour	6.00	6.00	6.00	6.00
Iodized salt	.25	.25	.25	.25
Vitamin premix[a]	.5	.5	.5	.5
Hanganese oxide	.025	.025	.025	.025
Zinc oxide	.025	.025	.025	.025
	100.00	100.00	100.00	100.00

[a] Supplied per kilogram of diet: 11,000 IU vitamin A; 3,300 ICU vitamin D3; 2.2 mg menadione sodium bisulfite; 5.5 IU D-a-tocopherol acetate; 4.4 mg riboflavin; 11 mg D-calcium pantothenate; 27.5 mg niacin; 50 mg choline chloride; 13 mg vitamin B12.

TABLE 12. EODY WEIGHTS AND FEED CONVERSION OF BROILERS FROM 2l-DAY EXPERD1ENTS 1 AND 2

Treatment	Experiment 1: Average body wt. (g)	Experiment 1: Feed conversion	Experiment 2: Average body wt. (g)
UW milo[a]	539	1.43	325
10% W milo[b]	545	1.41	315
25% W milo	540	1.38	317
50% W milo	525	1.40	321
100% W milo	521	1.44	314

[a] Indicates all of the grain from No. 2 milo.

[b] Indicates weather damaged milo.

in the diets increased. Total mortality was less than 1 percent for all diets in experiments 1 and 2.

In the second experiment unusually wet and cold weather prevented optimum growth at the low bird density in the floor pens. Even though optimum growth was not obtained and the chicks were uneven in size there was no indication that weathered milo had any substantial effect on broiler growth even under the stress conditions. There were no statistical differences between any of the diets when body weights were examined.

Experiment 3. Data on the growth performance of tutkeys is given in Table 13. There were no statistical differences between groups when males and females were combined at six weeks of age. However, the males fed 100 percent weathered milo were numerically heavier than the controls while the females were lighter. Feed conversion at six weeks remained relatively constant for all four treatments. Since the turkey is considered to be very sensitive to afl~toxins, the low mortality for all groups would indicate that any toxins which may have been present were in very low concentrations. It was concluded that weather damaged milo had no deleterious effects on growing turkeys.

Experiment 4. A summary of the data for the laying hen experiment is given in Table 14. During four 28-day feeding periods, hens fed 21.5 or 43.0 percent weathered milo produced more eggs than those fed No.2 milo. This stimulation in egg production closely approached statistical significance. It is felt that this increase in egg production was real and probably due to Penicillin species of molds present in the grain. The limited quantity of weathered grain from the same source limited the number of hens and length of time feeding trials could be run.

Egg size, egg weight and percent shell were the same for all groups and mortality remained low during the five feeding periods. Histopathological examination of liver and kidney tissue revealed no damage due to toxins.

TABLE 13. BODY WEIGHT, FEED CONVERSION AND MORTALITY OF TURKEYS, EXPERIMENT 3

Diet	Body weight: 3 weeks ♂ g	3 weeks ♀ g	( ) weeks ♂ g	( ) weeks ♀ g	Av. ♂ & ♀ g	Feed Conversion	Total Mortality %
UW[a]	605	494	2097	1407	1901	1.63	1
1/3 W[b]	577	502	1981	1676	1829	1.72	2
2/3 W	611	495	2025	1699	1862	1.70	2
W	627	502	2135	1633	1884	1.64	1

[a] Indicates all of the grain from No. 2 milo.

[b] Indicates porportion of grain replaced with weather damaged milo.

TABLE 14. SUMMARY OF HEN-DAY PRODUCTION, HORTALITY AND EGG CHARACTERISTICS (5 28-DAY PERIODS). EXPERIMENT 4

Diet	Hen-day production	Egg weight	Albumen height	Shell	Total mortality	Kg. feed per dozen eggs
	%	g	mm	%	%	
Control	75.47	59.37	5.66	9.7	3	1.92
1/3 W[a]	82.10	59.83	6.21	9.8	5	1.90
2/3 W	76.12	59.58	5.98	10.3	3	1.89
W	76.84	58.85	5.83	9.9	2	1.91

[a] W indicates percent of grain portion of diet replaced with weather damaged milo.

It is concluded that grain sorghum is not significantly altered nutritionally by weather damage. It is felt however, that it would be most advantageous to feed damaged sorghum to laying hens where a gain in egg production might be achieved.

REFERENCES

Adams, R. L. and John Tuite. 1976. Feeding Gibberella zeae damaged corn to laying hens. Poultry Sci. 55:1991-1993.

Bacon, Charles W. and Henry L. Marks. 1976. Growth of Broiler and Quail fed Fusarium (Gibberella zeae) infected corn and Zearalenone (F-2). Poultry Sci. 55:l53l-l5~

Harms, R. H. and O. E. Goff. 1957. The feeding value of different grades of yellow corn for broilers. Univ. of Tennessee Agr. Exp. Sta. Bull. 269:1-19.

Leeson, S. and J. D. Summers. 1976. Effect of adverse growing conditions on corn maturity and feeding value for poultry. Poultry Sci. 55:588-593.

Leeson, S., J. D. Summers and T. B. Daynard. 1977. The effect of kernel maturity at harvest as measured by moisture content, on the metabolizable energy value of corn. Poultry Sci. 56:154-156.

Peck. Lyman. 1946. Feeding value of moldy grain. Feedstuffs, 46(26): 18-22.

Sanford, Paul E. and C. E. Deyoe. 1974. Performance of laying hens fed new crop field sprouted and old crop nonsprouted sorghum grain. Poultry Sci. 53:1975.

Speers, G. M., R. A. Meronuck, D. M. Barnes and C. J. Mirocha. 1971. Effect of feeding Fusarium Roseum K. ~. graminearum contaminated corn and the mycotoxin F-2 on the growing chick and laying hen. Poultry Sci. 50:627-633.

Speers, G. M., C. J. Mirocha, C. M. Christensen and J. C. Behrnes. 1977. Effects on laying hens of feeding corn invaded by two species of Fusarium and pure T-2 mycotoxin. Poultry Sci. 56:98-102.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book *Co.,* New York.

Sunde, M. L., Muhammad G. Din and G. P. Holm. 1976. Feeding value of low bushel weight corn and propionic acid treated corn for broiler chicks. Feedstuffs. 48(15):18-20.

Summary

An 8-week comparison of weathered and nonweathered sorghum grain at a level of 64.25 percent in concentrate rations using 20 lactating Holstein cows showed that the weather damaged grain was as nutritious as nonweathered grain. Feed intake, milk yield and composition of the milk were not significantly affected by weahtering. There was no indication of toxins in milk samples submitted for determination, and the two groups of cows showed no difference in rebreeding schedule.

WEATHERED SORGHUH FOR DAIRY COWS

G. T. Lane and R. C. Brian [I]

An 8-week comparison of weathered and nonweathered sorghum grain in concentrate rations for dairy cows was conducted at College Station. Twenty lactating Holstein cows were selected from the ,Texas A&H dairy herd and randomly assigned to one of two treatment groups so that the average weight and production of the two groups was approximately the same (Table 15).

The treatments were simple concentrate mixtures containing 64.25 percent of either weathered or nonweathered grain (Table 16). In addition to concentrate~ the cows were fed alfalfa and hybrid sorghum hay. The cows were individually fed twice daily in experimental stalls where they were allowed appro~imately 2 hours to consume their feed. During the remainder of the time they were kept together in a small lot with access to water and mineral supplements.

The cows were weighed on 2 consecutive days at the beginning, after 4 weeks and at the end of the 8-week study. A 2-week preliminary period pre-ceeded collection of any data. Milk samples were collected weekly and analyzed for percent fat, total solids, protein and solids nonfat. talk yield and feed intake were recorded daily.

One of the questions concerning the weather damaged grain was whether the cows would consume it as well as normal grain. The cows in this study made no distinction between the two rations in voluntary consumption. The group fed nonweathered grain consumed 2.35 pounds of concentrate per 100 pounds of body weight per day while the weathered grain group consumed 2.27 pounds per 100 pounds body weight for the 8-week study (Table 17). There was likewise, no difference in hay consumption, intakes being 1.88 and 1.84

TABLE 15. STATUS OF THE COWS AT THE BEGINNING OF THE EXPERIMENT

	Nonwea there d	Weather damaged
Milk yield, lb.	55.8	55.52
Days in milk	77.9	64.9
Hilk fat, %	3.13	3.22
Body weight, lb.	1155	1199

TABLE 16. COMPOSITION OF RATIONS

Ingredient	Nonweathered	Weather damaged
	(%)	
Nonweathered sorghum	64.25	
Weather damaged sorghum		64.25
Rolled oats	20.0	20.0
Cottonseed meal	15.0	15.0
Salt	0.5	0.5
Vitamin A&D supplement	0.25	0.25

TABLE 17. CONSUMPTION OF HAY AND CONCENTRATE CONTAINING NONWEATHERED OR WEATHER DAHAGED SORGHUM

	Nonweathered	Weathered
	1b / 100 lb. body weight	
Hay	1.88	1.84
Concentrate	2.35	2.27
Total	4.23	4.11

pounds per 100 pounds body weight for the nonweathered and weathered groups, respectively.

These Holstein cows produced as much milk on weather damaged sorghum as the controls fed normal grain (Table 18). There was no significant difference in actual yield, 4 percent fat corrected yield, or percent fat, protein and solids content of the milk produced by the 2 groups. Yield of milk was maintained at a persistent level throughout the experiment, decreasing by only 4.7 and 5.2 pounds for the nonweathered and weather damaged sorghum fed cows, respectively.

According to the results of this experiment, the weather damaged sorghum mixed into a concentrate ration at 64.25 percent was as nutritious for lactating dairy animals as nonweathered grain. Intake, milk yield, and composition of the milk produced were not significantly affected by weathering. There was no indication of toxins in milk samples submitted for determination and the 2 groups of cows showed no difference in rebreeding schedule.

TABLE 18. HILK YIELD AND COHPOSITION BY WEEKS FOR COWS FED NONWEATHERED (m..,) AND WEATHER DANAGED (W) SORGHUM GRAIN

Week	Milk yield (lb)		4% FCM yield (lb)		Protein		Fat		Total solids	
					(%)					
	NW	W	NW	W	NW	W	ffi.l	W	NW	W
1	57.5	59.4	48.2	50.9	3.9	3.9	2.9	3.0	11.3	11.5
2	58.4	56.8	53.5	51.0	3.4	3.5	3.4.	3.3	10.8	12.2
3	58.9	57.3	52.6	49.5	4.1	4.2	3.2	3.1	11.9	11.8
4	58.8	58.4	53.2	50.3	3.8	3.9	3.3	3.0	11.7	11.9
5	59.6	60.9	52.4	53.9	3.8	3.9	3.2	3.2	11.7	12.0
6	58.2	58.6	52.1	50.6	4.2	4.0	3.3	3.1	12.7	12.5
7	58.0	57.4	53.3	48.0	4.1	4.2	3.5	2.9	12.2	12.0
8	52.9	54.2	48.1	49.1	4.0	4.1	3.3	3.4	12.3	12.3
Average	57.9	57.9	51.7	50.4	3.9	4.0	3.3	3.1	11.8	12.0

Sununary

Two short-term feeding trials (initial pig weights of 15 and 50 pounds) and a long-term growing-finishing trial -were conducted using weather-damaged sorghum. The weathered sorghum was classified as sample grade, contained 2?6 percent damaged kernels and was free of mycotoxins. Compared to nonweathered sorghum, the weathered grain had a slightly higher crude fiber content but the gross energy content and amino acid profile were essentially the same.

Small pigs (15 pounds initial weight) tended to consume less feed and gain slower when the grain portion of the diet was 100 percent weathered sorghum, but pig performance was similar to those fed nonweathered grain when diets contained only 50 percent weathered sorghum. Performance of larger pigs (initial weight of about 50 pounds) fed the weathered sorghum diets was excellent and was essentially the same as those fed nonweathered grain.

WEATHERED SORHGUM FOR PIGS

T. D. Tanksley

Two short-term acceptability trials with pigs of different initial weights (15 and 50 pounds), a long-term growing-finishing trial and a metabolism trial were conducted to determine the usefulness, value and digestibility of diets containing weather damaged grain sorghum for swine. The weathered grain obtained from adem, Texas, described elsewhere in this publication, was compared with nonweathered grain grown on the Texas A&M Plantation in Burleson County near College Station. The grains were physically and chemically characterized, and a portion of the weathered grain was cleaned using a Burrows scalper (2-screen model). During cleaning, .70 percent of the weight was re~oved as "coarse trash" (stems, sprouts, seed hulls, etc.) and **9.1** percent of the weigh t was removed as "fines" (small and broken kernels, sand and dirt).

Composition of Starter, Grower and Finisher diets used is shown in Table 19. Four dietary treatments were obtained by substituting the different sorghums on a pound-for-pound basis: 1) 100 percent nonweathered grain; 2) 100 perceht weathered grain; 3) 50 percent weathered - 50 percent nonweathered grain; 4) 100 percent cleaned weathered grain.

The sorghum was ground through a Bel1co hammer mill (1/4 inch screen) and mixed with the other ingredients in a horizontal mixer. A representative sample of each 400-pound mixture was obtained, plac'ed in an air-tight bag and stored in a cool room. After each test or growth period, samples for each diet were pooled for chemical analysis.

TroiaZ I -- AcceptahiZity TnaZ with Z5-Pound Pigs

Sixty-four crossbred pigs from the TAES herd, averaging about 15 pounds and 29 days of age, were allotted at weaning to 8 outcome groups based on

Table 19. PERCENTAGE COMPOSITION OF DIETS[a]

Ingredients	Starter	Grower	Finisher
Sorghum, ground	64.30	76.75	82.45
Soybean meal, 44% solvent	18.15	20.65	14.95
Menhaden fish meal, 60%	5.00		
Dried whole whey, 12%	10.00		
Ground limestone	.20	.60	.80
Deflourinated phosphate	1.10	1.20	1.00
Salt	.35	.35	.35
Trace-mineral premix	.15	.15	.15
Vitamin premix	.50	.25	.25
ASP-250[b]	.25		
Oxytetracycline (50 glIb)		.05	.05
Total	100.00	100.00	100.00
Calculated analysis, %[c]			
Protein	18.0	16.0	14.0
Calcium	.85	.70	.70
Phosphorus	.75	.61	.55
Lysine	1.02	.71	.60

[a] As-fed basis.

[b] Contributed the following per ton of diet: chlortetracycline (100 g), sulfamethazine (100 g), pennicillin (50 g).

[c] Based on "average" values for sorghum (9.0% protein, .22% lysine). sDybean meal (44.0% protein, 2.60% lysine), Menhaden fish meal (60% protein, 5.20% lysine) and dried whole whey (12.0% protein. 1.10% lysine)

litter, sex and weight. Within weight blocks, the outcome groups (4 barrows, 4 gilts) were allotted to the four dietary treatments. Each group was fed in a 4 x 4.5 foot nursery pen with completely slotted floors. Pigs were provided 18 percent protein Starter diets (Table 19) and water *ad libitum.* Individual pig weights and pen feed consumption were recorded every 7 days.

Trial II -- Acceptability Trial with 50-Pound Pigs

Sixty-four crossbred pigs from the TAES herd, averaging about 50 pounds, were allotted to 8 outcome groups (4 barrows, 4 gilts) based on litter, sex and weight. Within weight blocks, the outcome groups were allotted to the four dietary treatments. Pigs were fed in 5 x 9 foot slotted floor nursery pens for the first 21 days and then moved to a 7 x 22 foot concrete-floored, open-fronted building for the final week of the 28-day test period. Pigs received the 16 percent protein Grower diets (Table 19) and water *ad libitum.* Individual pig weights and pen feed consumption were recorded every 7 days.

Trial III -- Growing-Finishing Trial

Pig allottment and management for the first 28 days was the same as described for Trial II. Pigs were fed the 16 percent protein Grower diets until the pigs avera~ed about 120 pounds and then switched to the 14 percent protein Finisher diets (Table 19). As the pen of pigs was switched from the 16 percent to 14 percent diets, they were wormed with dichlorovos. Pigs were removed from test when the average pen weight (8 pigs) was about 206 pounds. Carcasses were inspected at slaughter and livers and kidneys from 4 pigs each from the 100 percent weathered and 100 percent nonweathered grain diets were examined at the Department of Veterinary Pathology for evidence of abnormality.

RESULTS AND DISCUSSION

The weather-damaged sorghum had a higher crude fiber content than the nonweathered sorghum, but the gross energy values for the two grains were essentially the same (Table 20). The amino acid profiles for the weathered and nonweathered grains were quite similar with lysine (the first limiting amino acid in sorghum for swine) being higher in weathered than in nonweathered grain (.20 vs. .18%). Cleaning the weathered grain reduced the fiber content (2.88 vs. 2.27%), but had little effect on protein, ether extract, gross energy or amino acid composition.

Trial I -- Acceptability Trial With 15-Pound Pigs

Although there were no significant differences (P<.10) in pig performance among dietary treatments, pigs consuming the 100 percent weathered grain diet (treatment 2, Table 21) tended to eat less and gain slower than those consuming the nonweathered sorghum. However, cleaning the weathered grain or feeding it on a half-and-half basis with nonweathered grain supported feed intakes and daily gains equal or superior to those obtained from nonweathered grain. The feed efficiency for pigs fed 100 percent weathered grain was quite close to that for nonweathered grain (98.6%).

Trial II -- Acceptability Trial With 50-Pound Pigs

Pigs started at 50 pounds liveweight gained at the same rate with the same feed utilization on the 100 percent weathered sorghum diet as those fed nonweathered grain (Table 22). In fact pigs fed the 100 percent weathered grain diet consumed the most feed and exhibited the highest daily gains of the 4 treatment groups. Feed efficiencies were quite similar for all treatments.

Trial III -- Growing-Finishing Trial

Pig performance for the 100-day growing-finishing trial is shown in Table 23. Daily gains and feed efficiency for pigs receiving the 100 percent

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TABLE 20. PHYSICAL AND CHEMICAL CHARACTERISTICS OF GRAINS AND SOYBEAN MEAL USED

	Weathered[a]	Cleaned weathered[b]	Non-weathered[c]	Soybean meal
Sample grade	4		2	
Bushel weight	53	50.4	56.7	
Damaged kernels, %	28.6	?	?	
Chemical analysis[d]				
Moisture	11.8	11.0	13.0	11.2
Crude protein, %	8.72	8.59	8.43	43.8
Ether extract, %	2.75	2.68	3.01	1. 38
Crude fiber, %	2.88	2.27	2.32	5.72
Ash, %	1. 36	1. 18	1. 70	5.44
Gross energy, kcal/g	3.91	3.93	3.89	4.16
Selected amino acids, %				
Lysine	.20.	18	. 18	2.41
Histidine	.18	.14	.18	1.00
Arginine	.31	.30	.31	2.90
Threonine	.25	.24	.24	1.54
Alanine	.64	.63	.59	1.65
Valine	.61	.60	.56	3:29
Methionine	.18	.15	.21	.44
Leucine	.98	.94	.94	3.14
Isoleucine	.34	.31	.34	1.81
Tyrosine	.33	.33	.31	1.48
Phenylalanine	.40	.40	.38	2.05

[a]Elevator run sorghum purchased from Planters Grain Coop, Odem, Texas.

[b]Obtained aftel" cleaning the weathered grain using a Burrows Scalper (2-screen model). During cleaning, .70% of the weight was removed as "coarse trash" (sterns, seed hulls, etc.) and 9.1% of the weight vlas removed and classified as "fines" (small and broken kernels, sand and dirt. etc.).

[c]Sorghum (EXCEL 808) grown on the Texas A&M Plantation, Burleson County.

[d]As-fed basis.

TABLE 21. PERFOR~1ANCE OF 15-POUND PIGS FED WEATHER-DAMAGED SORGHUM DIETS[a]

Treatment	1	2	3	4
Percent weathered sorghum in grain portion of diet[b]	0	100	50	100 (cleaned)
Initial wt., lb	15.3	15.1	15.3	15.3
Final wt., lb	33.8	31.9	35.9	34.1
Avg feed intake/day, lb	1.42	1.31	1.39	1.47
Avg daily gain, lb	.67	.60	.70	.67
Feed/gain	2.16	2.19	1.98	2.21
Relative efficiency, % /nonweathered sorghum		98.6	108.3	97.4

[a]28-day test, 16 pigs/treatment (2 pens/8 pigs).

[b]All diets contained the same amount of soybean meal (18% protein sorghum-soybean meal diets).

TABLE 22. PERFORMANCE OF 50-POUND PIGS FED WEATHER-DAMAGED SORGHUM DIETS[a]

Treatment	1	2	3	4
Percent weathered sorghum in grain portion of diet	0	100	50	100 (cleaned)
Initial wt., lb	49.1	49.9	49.6	50.3
Final wt., lb	76.7	80.1	76.2	78.6
Avg feed intake/day, lb	4.06	4.48	3.75	4.12
Avg daily gain, lb	1.31	1.44	1.27	1.35
Feed/gain	3.09	3.11	2.96	3.06
Relative efficiency, % /nonweathered sorghum		99.4	104.2	101.a

[a]28-day test, 16 pigs/treatment (2 pens/8 pigs).

[b]All diets contained the same amount of soybean meal (16% protein sorghum-soybean meal djets).

TABLE 23. PERFORMANCE OF GROWING-FINISHING PIGS FED WEATHER -D~~GED SORGHUM DIETSa

Treatment	1	2	3	4
Percent weathered sorghum in grain portion of diet b	0	100	50	100 (cleaned)
Initial wt., lb	49.1	49.9	49.6	50.3
Final wt., lb	202.5	208.7	209.4	205.5
Avg feed intake/day, lb	6.12	6.23	6.33	6.02
Avg daily gain, lb	1.58	1. 63	1. 69	1. 59
Feed/gain	3.87	3.82	3.75	3.78
Relative efficiency, % /nonweathered sorghum		101. 3	103.1	102.3

a16 pigs/treatment (2 pens/8 pigs).

bAll diets contained the same amount of soybean meal (16% protein diets fed to 120 pounds, 14% protein fed from 120-~206 pounds).

weathered sorghum diets were equal to or slightly higher than those consuming nonweathered sorghum. The relative feed efficiencies compared to the nonweathered grain diet were 101.3, 103.1 and 102.3% for diets containing 100 percent weathered grain, 50 percent weathered grain and 100 percent cleaned weathered sorghum, respectively. It appears that very little was gained from cleaning the weathered sorghum before feeding it in practical swine diets.

Weathered grain diets proved very satisfactory for pigs in short term acceptability studies and in a 100-day growing-finishing trial. Pigs started at approximately 50 pounds liveweight gained at the same rate with the same feed utilization as those eating nonweathered grain diets. When l5-pound pigs were fed the weathered sorghum diets, feed intake and daily gains were slightly lower than those for pigs receiving nonweathered grain. However, cleaning the weathered grain or feeding it on a half and half basis with nonweathered grain resulted in gains equal or superior to those made from nonweathered sorghum.

Daily feed intake and gains were essentially the same for pigs consuming diets with either weathered or nonweathered during the 100-day growing-finishing trial. Feed efficiency for the weathered grain diet was only 98.6 percent of the nonweathered grain diets but was slightly superior to the nonweathered diet when 50 percent weathered grain and cleaned weathered grain was used (101.8 and 101.1%, respectively).

Neither gross nor microscopic lesions suggestive of mycotoxicosis, more specifically aflatoxicosis, were found by pathological examination of livers and kidneys of 4 pigs fed the weathered or nonweathered grains.

Summary

Weather damaged grain sorghum produced in the Texas Coastal Bend area in 1976 was compared with nonweathered No. 2 grain sorghum for feeding light weight beef heifers at Beeville in an 84-day feeding trial. The grains, "elevator" run from commercial outlets in the area, were fed in mixtures containing 60 percent ground grain, 28 percent ground sorghum hay, 10 percent guar meal, 1 percent steamed bonemeal and 1 percent trace mineralized salt. Control mixture contained only nonweathered United States No. 2 grade grain; a second mi.rture contained only United States No. 4 grade weathered grain, while a third mixture contained the weathered and nonweathered grains in equal parts. Sixty Brahman crossbred heifers were used, all geing injected with one million units of vitamin A at the start.

The weather damaged grain showed slightly higher crude fiber and ash content than the nonweathered grain, but gross energy and protein levels were almost the same for the two grains.

The difference in gain between heifers fed only nonweathered or weathered grains was negligible (2.04vs. 2.00 pounds daily) while those fed the 50-50 mixture gained somewhat more (2.16 pounds). Although daily fed intake was about 10 percent greater for the mixed grain group than for the others, feed per pound of gain was very similar (7.93 vs. 7.59 and 7.85). The weathered grain used in this feeding trial gave almost the same performance as the nonweathered when used as the only grain in the feed mixtures. The stimulation of feed intake and gain by combining the weathered and nonweathered grains is of particular interest since similar results were observed with poultry and swine.

No evidence of mycotoxicosis was revealed by pathological examination of livers and kidneys at slaughter.

WEATHERED SORGHUM FOR BEEF CATTLE

J. N. WiZtbank and J. K. Riggs

Weather damaged grain sorghum produced in the Texas Coastal Bend area in 1976 was compared with nonweathered No. 2 grain sorghum for feeding light weight beef heifers at Beeville. The grains were "elevator run" obtained from commercial outlets in the area. Feed mixtures used contained 60 percent ground grain, 28 percent ground sorghum hay, 10 percent guar meal, 1 percent steamed bonemeal and 1 percent trace mineralized salt. The control mixture contained only nonweathered U. S. No.2 grade grain, a second mixture contained only U. S. No.4 grade weathered grain while a third mixture contained weathered and nonweathered grain in equal parts. All mixtures contained approximately 12 percent crude protein and 5 milligrams of antibiotic per pound of finished feed.

Sixty South Texas Brahman crossbred type heifers were used in the 84-day drylot feeding test. All were injected with one million units of vitamin A at the start. Two groups of heifers, 10 heavier (average weight about 400 pounds) and 10 lighter (average weight about 300 pounds) were fed each feed mixture according to appetite. They were slaugl1ter~dat the end of the feeding period for examination of carcasses, livers and kidneys by a member of the Department of Veterinary Pathology.

ResuZts and Discussion

The wea~her damaged grain showed slightly higher crude fiber and ash content than the nonweathered grain, but gross energy and protein levels were nearly the same for the two grains.

Feedlot performance of the 300-pound heifers for the 84-day feeding trial is summarized in Table 24. Although there was no significant difference in performance of calves fed all weathered or all nonweathered grain, those fed a 50-50 mixture of the two grains consumed 3.4% more feed than the nonweathered group and 9% more than the weathered group. They also gained 5.9% more than the other two groups but were intermediate in feed efficiency.

Table 24. Performance of 300~Pound Heifer Calves Fed Mixtures Containing Weath1red And/Or Nonweathered Sorghum Gra~ for 84 Days

Kind of grain	100% No. 2 nonweathered	50% No. 2 50% No. 4	100% No. 4 weathered
Number of heifers	10	10	10
Initial weight, lb.	311	299	294
Final weigh t, lb.	469	466	452
Di1ily gain, lb.	1.88	1.99	1.88
Feed consumption			
Daily, lb.	14.8	15.3	14.0
% of ave. wt./ dry, %	3.79	3.99	3.75
Per lb. gain, lb.	7.87	7.69	7.44

a/ Mixtures contalned 60% ground graln.

The 400-pound heifers showed the same pattern of performace (Table 25) as the lighter 300 lb. gr~up in that those receiving the combination of weathered and nonweathered grains gained 6.4% faster than those fed only nonweathered grain and 9.9% faster than those fed only weathered grain. Heifers fed the mixed grains also consumed 17.4 and 8.1% more feed per day than those fed only nonweathered or weathered grains, respectively, but their feed efficiency was intermediate as was the case with the lighter heifers.

Table 25. Performance of 400-Pound Heifer Calves Fed Mixtures Containing Weather~d And/Or Nonweathered Sorghum *Gra~1* for 84 Days

Kind of grain	100% No. 2 nonweathered	50% No. 2 50% No. 4	100% No. 4 weathered
Number of heifers	10	10	10
Initial weight, lb.	407	404	386
Final weight, lb.	591	600	564
Daily gain, lb.	2.19	2.33	2.12
Feed consumption			
Daily, lb.	16.1	18.9	17.4
% of ave. wt./ dry, %	3.23	3.76	3.66
Per lb. gain, lb.	7.35	8.09	8.22

[a] Mixtures contal.ne d 60% groun d gral.n.

When the results for the two weight groups of heifers were combined (Table ~) the difference in gain between those fed only nonweathered or weathered grains was negligible (2.04 *vs.* 2.00 pounds daily) while those fed the 50-50 mixture gained somewhat more (2.16). Although daily feed intake was about 10% greater for the mixed grain group than for the others, feed per pound of gain was very similar (7.93 *vs.* 7.59 and 7.85).

Table 26. Performance of 300- and 400-Pound Heifer Calves Combined When Fed Weathered And/Or Nonweathered Sorghum Grain

Kind of grain	100% No. 2 nonweathered	50% No. 2 50% No. 4	100% No. 4 weathered
Number of heifers	20	20	20
Initial weight, lb.	359	352	340
Final weight, lb.	530	533	508
Daily gain, lb.	2.04	2.16	2.00
Feed consumption			
Daily, lb.	15.45	17.10	15.70
% of ave. wt./ dry, %	3.48	3.87	3.70
Per lb. gain, lb.	7.59	7.93	7.85

The major part of variation in performance was attributable to the initial weight of the light and heavy heifers. When the weight groups were combined across grain treatments (Table 27) the heavier heifers gained significantly faster than the lighter ones (2.21 *vs.* 1.92 pounds per day), consumed significantly more feed (17.5 *vs.* 14.7 pounds per day) and required about 2.8% more feed per pound of gain (7.89 *vs.* 7.67 pounds). This difference in feed efficiency was expected.

When the heifers were slaughtered no evidence suggestive of myco-tixicosis was found by pathological examination of livers and kidneys.

The weathered grain used in this feeding trial gave almost the same performance as the nonweathered grain when used as the only grain in the feed mixtures. The stimulation of feed intake and gain by combining the weathered and nonweathered grains is of particular interest since similar results were observed with poultry and swine.

Table 27. Performance of Light and Heavy Heifers In 84-Day Feeding Experiment

Weight group of heifers	Light	Heavy
Number of heifers	30	30
Initial weight, lb.	301	399
Final weight, lb.	462	585
Average weight, lb.	382	492
Total gain, lb.	161	186
Daily gain, lb.	1.92	2.21
Feed consumption		
Total, lb.	1235	1467
Daily, lb.	14.7	17.5
% of ave. wt./ d~, %	3.84	3.55
Per lb. gain, lb.	7.67	7.89

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The effect of weathering on the physical and chemical aspects of grain utilization by ruminants was evaluated. Weathered sorghum contained significantly greater concentrations ?f ash than nonweathered grain. In addition, weathered grain contained a greater proportion of small particles and fragmented into smaller particles when processed. This resulted in a very "dusty" nature of the rations containing weathered sorghum.

When compared with the same variety of nonweathered sorghum, intakes of rations containing 80 percent weathered grain were less. Animals, when offered a choice, selected rations containing nonweathered grain. The addition of water to the rations reduced selectivity. Although *in vivo* digestibility was similar, ruminal digestibility of weathered sorghum was greater. Ruminal digestibility of weahtered sorghum differed among lines, indicating the possibility of resistance. Differences in site of digestibility affected the proportion of volatile fatty acids in the rumen.

EFFECT OF WEATHERING ON VOLUNTARY INTAKE AND DIGESTIBILITY OF SORGHUM GRAIN

R. E. Lichtenwalner

Excessive rainfall in 1976 along the Gulf Coast of Texas caused changes in the physical and chemical nature of the sorghum crop. The objective of this research was to determine the effect of weathering on voluntary intake and digestibility of sorghum grain.

EXPERIMENTAL PROCEDURE

Voluntary intake. A single variety of grain was used to determine the effect of weathering and processing on voluntary intake. The grain chosen was a variety which weathered most severely. The weathered grain was obtained from Robstown, and the non-weathered grain of the same variety was obtained from Waco. Portions of each grain were processed by one of the following methods: 1) none, 2) cleaned and 3) cleaned and micronized. Chemical and physical characteristics were determined for the grain on the original sample before cleaning.

Sixteen mature weathers were randomly allotted to four groups and fed *ad libitum* rations containing either the weathered or non-weathered grain of one processing method. Following data collection on one processing method, the sheep were weighed and randomly reallotted to two groups and fed the weathered and non-weathered grains of the second processing method. The same procedure was followed after the second feeding trial. The rations contained 80% grain, 19% cottonseed hulls and 1% premix. Water was available at all times. Daily feed intake and body weight changes during each two-week feeding period were recorded.

After the third feeding period, the sheep were weighed and reallotted to two groups for a cafeteria style intake trial. Cleaned weathered grain was exchanged for cleaned non-weathered grain to yield seven rations in which the weathered grain comprised 0, 10, 20, 40, 60, 80 and 100% of the grain component. The mixed grains comprised 80% of the ration as previously described except that 12.5% water was added to the ration fed to one group of sheep. The rations were randomly placed in feeders to avoid feeder selection. The 7 rations were fed to a pen of 8 sheep. Daily feed intake of each ration was recorded during the IO-day trial.

Digestibility trial. Two digestibility trials were conducted. The effect of weathering on *in situ* digestibility was determined on the fifteen varieties harvested before and after the rains at the Corpus Christi Station. The varieties were evaluated in the *as is* and in the cleaned form. Cleaned grain was obtained by hand selecting whole kernels of grain and removing the hulls. The grains were ground through a lmm screen and 1 gram portions weighed into tared I oz. jars. Twenty-five ml of physiological saline were added and the jar sealed with an inert material having a pore size less than 5 microns. The jars were placed in the rumen of a fistulated steer fed a 60% concentrate ration. After 24 and 72 hrs. *in situ* time, the jars were removed and dry matter disappearance (DMD) from the jars calculated.

In vivo digestibility was determined on the single variety of grain used in the voluntary intake trial. The grains were rolled prior to mixing into the ration shown in table 28. The rations were fed twice daily to four half-sib Holstein steers housed in metabolism stalls. After a 5-day adjustment period, All feces and urine were collected and preserved for analysis. Digestibility of dry matter and nitrogen and nitrogen balance was calculated.

TABLE 28. PHYSICAL CHARACTERISTICS OF GRAIN AND COMPOSITION OF RATIONS

ITEM	NON-WEA.THERED		WEA'YrlERED
Characteristics			
bushel weight, lbs.	58.0		42.0
% trash	1.3		7.2
% fines			3.8
Composition, %			
grain	52.3		52.3
cottonseed hulls		40.0	
cottonseed meal		7.3	
limestone		.4	
Crude protein, %		9.0	

The rations (table 28) were also fed to 4 ruminally fistulated Holstein steers to determine volatile fatty acid (VFA) levels in rumen fluid. The steers were fed twice daily and trained to consume the ration within 1 hr. After a 10-day adjustment period, rumen samples were obtained prior to the a.m. feeding and at 2-hour intervals for the next 12 hrs. Water was withheld during the VFA collection period. Rumen samples were squeezed through cheesecloth and the fluid preserved for. later VFA analysis.

RESULTS

The effect of weathering on chemical composition of 12 sorghum varieties is presented in table 5. The percent sprout and mold damage and degree of discoloration of weathered grains is shown in table 4. Resistance of some lines to the effects of weathering was evident in the physical aspects of the grain. Bushel weight and percent trash and fines of the single line of grain evaluated in the *in vivo* trials is shown on page 9.

VoZuntary intake. Intake of processed grains by sheep is shown in table 29. Sheep consumed significantly less of the weathered grain than of the nonweathered grain rations. The depression in intake by weathered grain was consistent across all grain processing methods. Sheep consumed less of the micronized rations than of the other processed grain rations. Adjustment of the voluntary intake to an equal body weight basis did not statistically change the difference.

The effect of ratio of weathered:nonweathered grain and mois.ture level of the ration on voluntary intake is shown in table 30. The data confirm visual observations of selectivity of the dry, nonweathered ration. Sheep consumed approximately three times as much of the dry, nonweathered grain ration than the weathered grain rations. Intake of the 100% weathered

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TABLE 29. EFFECT OF PROCESSING OF WEATHERED SORGHUM ON VOLUNTARY INTAKE BY SHEEP

Process:	As is		Cleaned		Micronized	
Grain:	NON-WEATHERED	WEATHERED	NON-WEATHERED	WEATHERED	NON-WEATHERED	WEATHERED
Intake, lbs/hd/day	2.09	1.74	2.33	1.52	1.99	1.34
Weathered, % of non-weathered	83.3		65.2		70.2	
Body Weight, lbs.	84.2	80.4	87.1	75.2	83.8	76.0
Intake, g/lb bi-T	11.3	9.6	12.2	9.2	10.8	8.4
Weathered % of non-weathered	87.2		75.4		77.4	

Table 30. EFFECT OF RATIO OF WEATHERED TO NONWEATHERED GRAIN AND MOISTURE LEVEL OF RATION ON VOLUNTARY INTAKE BY SHEEP

	ADDED MOISTURE 0		12.)	
% HEATHERED GRAIN	INTAKE g/hd/ day	% OF TOTAL	INTAKE g/hd/day	% OF TOTAL
0	355	32.6	141	13.5
10	143	13.1	169	16.2
20	163	14.9	212	20.3
40	103	9.6	193	18.5
60	172	15.6	60	5.8
80	133	12.2	230	22.1
100	22	2.0	--R	3.6
	1091	100.0	1042	100.0

grain ration was lowest. The addition of water to the rations appeared to eliminate selectivity. No differences in intake were noted between o to 40% rations. Sheep consumed less of the moist 60 and 100% weathered grain rations, but consumed more of the 80% ration than any of the moist rations. This might indicate a possible feeder difference although no visual differences in feeders were evident.

DigestibiUty trial. Twenty-four hr. *in situ* dry matter disappearance (DMD) of weathered grains was consistently higher than the same grain harvested before the rains (table 31). After 72 hr. *in situ,* D}ID of the grains were similar indicating that the effect of weathering on DMD was on the rate of digestion and not total digestibility. Selection of whole kernels and removal of the hull did not consistently affect *in situ* DMD. Generally, cleaning improved the DMD of the nonweathered grain but not weathered grain.

The similarity in *in vivo* digestibility of weathered and nonweathered rations also indicates that total digestibility is not affected (table 32). Visual observations indicated less grain in the feces of steers fed weathered grain than nonweathered rations. Ruminal volatile fatty acids, were lower in steers fed the weathered grain (table 32). In addition, the ratio of acetic to propionic acid was much wider in rumen fluid of steers fed weathered grain.

DISCUSSION

The effects of excessive rain on maturing sorghum does not appear to affect the nutritive value of the grain. Weathering does increase the dustiness of the grain which may inhibit intake by certain livestock unless the dust is controlled. The addition of molasses or fat to dry livestock rations should do this effectively as would the use of moist

TABLE **31.** *IN SITU* DRY MATTER DIGESTIBILITY OF vlliATHERED GRAINS

	24 HOURS				72 HOlJRS			
	NON- ~lEli T"rlERED		WEA T"rlERED		NON-'..rEA'J.'tiERED		wMTHERED	
GRAIN :J rr	*as 1.-S*	cleaned	*as is*	cleaned	*as is*	cleaned	*as is*	cleaned
1	14.7	14.8	20.1	23.9	60.1	59.9	67.3	67.3
2	16.1	18.0	21.5	21.0	61.1	63.1	68.6	70.6
3	19.7	23.2	26.6	28.1	69.3	70.9	70.7	69.7
4	15.8	15.8	18.1	20.2	70.0	72.0	71.9	75.5
5	16.8	20.6	19.1	17.4	73.5	70.5	69.7	67.8
6	17.)~	14.3	19.0	25.9	68.3	68.2	65.5	64.7
7	25.8	28.8	26.9	2..5<,l	6.7,1.	~.2	**70.9**	71.5
8	18.2	19.3	19.6	21.6	67.2	72.7	70.3	70.0
9	24.6	28.8	28.0	31.5	71.4	73.3	72.0	71.1
10	15.9	18.1	24.8	24.3	70.4	73.3	72.3	73.1
LL	22.2	25.3	22.0	25.6	72.8	75.6	77.5	75.2
1">-C:	19.6	17.7	21.8	20.5	68.5	70.0	67.3	72.6
13	23.3	24.5	28.1	26.1	74.4	74.0	79.9	71.5
',I,	18.9	?~ 7	**19.4**	19.3	76.2	69.7	72.4	70.5
~:.J	16. Lf	16.6	17.0	17.2	68.6	68.3	TO.l	69.9

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TABLE 32. EFFECT OF WEA'YrlERINGON *IN VIVO* DIGESTIBILITY OF SORGHUM RATIONS

ITEM	NON-WEATHERED	WEATHERED
Digestibility, %		
dry matter	55.6	54.0
nitrogen	43.4	42.1
Nitrogen balance		
g/day	9.8	8.7
Volatile fatty acids		
total, mm/l	118.7	100.6
acetic, % of total	59.0	67.3
propionic, % of total	28.7	19.8
butyric, % of total	12.3	12.9
Acetate :prionate	2.08:1	3.42:1

grain either early harvested or reconstituted. Inclusion of silage in the ration should also be helpful.

Perhaps of greater consequence to the feedlot industry is the soft nature of weathered grain. Although the larger amount of fines associated with weathered grain would not detract from the nutritive value of the grain, the processing characteristics of weathered grain would be different than normal grain. Even when weathered grain was thoroughly cleaned to remove all the fines and broken kernels, micronized weathered grain did not hold its shape and was still extremely dusty. Sheep refused more of the micronized weathered grain than of the cleaned or *as is* weathered grain.

The lack of structural integrity of weathered grains may also be a benefit to livestock in that, generally, the smaller the particle size, the more digestible the feed. Although particle size was not determined, results of the *in situ* trial indicated a clear advantage in DMD of weathered grains particularly at 24 hr. This indicates more readily available nutrients in weathered grain. However, in the *in vivo* trial, ruminal levels of total VFA and the molar percentage of propionic acid were lower in the steers fed the weathered grain. This might be due to a faster rate of passage through the rumen of the smaller weathered grain particles which would result in the grain portion of the ration being digested post-ruminally and the fibrous portion being fermented in the rumen. Since post-ruminal digestion of starch is energetically more efficient than ruminal fermentation, ruminants fed equal amounts of weathered grain would have a slight advantage over those fed normal grain. In addition, the observed reduction of grain would indicate more complete digestion of weathered grains. The lack of differences in *in vivo* digestibility may be due to the high roughage content of the ration.

CONCLUSIONS

It seems evident that weathering has considerably less effect on the nutritive value of sorghum grain than was originally expected. Apparently the primary effects are the lowered yield and grade, both of which are suffered by the grain producer.

Despite the rather favorable showing of weathered grain in comparison with more normal No. 2 grain in the multi-species studies conducted, it is doubtful that any of the personnel involved would be willing to recommend weather damaged grain sorghum as the full equal of nonweathered grain. Although no evidence of toxic effects occurred in any of the species tested, it must be kept in mind that the risk of mycotoxin production by fungi in weathered grain is always present even though grain sorghums seem less susceptible than corn, barley, cottonseed and peanuts. Nothing could be more detrimental to the marketability of sorghum than to have sickness or death of humans traced to the presence of aflatoxin in animal or plant products consumed. Whenever moldy grain are to be used, the only safe way to proceed would be to both plate out samples of the grain to determine the organisms present and chemically analyze the grain for the persence of mycotoxins.

On the other hand, the fungi are always presen~ ready to grow when conditions are right. And there is likely to be low level mold growth in much of our normal feed supply. J. Harrison, Consultant in Grain and Forage Storage in the United Kingdom, writing in the International,.Journal of Environmental Studies (1975, Vol. 8, pp. 195-198), made the following summary statement:

> "The visible presence of mould on food or animal feeding stuff does not indicate that the food is necessarily poisonous. An obvious example is the Stilton (blue) chu. All feeds showing

mould growth must not be discarded as dangerous; Economically the world could not survive such a policy and famine would soon follow. Many fungal metabolites occur only when every factor in their environment, such as moisture, temperatu~e, food composition, leads to the mould producing a toxin during growth; for example, Aspergillus flavus, one of the chief mould contaminants of barley. This mould produces aflatoxin, which caused 'Turkey X disease', from which thousands of turkey poults died in the early 1960's. This paper mentions circumstantial evidence that various animal diseases of unknown origin may well be produced by mycotoxins. It suggests too that fungi could well be one of the quickest producers oD ,.'useable food protein and other necessities, such as fats. Common sense and new knowledge must be applied when deciding to use or destroy any form of food."

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