AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch #24

1. SUBJECT CLASSIFICATION

A. PRIMARY: Serials — Y-AF30-0170-0000

B. SECONDARY: Agriculture--Plant breeding--Cereals--Sorghum

2. TITLE AND SUBTITLE
Inheritance and improvement of protein quality and content in Sorghum vulgare Pers.; semi-annual report,July-Dec.1969

3. AUTHOR(S)
(101) Purdue Univ. Dept.of Agronomy

4. DOCUMENT DATE: 1970

5. NUMBER OF PAGES: 25p.

6. ARC NUMBER: ARC 633.174.P985

7. REFERENCE ORGANIZATI ME AND ADDRESS
Purdue

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAB-397

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Proteins
Sorghum

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-1175 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

INTERNATIONAL SORGHUM IMPROVEMENT

SEMI-ANNUAL REPORT

July 1, 1969 to December 31, 1969

Report No. 6

"INHERITANCE AND IMPROVEMENT OF PROTEIN QUALITY AND CONTENT IN *SORGHUM VULGARE* PERS."

Prepared by

R. C. Pickett

Contract AID/csd-1175

U.S. Agency for International Development
Department of State
with
Purdue Research Foundation
Lafayette, Indiana

PROJECT STAFF - 1969

1. Dr. R. C. Pickett, Principal Investigator
   Professor, Agronomy

2. Dr. E. T. Hertz
   Professor, Biochemistry

3. Dr. R. Jambunathan, Post-Doctorate
   Department of Biochemistry

4. Dr. D. T. Cooper, Post-Doctorate
   Department of Agronomy

5. Robert Schaffert
   Graduate Student

6. D. P. Mohan - India, U.P.A.U.
   Graduate Research Assistant (3/4 time this project)
   began September 1, 1969

7. Greg Hinze
   Graduate Research Assistant (sorghum testing 3/4 time)
   suceeded by Dallas Oswalt, September 1, 1969

8. Samwiri Mukuru
   Rockefeller Fellow - Graduate Student - Uganda, Serere
   began September 1, 1969

9. Bantayehu Gelaw
   Rockefeller Fellow - Graduate Student - Ethiopia, Alemaya

10. Rameshwar Singh
    Rockefeller Fellow - Graduate Student - India, U.P.A.U.
    began September 1, 1969

11. R. C. Worley
    Field Technician

12. Shirley Tyner
    Laboratory Technician

13. Kathleen Flood
    Assistant Laboratory Technician

14. Ardith Spies
    Administrative Assistant

"INHERITANCE AND IMPROVEMENT OF PROTEIN QUALITY AND CONTENT IN SORGHUM VULGARE PERS."

1969 Summary

Important aspects related to obtaining high yield of sorghum with improved protein amount and quality include bird, weather and lodging resistance in addition to digestibility. These are in addition to the necessary local adaptations and resistance to disease and pests which are the objectives in most improvement programs. The work in Indiana in 1969 included a bird damage trial which is reported in Table 1. Bird resistance still seems to be associated with fairly open heads with higher tannin content in grain. The taller larger headed hybrid BR 64 avoided bird damage almost completely and had the highest yield. Bird resistance will be tested on many high yield, high protein lines and hybrids. Bird damage varied from 0 percent to 95 percent.

Representatives of the commercial hybrids of grain and forage types were tested for In Vitro rumen digestibility. These are reported in Tables 2 and 3. The plants were separated into grain, leaves, and stems while relative yield, digestible dry matter and protein percentage and amounts were determined. The first thing that is apparent is the great variation in digestibility from 42 to 71 percent. The highest grain yield also had the highest digestibility in this trial. This association, together with 9.8 percent protein also gave the highest protein yield of 870 lbs/A in the grain. Leaf digestibility was at a slightly higher average in the case of the forage types with a digestibility of 59 percent compared to 55 percent in the grain. The leaves in the grain hybrid had only 56 percent digestibility compared to 63 percent in the grain. In both the stems were significantly lower in digestibility with an average of 46 and 43 percent respectively. The percent of grain in the total plant varied from 9 to 53 percent in the forage types and grain types had a relatively low range of 40 to 44 percent grain in the total plant. This agrees with previous data suggesting that some of the intermediate high forage hybrids with high grain production have

the highest yield of grain and can be toward the top in percent grain. NK300 in this case had both the highest percent grain at 53 and high yield of grain at 9110 lbs/A.

It should be emphasized that these results are on the present commercial material but they do show interesting variation in nutritional quality factors and the work in 1970 will compare the newer high yield, high protein materials with them.

Mineral analysis for forage types are shown in Table 4. Analysis was done for N, P, K, Ca, Mg, Mn, Fe, Cu, Zn and B. There was considerable variation in each of these elements but perhaps the most occurred in N, Ca, Fe, Mg, Zn and B. The significance of these variations will be studied in relation to yield and other chemical compounds and the overall nutritional value.

The narrow row trials of commercial grain hybrids gave the highest yield of protein per acre and are reported in Table 5. Here one hybrid yielded 14,000 lbs of dry weight in the head per acre. This combined with 9.5 percent protein gave a protein yield of 995 lbs/A. This compared with the check hybrid RS610 at 7790 pounds of dry weight in the heads per acre. At 10 percent protein this gave a protein yield per acre of 615 pounds. Grain in the heads varied from 75 to 82 percent. Perhaps the unexpected result was the higher level of protein in the heads compared to the green mature leaves. The average was 10.3 in the heads compared to 9.7 in the leaves. As expected the stems were much lower with 2.96 percent protein.

The commercial grain hybrids grown in 30-inch rows are reported in Table 6. As expected the average dry weight yield was less in the wider rows, but the peak dry matter yield differed even more with 11,030 pounds of dry weight in the heads compared to the 14,000 in the narrow row trial. Again the protein percent in the grain was not significantly different from that in the leaves while the yield of protein averaged 706 in the grain compared to 221 in the leaves.

Mineral analyses from that latter trial are reported in Table 7 for the same 10 elements, with similar variation compared to the narrow row trial. In this case the stems had by far the lowest N level. Again the grain and leaves were approximately the same in N content while the grain had doubled the concentration of phosphorus in the leaves, while the leaves had twice as much potassium as the grain. There was just a trace of calcium in the grain while the leaves had a relatively high percent of 5.89. Mg was almost three times as high in the leaves as in the grain while Mn was five times higher in the leaves. Over ten times as much Fe was found in the leaves as in the grain. Amounts were relatively the same for Cu and Zn while seven times as much B was in the grain as in the leaves and three times as much as in the stems.

The current program of work for developing simple methods of determining lysine and tryptophan is reported by Mertz and Raminathan on page 20.

TABLE 1: 1969 COMMERCIAL GRAIN SORGHUM BIRD DAMAGE TRIALS IN INDIANA

Location	Lafayette (1)					Southern Indiana (2)				
Planting Date	May 26					May 3				
Row Spaces	30 inches					20 inches				
Harvest Date	October 29					September 11				
Number of Reps.	4					6				
Entry	918					928				
Character	Yield Bu/A (15.5%) (3)	Days to 50% Bloom	Heighth Inches	No. of Heads Per A. (4)	Bird Damage %	Yield Bu/A 15.5% (3)	Days to 50% Bloom	Heighth Inches	No. of Heads Per A. (4)	Bird Damage %
DeKalb:										
BR64	150	73	65	98	0	139	83	60	93	1
McNair:										
546	126	69	56	92	0	117	75	50	94	5
Northrup King:										
Savanna						125	73	54	94	2
X4041						134	71	58	98	4
Pioneer:										
XB889	119	69	54	106	0	118	79	52	101	2
Taylor-Evans:										
Bird-a-boo	130	70	56	94	5	102	74	48	91	3
Exp.18105	51	74	66	102	70	13	83	70	88	90
Exp.11105	35	73	65	91	90	7	84	69	89	95
Other:										
RS610	104	66	61	97	40.	84	68	54	85	40
Average	102	71	60	96	29	93	77	57	92	27
C.V.	14.8%	2.0%	2.9%	7.7%		19.9%	1.3%	3.4%	6.8%	
L.S.D.	22.5	2.2	2.6	11		21.5	0.7	2.3	7	

(1) Applied 510 lb./acre of nitrogen.
(2) Applied 100 lb. N, 80 lb. of phosphate, and 80 lb. of potash per acre.
(3) Not corrected for damage done by birds.
(4) Counted all heads at harvest time, reported as thousands per acre.

Table 2: *In Vitro* rumen fermentation determination of the amount of digestible dry matter in late planted (June 17) 1969 commercial grain sorghum trial at Lafayette, Indiana (1).

Company and Variety	Plant Part	DRY MATTER YIELD %	DRY MATTER YIELD lb/A	DRY MATTER DIGESTED %	DRY MATTER DIGESTED lb/A	DRY MATTER PROTEIN %	DRY MATTER PROTEIN lb/A	YIELD(2) bu/A
DeKalb								
A-25	Grain	43	6560	50	3290	13.3	870	110
	Leaves	15	2260	55	1230	12.0	270	
	Stems	28	4300	55	2360	4.4	190	
	Total	46	13,120	55	6,880	10.1	1330	
C-42a	Grain	44	7660	70	5360	9.7	740	119
	Leaves	18	3120	55	1720	10.9	340	
	Stems	22	3960	40	1590	3.4	140	
	Total	41	14,740	60	8,670	8.2	1220	
BR 44	Grain	40	5670	50	2810	10.0	560	139
	Leaves	16	2210	57	1260	12.4	270	
	Stems	30	4210	47	2000	4.1	170	
	Total	38	12,090	50	6,070	8.3	1000	
Pioneer								
866	Grain	42	8850	71	6310	9.8	870	138
	Leaves	13	2740	55	1500	12.0	330	
	Stems	28	5980	40	2420	3.7	220	
	Total	47	17,570	58	10,230	8.1	1420	
846	Grain	41	7290	67	4910	9.7	710	123
	Leaves	18	3160	54	1720	12.7	400	
	Stems	24	4320	40	1720	3.9	170	
	Total	44	14,770	57	8,350	8.6	1280	
Taylor-Evans								
Exp.11105	Grain	40	8890	67	6020	8.3	730	120
	Leaves	17	3910	53	2090	11.1	430	
	Stems	26	5790	35	2020	3.1	180	
	Total	46	18,590	55	10,130	7.2	1340	
Others								
RS610	Grain	41	6570	67	4410	9.7	640	135
	Leaves	14	2320	60	1410	12.1	280	
	Stems	30	4880	41	2020	3.7	180	
	Total	43	13,770	57	7,830	7.9	1100	
Average	Grain	41	7350	63	4730	10.1	732	126
	Leaves	16	2820	56	1560	11.9	332	
	Stems	27	4780	43	2010	3.7	177	
	Total	44	14,950	56	8,300	8.3	1241	
C.V. (%)	Grain	4.9	12.1	5.9	13.8	5.8	11.1	6.5
	Leaves	6.5	9.3	5.0	8.7	4.0	11.2	
	Stems	5.1	12.1	4.7	11.4	9.6	18.5	
	Total	2.8	10.5	-	9.9	-	9.3	
L.S.D. (.05)	Grain	N.S.D.	N.S.D.	5.6	1370	1.4	N.S.D.	8.9
	Leaves	2.5	640	4.2	290	N.S.D.	91	
	Stems	3.3	N.S.D.	2.9	340	N.S.D.	N.S.D.	
	Total	3.0	3850	-	1210	-	N.S.D.	

1 Two reps were digested by the two-stage *In Vitro* rumen fermentation technique (R. F. Barnes). Fertilizer applied: 274 lbs. N, 57 lbs. phosphate and 322 lbs. potash per acre. Planted June 17 and harvested October 21.

2 Calculated from 7 reps.

Table 3: *In Vitro* rumen fermentation determination of the amount of digestible dry matter in forage sorghums harvested from the 1969 commercial trials at Lafayette, Indiana (1).

Company and Variety	Plant Part	DRY MATTER YIELD lb/A	YIELD %	DIGESTED %	DIGESTED lb/A	PROTEIN CONTENT %	PROTEIN CONTENT lb/A
DeKalb							
FS-24	Heads	4190	29	48	2040	10	410
	Leaves	2980	21	56	1690	12	370
	Stems	6910	50	48	3280	3	170
	Total	14,080	22	50	7010	6.7	950
FS-26	Heads	3970	22	54	2100	11	430
	Leaves	3550	19	60	2130	14	500
	Stems	11,210	59	51	5800	3	290
	Total	18,730	21	54	10,030	6.5	1220
Pioneer							
931	Heads	6040	25	42	2490	9	520
	Leaves	3940	16	59	2330	13	500
	Stems	14,230	59	37	5300	3	370
	Total	24,210	31	42	10,120	5.7	1390
XF639	Heads	6660	41	61	4070	9	590
	Leaves	3010	18	55	1650	10	300
	Stems	6780	41	40	2720	3	180
	Total	16,450	27	51	8440	6.5	1070
Taylor-Evans							
TDN	Heads	5070	25	57	2920	10	510
	Leaves	4900	22	62	3060	15	740
	Stems	11,890	53	49	6680	3	350
	Total	21,860	25	55	12,660	7.3	1600
Others							
SART	Heads	1350	9	69	930	11	150
	Leaves	2860	19	62	1780	14	400
	Stems	11,040	72	54	5980	3	350
	Total	15,250	21	57	8690	5.8	900
NK300	Heads	9110	53	44	3980	8	740
	Leaves	2600	15	55	1440	12	300
	Stems	5320	32	38	2020	2	110
	Total	17,030	26	44	7440	6.7	1150
Corn							
Funks G 4097	Heads	11,030	52	67	7460	9	1030
	Leaves	3740	18	59	2240	10	380
	Stems	6550	30	48	3110	5	320
	Total	21,320	28	60	12,810	8.1	1730
Average	Heads	5930	32	55	3250	9.7	550
	Leaves	3450	19	59	2040	12.5	440
	Stems	9240	49	46	4360	3.0	270
	Total	18,610	25	52	9650	6.7	1260
C.V. (%)	Heads	16.8	12.7	12.2	24.3	6.8	20.5
	Leaves	23.6	4.5	3.4	22.5	10.9	30.3
	Stems	29.4	8.9	6.7	26.7	37.8	31.1
	Total	20.5	14.2	-	22.4	-	23.1
L.S.D. (.05)	Heads	2360	9.6	10.0	1160	1.6	267
	Leaves	N.S.D.	2.0	3.2	680	N.S.D.	N.S.D.
	Stems	N.S.D.	10.5	4.5	1710	N.S.D.	N.S.D.
	Total	N.S.D.	6.2	-	3110	-	N.S.D.

1 These data are from 2 reps which were separated into heads, leaves and stems at harvest time. All plots were planted May 6 in 30 inch rows and harvested September 5. All plots received 275 lbs. N, 56 lb. phosphate and 333 lb. potash per acre. The ground heads, leaves and stems were digested by the two-stage *IN VITRO* rumen fermentation technique (R. F. Barnes, Purdue University and USDA, ARS-1970).

Table 4: Part one. 1969 Mineral Analysis of Forage Sorghums Yield Trials at Lafayette, Indiana (1).

Company and variety		Plant part	Pounds dry matter per acre	Nitrogen %	Nitrogen lb/A.	Phosphorus %	Phosphorus lb/A.	Potassium %	Potassium lb/A.
Taylor-Evans	TDN	Heads	5,070	1.59	81	.295	15	.40	20
		Leaves	4,900	2.40	119	.200	10	1.46	71
		Stems	11,890	.51	55	.040	5	1.78	176
		Total	21,860		255		30		267
Pioneer	931	Heads	6,040	1.39	84	.305	19	.44	26
		Leaves	3,940	2.05	81	.185	7	.79	31
		Stems	14,220	.42	59	.030	4	.97	138
		Total	24,200		224		30		195
	XF639	Heads	6,660	1.44	95	.300	20	.43	29
		Leaves	3,010	1.63	48	.185	6	1.18	35
		Stems	6,780	.42	29	.035	2	1.97	132
		Total	16,450		172		28		196
DeKalb	FS-24	Heads	4,190	1.61	66	.305	13	.48	21
		Leaves	2,980	1.97	59	.165	5	1.31	38
		Stems	6,910	.40	27	.040	3	1.63	108
		Total	14,080		152		21		167
	FS-26	Heads	3,970	1.75	69	.315	12	.34	13
		Leaves	3,550	2.26	80	.215	7	1.33	47
		Stems	11,210	.42	47	.035	4	1.29	142
		Total	18,730		196		23		202
Corn	Funks G. 4097	Heads	11,030	1.49	165	.320	36	.46	50
		Leaves	3,740	1.61	61	.165	6	1.66	63
		Stems	6,540	.76	52	.050	3	1.04	67
		Total	21,310		278		45		180
Others	NK300	Heads	9,110	1.31	119	.380	37	.54	49
		Leaves	2,600	1.85	48	.145	4	.90	23
		Stems	5,330	.34	18	.020	1	1.99	106
		Total	17,040		185		42		178
	SART	Heads	1,350	1.82	24	.335	5	.65	9
		Leaves	2,860	2.23	64	.200	7	1.13	32
		Stems	11,030	.53	56	.040	4	1.01	108
		Total	15,240		144		16		149
Average		Heads	5,930	1.55	88	.319	19	.47	27
		Leaves	3,450	2.00	70	.183	6	1.22	43
		Stems	9,240	.47	43	.036	3	1.46	122
		Total	18,620		201		28		192
C.V. (%)		Heads	16.8	6.9	20.4	14.3	34.9	11.4	22.7
		Leaves	23.6	10.9	30.4	29.9	24.5	12.6	27.4
		Stems	29.4	37.9	31.1	27.6	32.8	34.7	14.5
		Total	20.5		23.0		27.0		12.1
L.S.D. (.05)		Heads	2,362	.25	42	N.S.D.	16	.13	15
		Leaves	N.S.D.	.52	N.S.D.	N.S.D.	N.S.D.	.36	28
		Stems	N.S.D.	N.S.D.	N.S.D.	N.S.D.	N.S.D.	N.S.D.	42
		Total	N.S.D.		N.S.D.		N.S.D.		55

1 All plots were planted May 6 and harvested September 5 from 30 inch rows. All plots received 274 lb. N, 57lb. phosphate and 332 lbs. potash/A ploughed down. Only two reps were used for this analysis.

Table 4: Part Two. 1969 Mineral Analysis of Forage Sorghums Yield Trials at Lafayette, Indiana (1).

Company and variety	Plant part	Calcium %	Calcium lb/A.	Magnesium %	Magnesium lb/A.	Manganese p.p.m.	Manganese lb/A.	Iron p.p.m.	Iron lb/A.
Taylor-Evans TDN	Heads	.075	3.9	.210	11	17.0	.086	71	.37
	Leaves	.575	28.1	.365	18	36.5	.159	163	.81
	Stems	.230	25.6	.225	26	20.5	.179	16	.19
	Total		57.6		55		.424		1.37
Pioneer 931	Heads	.110	6.6	.240	15	22.0	.129	321	1.91
	Leaves	.690	27.2	.430	17	37.5	.147	192	.76
	Stems	.170	24.1	.195	28	12.5	.180	23	.32
	Total		57.9		60		.456		2.99
XF639	Heads	.070	4.7	.240	16	12.0	.081	255	1.75
	Leaves	.635	19.1	.445	13	36.0	.108	170	.51
	Stems	.285	19.2	.370	25	17.5	.121	33	.22
	Total		43.0		54		.310		2.48
DeKalb FS-24	Heads	.060	2.6	.225	9	13.0	.054	58	.25
	Leaves	.630	18.9	.455	14	39.5	.117	163	.49
	Stems	.190	13.4	.235	17	15.5	.105	23	.16
	Total		34.9		40		.276		.90
FS-26	Heads	.075	2.8	.215	8	18.5	.075	242	.99
	Leaves	.650	23.1	.480	17	41.5	.145	231	.82
	Stems	.190	20.7	.230	25	13.0	.131	48	.52
	Total		46.6		50		.351		2.33
Corn Funks G. 4097	Heads	.015	1.7	.165	19	4.5	.048	23	.26
	Leaves	.735	27.5	.460	17	33.5	.127	150	.57
	Stems	.240	16.0	.300	20	14.5	.097	37	.24
	Total		45.2		56		.272		1.07
Others MK300	Heads	.035	3.2	.245	22	13.0	.120	77	.70
	Leaves	.655	17.0	.505	13	51.0	.134	184	.47
	Stems	.260	13.8	.410	22	18.0	.095	21	.11
	Total		34.0		57		.349		1.28 ?
SART	Heads	.120	1.6	.260	3	21.5	.029	116	.15
	Leaves	.820	23.7	.565	16	39.5	.110	176	.50
	Stems	.140	15.3	.165	18	11.5	.111	17	.18
	Total		40.6		37		.250		.83
Average	Heads	.070	3.4	.225	13	15.2	.078	145	.796
	Leaves	.674	23.1	.463	16	39.4	.131	178	.617
	Stems	.213	18.5	.266	22	15.4	.128	27	.240
	Total		45.0		51		.337		1.653
C.V. (%)	Heads	31.8	35.7	12.5	29.5	21.1	25.7	64.2	82.4
	Leaves	9.6	25.3	12.4	28.8	38.4	33.2	16.9	30.0
	Stems	18.6	23.2	19.9	27.6	72.0	67.0	31.1	31.5
	Total		24.4		25.9		38.2		50.0
L.S.D. (.05)	Heads	N.S.D.	N.S.D.	N.S.D.	9.0	7.58	.05	N.S.D	N.S.D.
	Leaves	N.S.D.	N.S.D.	N.S.D.	N.S.D.	N.S.D.	N.S.D	N.S.D	N.S.D.
	Stems	.092	N.S.D.	.125	N.S.D.	N.S.D.	N.S.D	19.7	.18
	Total		N.S.D.		N.S.D.		N.S.D		N.S.D.

1 All plots were planted May 6 and harvested September 5 from 30 inch rows. All plots received 274 lb. N, 57 lb. phosphate and 332 lbs. potash/A ploughed down. Only two

Table 4: Part Three. 1969 Mineral Analysis of Forage Sorghums Yield Trials at Lafayette, Indiana (1).

Company and variety	Plant part	Copper p.p.m.	Copper lb/A.	Zinc p.p.m.	Zinc lb/A.	Boron p.p.m.	Boron lb/A.
Taylor-Evans TDN	Heads	9.0	.049	29.5	.150	1.5	.008
	Leaves	9.5	.046	24.5	.114	5.5	.026
	Stems	6.5	.0[illegible]5	25.5	.23[illegible]	.0	.[illegible]00
	Total		[illegible]		.50[illegible]		.034
Pioneer 931	Heads	10.5	.06[illegible]	[illegible]7.0	.22[illegible]	4.5	.027
	Leaves	9.0	.035	24.0	.094	5.5	.022
	Stems	7.0	.100	[illegible]	.1[illegible]1	.0	.0
	Total		.1[illegible]8		.437		.049
XF639	Heads	9.0	.060	30.5	.204	5.0	.034
	Leaves	9.0	.027	24.0	.073	5.5	.017
	Stems	[illegible]	.057	17.5	.117	.5	.003
	Total		.144		.394		.054
DeKalb FS-24	[illegible]	8.5	.036	28.5	.119	2.5	.012
	[illegible]	8.0	.024	18.0	.054	5.0	.015
	[illegible]	7.5	.052	12.[illegible]	.08[illegible]	.0	.0
	Total		.112		.258		.027
FS-25	Heads	9.0	.036	37.0	.147	3.0	.011
	Leaves	9.0	.032	35.0	.122	5.5	.019
	Stems	7.0	.077	25.5	.256	.0	.0
	Total		.145		.525		.030
Corn Funks G. 4097	Heads	11.5	.1[illegible]4	29.0	.322	2.0	.021
	Leaves	12.0	.045	22.0	.081	7.0	.026
	Stems	8.5	.056	7.5	.051	2.0	.015
	Total		.2[illegible]5		.454		.062
Others NK300	Heads	9.0	.082	30.5	.278	2.0	.018
	Leaves	7.0	.018	18.0	.047	4.0	.010
	Stems	8.5	.045	11.5	.061	.0	.0
	Total		.145		.386		.028
SART	Heads	9.5	.0[illegible]3	31.5	.042	5.0	.007
	Leaves	9.0	.026	2[illegible].0	.057	7.5	.022
	Stems	5.5	.060	11.0	.112	.0	.0
	Total		.099		.211		.029
Average	Heads	9.5	.058	31.7	.186	3.2	.017
	Leaves	9.1	.032	23.2	.080	5.7	.020
	Stems	7.4	.065	14.9	.130	.3	.002
	Total		.155		.396		.039
C.V. (%)	Heads	14.8	17.4	6.1	21.6	53.6	58.5
	Leaves	7.1	24.5	22.2	22.7	18.1	32.1
	Stems	10.2	21.6	75.0	59.0	98.0	98.0
	Total		18.2		27.7		42.7
L.S.D. (.05)	Heads	N.S.D.	.02	4.6	.09	N.S.D.	N.S.D.
	Leaves	1.52	N.S.D.	N.S.D.	.13	N.S.D.	N.S.D.
	Stems	1.78	N.S.D.	N.S.D.	N.S.D.	N.S.D.	N.S.D.
	Total		.07		N.S.D.		N.S.D.

1 All plots were planted May 6 and harvested September 5 from 30 inch rows. All plots received 274 lb. N, 57 lb. phosphate and 332 lbs. potash/A ploughed down.

Table 5: 1969 Commercial Grain Sorghum Dry Weight and Protein Content of Normal Grain Trials (15") at Lafayette (1).

Company and variety	Plant parts	Grain yield bu/A.	Dry Weight %	Dry Weight lb/A.	Protein %	Protein lb/A.	Thresh %	Number of plants/A. (thousands)
DeKalb								
C48a	Heads		64	12,030	9.9	930		
	Leaves		14	2,590	8.7	220		
	Stems		22	4,350	2.9	125		
	Total	162	47	18,970		1275	78	116.7
E-55	Heads		57	8,740	11.0	730		
	Leaves		16	2,490	9.8	240		
	Stems		27	4,550	3.1	130		
	Total	118	45	15,280		1100	76	115.0
Northrup King								
Savanna	Heads		58	8,870	10.7	680		
	Leaves		15	2,220	10.6	235		
	Stems		27	4,200	3.5	145		
	Total	139	44	15,290		1060	72	128.9
222A	Heads		58	9,020	10.3	675		
	Leaves		16	2,450	10.9	265		
	Stems		26	4,000	3.0	120		
	Total	126	42	15,470		1060	73	113.3
280	Heads		61	10,390	9.8	790		
	Leaves		14	2,410	9.7	230		
	Stems		25	4,280	2.9	120		
	Total	159	44	17,080		1140	77	115.0
X4041	Heads		59	8,940	12.0	780		
	Leaves		15	2,200	9.5	210		
	Stems		26	4,010	3.2	130		
	Total	137	51	15,150		1120	73	120.2
Pioneer								
866	Heads		58	9,640	11.3	820		
	Leaves		14	2,390	9.9	235		
	Stems		28	4,620	3.2	150		
	Total	145	46	16,650		1205	75	130.7
Taylor-Evans	Heads		59	6,650	12.0	555		
Bird-a-boo	Leaves		16	1,740	8.7	150		
	Stems		25	2,870	3.7	105		
	Total	99	46	11,260		810	70	122.0
Mucho	Heads		57	9,570	11.1	825		
	Leaves		14	2,310	10.8	250		
	Stems		29	4,830	3.0	145		
	Total	128	44	16,710		1220	78	137.7
Exp.18114	Heads		57	9,410	10.1	905		
	Leaves		15	2,340	10.4	245		
	Stems		28	4,800	2.6	125		
	Total	133	44	16,650		1275	76	115.0

Table 5: Continued Page 2.

Company and variety	Plant parts	Grain yield bu/A.	Dry Weight %	Dry Weight lb/A.	Protein %	Protein lb/A.	Thresh %	Number of plants/A. (thousands)
Taylor-Evans								
Exp.20107	Heads		57	8,210	9.8	625		
	Leaves		14	2,670	9.0	185		
	Stems		29	4,080	2.9	120		
	Total	113	44	14,360		930	78	113.3
Exp.18105	Heads		58	14,000	9.5	995		
	Leaves		15	3,660	10.2	375		
	Stems		27	6,550	2.3	150		
	Total	185	46	24,210		1520	75	116.7
Exp.11105	Heads		58	11,360	9.2	805		
	Leaves		16	3,100	9.7	300		
	Stems		26	4,960	2.6	130		
	Total	159	45	19,420		1235	76	108.0
Others RS610	Heads		57	7,790	10.0	615		
	Leaves		15	1,930	10.1	195		
	Stems		28	3,750	2.6	95		
	Total	129	43	13,470		905	78	94.1
Corn								
US13	Heads		59	9,960	8.7	710		
	Leaves		14	2,480	7.4	175		
	Stems		27	4,530	3.0	135		
	Total	174	41	16,970		1020	82	34.9
Average	Heads		58	9,640	10.3	763		
	Leaves		15	2,420	9.7	234		
	Stems		27	4,390	2.96	128		
	Total	140.5	45	16,450		1125	76	118.1
C.V. (%)	Heads		4.6	20.1	6.1	20.6		
	Leaves		15.3	19.4	8.0	18.1		
	Stems		3.8	20.2	10.2	24.4		
	Total	16.5	5.3	18.7		19.0	4.3	9.1
L.S.D. (.05)	Heads		3.7	4,150	1.4	337		
	Leaves		4.9	1,010	1.7	91		
	Stems		2.2	1,910	0.6	67		
	Total	49.8	5.1	6,610		460	7.1	23.6

1/ Only the grain from the two reps selected for division into heads, leaves and stems was used for the calculations of dry weight and protein analysis.

Table 6. 1969 Commercial Grain Sorghum Dry Weight and Protein Centers of Normal Grain Trials (30") at Lafayette (1).

Company and variety		Plant parts	Grain yield bu/A.	Dry Weight %	Dry Weight lb/A.	Protein %	Protein lb/A.	Thresh %	Number of plants/A. (thousands)
DeKalb	C-48a	Heads		60	8,740	10.4	685		
		Leaves		15	2,120	9.0	185		
		Stems		25	3,580	3.1	110		
		Total	142	46	14,440		980	75	105.5
	E-55	Heads		61	9,700	10.1	745		
		Leaves		13	1,980	10.1	200		
		Stems		26	4,300	2.9	120		
		Total	153	47	15,980		1065	77	91.6
Northrup King Savanna		Heads		62	9,820	10.2	770		
		Leaves		12	2,000	10.8	215		
		Stems		26	4,120	3.1	130		
		Total	143	46	15,940		1115	76	110.8
	222A	Heads		60	9,130	9.8	640		
		Leaves		15	2,270	9.4	215		
		Stems		25	3,690	3.2	120		
		Total	137	44	15,090		975	72	100.3
	280	Heads		57	8,080	10.0	660		
		Leaves		13	1,810	11.1	200		
		Stems		30	4,210	2.7	115		
		Total	150	43	14,100		975	82	95.9
	X4041	Heads		59	11,030	9.9	735		
		Leaves		16	2,660	9.2	245		
		Stems		25	4,210	3.0	125		
		Total	144	51	16,900		1105	74	121.2
Pioneer	866	Heads		57	6,320	10.9	575		
		Leaves		15	1,680	10.6	180		
		Stems		28	3,100	3.2	100		
		Total	156	43	11,100		855	84	110.8
Taylor-Evans Bird-a-boo		Heads		62	9,240	9.8	635		
		Leaves		13	1,950	10.1	195		
		Stems		25	3,800	3.2	120		
		Total	142	47	14,990		980	73	112.5
Mucho		Heads		62	10,440	9.9	820		
		Leaves		12	2,060	10.5	215		
		Stems		26	4,260	3.2	135		
		Total	151	48	16,760		1170	79	104.7

Table 5: Continued Page 2

Company and variety	Plant parts	Grain yield bu/A.	Dry Weight %	Dry Weight lb/A.	Protein %	Protein lb/A.	Thresh %	Number of plants/A. (thousands)
Taylor Evans (con)								
Exp. 18114	Heads		57	8,960	9.7	650		
	Leaves		14	2,110	9.7	205		
	Stems		29	4,610	2.9	135		
	Total	146	44	15,680		990	75	109.0
Exp. 20107	Heads		58	8,350	10.7	710		
	Leaves		13	1,860	11.6	215		
	Stems		29	4,260	2.8	120		
	Total	148	44	14,470		1045	80	111.6
Exp. 18105	Heads		57	10,550	9.2	875		
	Leaves		16	2,970	10.1	295		
	Stems		27	5,070	2.3	140		
	Total	167	46	18,590		1310	76	98.6
Exp. 11105	Heads		55	10,060	9.0	690		
	Leaves		16	2,950	9.2	275		
	Stems		29	5,160	2.4	120		
	Total	171	48	18,170		1085	75	108.1
Other RS610	Heads		61	9,790	9.6	720		
	Leaves		11	1,770	11.1	200		
	Stems		28	4,500	2.8	125		
	Total	154	45	16,060		1045	77	89.8
Average	Heads		59	9,270	9.9	706		
	Leaves		14	2,200	10.0	221		
	Stems		26	4,200	3.0	127		
	Total	150	46	15,680		1054	76.9	104.8
C.V. %	Heads		3.4	18.7	6.6	24.5		
	Leaves		8.9	18.3	9.8	18.3		
	Stems		7.8	19.6	8.7	18.6		
	Total	11.1	6.0	17.0		20.9	5.3	9.1
L.S.D. (.05)	Heads		4.3	3,710	1.4	371		
	Leaves		2.7	880	2.1	87		
	Stems		4.5	1,780	0.6	51		
	Total	35.8	5.9	5,730		473	8.8	23.6

(1)Only the grain from the two reps selected for division into heads, leaves and stems was used for the calculations of dry weight and protein analysis.

Table 7: Part One. 1969 Mineral Analysis of Normal Grain Sorghum Yield Trials (30" rows) at Lafayette.(1)

Company and variety	Plant part	Pounds Dry Matter per acre	Nitrogen %	Nitrogen lb/A.	Phosphorus %	Phosphorus lb/A.	Potassium %	Potassium lb/A.
DeKalb C48a	Grain	6,550	1.67	110	.270	18	.240	16
	Leaves	2,120	1.43	30	.120	3	.660	14
	Stems	3,580	.50	18	.025	1	2.180	77
	Total	12,250		158		22		107
E-55	Grain	7,490	1.62	119	.260	20	.250	19
	Leaves	1,990	1.61	32	.120	2	.630	13
	Stems	4,310	.46	20	.020	2	1.865	63
	Total	13,790		171		24		95
Northrup King Savanna	Grain	7,490	1.64	124	.285	22	.220	17
	Leaves	2,010	1.72	35	.130	3	.695	14
	Stems	4,120	.50	21	.030	1	1.730	71
	Total	13,620		180		26		102
222A	Grain	6,580	1.57	102	.280	18	.310	20
	Leaves	2,270	1.51	35	.120	3	.710	17
	Stems	3,690	.51	19	.030	1	2.295	85
	Total	12,540		156		22		122
280	Grain	6,590	1.61	106	.255	17	.230	15
	Leaves	1,810	1.78	32	.140	3	.720	14
	Stems	4,210	.43	18	.030	1	1.710	72
	Total	12,610		156		21		101
X4041	Grain	7,430	1.59	118	.250	19	.250	19
	Leaves	2,660	1.47	39	.100	3	.595	16
	Stems	4,210	.48	20	.020	1	1.480	63
	Total	14,300		177		23		98
Pioneer 866	Grain	5,340	1.75	93	.310	17	.260	14
	Leaves	1,680	1.70	29	.155	3	.680	12
	Stems	3,100	.52	16	.035	1	2.135	66
	Total	10,120		138		21		92
Taylor-Evans Bird-a-boo	Grain	6,780	1.57	106	.260	18	.230	16
	Leaves	1,950	1.62	32	.135	3	.610	12
	Stems	3,800	.50	19	.030	1	2.400	93
	Total	12,530		157		22		121
Mucho	Grain	8,260	1.59	132	.290	24	.275	23
	Leaves	2,060	1.68	35	.135	3	.605	13
	Stems	4,260	.51	22	.030	1	2.255	96
	Total	14,580		189		28		132
Exp.18114	Grain	6,730	1.56	135	.275	19	.240	16
	Leaves	2,110	1.56	33	.125	3	.620	13
	Stems	4,610	.86	38	.030	2	1.885	86
	Total	13,450		206		24		115
Exp. 20107	Grain	6,710	1.71	115	.275	19	.205	14
	Leaves	1,860	1.86	35	.160	3	.655	12
	Stems	4,270	.46	20	.030	1	1.885	80
	Total	12,840		170		23		106

Table 7: Part one continued. Page 2.

Company and variety	Plant part	Pounds Dry Matter per acre	Nitrogen %	Nitrogen lb/A.	Phosphorus %	Phosphorus lb/A.	Potassium %	Potassium lb/A.
Taylor Evans								
Exp.18105	Grain	8,020	1.48	119	.330	28	.345	26
	Leaves	2,970	.62	47	.155	5	.480	4
	Stems	5,000	.75	34	.030	2	1.575	80
	Total	16,070		200		35		120
Exp.11105	Grain	7,560	1.45	110	.280	21	.285	21
	Leaves	2,950	1.47	44	.120	4	.460	14
	Stems	5,170	.38	20	.025	2	1.110	57
	Total	15,680		174		27		92
Others	Grain	7,540	1.53	115	.285	22	.240	19
RS610	Leaves	1,770	1.78	32	.145	3	.715	13
	Stems	4,500	.45	21	.025	2	1.910	85
	Total	13,810		168		27		117
Corn	Grain	7,000	1.49	105	.220	16	.225	16
US13	Leaves	3,480	1.29	44	.120	4	.420	15
	Stems	4,490	.69	31	.035	2	1.235	55
	Total	14,970	1	180		22		86
Average	Grain	7,070	1.59	114	.279	19.5	.256	17.9
	Leaves	2,240	1.60	35	.133	2.9	.631	13.4
	Stems	4,220	.53	22	.028	1.2	1.887	75.1
	Total	13,530		171		23.6		106.4
C.V. (%)	Grain	19.7	6.7	23.7	7.2	22.9	14.1	25.0
	Leaves	18.1	9.8	18.2	10.6	27.8	17.0	25.0
	Stems	19.6	34.8	26.9	62.0	45.8	10.7	16.6
	Total	17.0		17.1		23.1		15.9
L.S.D. (.05)	Grain	2,990	.23	58	.043	10	.078	10
	Leaves	880	.34	14	.030	2	.232	7
	Stems	1,780	.40	13	.012	1	.436	27
	Total	5,500		62		12		56

(1) Threshed grain was used for the grain analysis from two reps. Total fertilizer applied: 275 lb. N, 56 lb. phosphate, and 333 lb. potash per acre.

Table 7: Part Two. 1969 Mineral Analysis of Normal Grain Sorghum Yield Trials (30" rows) at Lafayette. (1)

Company and variety	Plant part	Calcium %	Calcium lb/A.	Magnesium %	Magnesium lb/A.	Manganese p.p.m.	Manganese lb/A.	Iron p.p.m.	Iron lb/A.
DeKalb C48a	Grain	.010	0.7	.155	10	7.5	.051	28	.184
	Leaves	.610	13.0	.345	7	46.0	.097	436	.954
	Stems	.285	10.0	.240	9	12.5	.049	32	.110
	Total		23.7		26		.197		1.248
E-55	Grain	.005	0.3	.145	11	5.0	.039	25	.192
	Leaves	.560	11.0	.385	8	42.0	.081	377	.774
	Stems	.240	10.0	.240	12	8.5	.041	28	.113
	Total		21.3		31		.161		1.079
Northrup King Savanna	Grain	.010	0.8	.165	13	6.5	.049	27	.204
	Leaves	.590	12.0	.380	8	38.0	.078	329	.715
	Stems	.285	11.5	.295	12	5.0	.021	33	.137
	Total		24.3		33		.148		1.056
222A	Grain	.010	0.7	.145	10	8.5	.057	35	.225
	Leaves	.650	15.0	.410	10	44.0	.099	400	.924
	Stems	.295	10.5	.335	13	15.5	.059	38	.139
	Total		26.2		33		.215		1.288
280	Grain	.005	0.4	.135	9	6.0	.040	26	.172
	Leaves	.635	11.5	.425	8	39.0	.070	343	.620
	Stems	.280	12.0	.315	13	9.5	.042	37	.155
	Total		23.9		30		.152		.947
X4041	Grain	.010	0.8	.150	11	6.5	.050	26	.195
	Leaves	.630	17.0	.415	10	38.0	.103	375	1.035
	Stems	.195	8.0	.205	9	5.5	.021	34	.168
	Total		25.8		30		.174		1.398
Pioneer 866	Grain	.005	0.3	.165	9	8.0	.043	31	.162
	Leaves	.565	9.5	.430	7	35.0	.060	375	.621
	Stems	.255	8.0	.310	10	9.5	.029	43	.133
	Total		17.8		26		.132		.916
Taylor-Evans Bird-a-boo	Grain	.005	0.3	.145	10	8.0	.055	21	.141
	Leaves	.560	11.0	.355	7	53.0	.104	337	.644
	Stems	.235	9.0	.240	9	5.0	.020	27	.101
	Total		20.3		26		.179		.886
Mucho	Grain	.005	0.5	.160	14	8.0	.066	28	.227
	Leaves	.605	12.5	.390	8	39.0	.081	360	.752
	Stems	.250	10.5	.250	11	12.5	.035	37	.119
	Total		23.5		33		.182		1.098
Exp.18114	Grain	.005	0.3	.145	10	5.0	.033	22	.147
	Leaves	.520	11.0	.360	8	44.0	.092	290	.626
	Stems	.270	12.5	.270	13	12.0	.060	54	.189
	Total		23.8		31		.185		.962
Exp.20107	Grain	.000	0.0	.140	10	5.0	.034	27	.181
	Leaves	.580	11.0	.390	7	34.0	.063	327	.604
	Stems	.255	11.0	.285	13	7.0	.039	37	.128
	Total		22.0		30		.136		.913

Table 7: Part Two. Continued Page 2.

Company and variety	Plant part	Calcium %	Calcium lb/A.	Magnesium %	Magnesium lb/A.	Manganese p.p.m.	Manganese lb/A.	Iron p.p.m.	Iron lb/A.
Taylor-Evans									
Exp.18105	Grain	.010	0.8	.165	14	9.5	.076	34	.275
	Leaves	.570	17.5	.465	14	34.0	.105	285	.937
	Stems	.285	10.0	.300	15	5.5	.028	37	.185
	Total		28.3		43		.209		1.397
Exp.11105	Grain	.010	0.8	.150	12	5.5	.041	28	.211
	Leaves	.575	16.5	.510	15	29.0	.088	260	.743
	Stems	.200	10.5	.275	14	2.5	.016	36	.190
	Total		27.8		41		.145		1.144
Others RS610	Grain	.000	0.0	.150	11	4.0	.033	23	.174
	Leaves	.590	10.5	.435	8	41.0	.072	313	.548
	Stems	.245	10.5	.275	12	12.5	.051	31	.144
	Total		21.0		31		.156		.866
Corn	Grain	.000	0.0	.115	9	1.0	.006	15	.105
US13	Leaves	.645	22.5	.310	11	32.5	.111	428	1.512
	Stems	.250	11.0	.340	15	9.0	.043	43	.190
	Total		33.5		35		.159		1.807
Average	Grain	.006	0.4	.151	11	6.6	.045	27	.186
	Leaves	.589	13.4	.407	9	39.7	.087	343	.800
	Stems	.249	10.3	.274	12	8.8	.037	36	.147
	Total		24.1		32		.169		1.133
C.V. (%)	Grain	69.0	78.0	3.7	21.4	28.5	39.7	13.6	27.1
	Leaves	8.0	21.2	13.2	24.1	20.5	33.4	14.4	26.6
	Stems	8.3	19.5	13.5	21.7	62.4	66.6	4.5	23.9
	Total		18.8		20.3		36.1		23.6
L.S.D. (.05)	Grain	.009	0.7	.059	4.9	4.1	.038	8.0	.108
	Leaves	.101	6.1	.116	4.6	17.4	.062	106.6	.457
	Stems	.004	4.3	.080	5.4	11.8	.052	7.4	.075
	Total				13.6		.129		.572

(1) Threshed grain was used for the grain analysis from two reps. Total fertilizer applied: 275 lb. N, 56 lb. phosphate, and 333 lb. potash per acre.

Table 7: Part Three. 1969 Mineral Analysis of Normal Grain Sorghum Yield Trials (30" rows) at Lafayette. (1)

Company and variety	Plant part	Copper p.p.m.	Copper lb/A.	Zinc p.p.m.	Zinc lb/A.	Boron p.p.m.	Boron lb/A.
DeKalb C43a	Grain	6.0	.040	20.5	.135	1.0	.007
	Leaves	7.5	.016	21.5	.046	9.0	.020
	Stems	12.5	.043	17.5	.061	3.0	.011
	Total		.099		.242		.038
E-55	Grain	6.5	.050	17.5	.132	0.5	.003
	Leaves	8.0	.016	19.5	.039	8.0	.016
	Stems	13.0	.056	16.0	.069	2.0	.008
	Total		.122		.240		.027
Northrup King Savanna	Grain	6.0	.045	21.0	.158	0.5	.004
	Leaves	8.0	.016	17.5	.036	9.0	.019
	Stems	8.5	.035	15.0	.062	2.0	.009
	Total		.096		.256		.032
222A	Grain	7.0	.046	19.5	.130	1.5	.009
	Leaves	8.0	.019	21.5	.050	9.0	.021
	Stems	9.5	.035	18.0	.066	3.0	.011
	Total		.100		.246		.041
280	Grain	7.0	.046	20.5	.136	0.5	.004
	Leaves	8.5	.015	21.0	.038	8.0	.015
	Stems	9.0	.039	18.5	.078	2.0	.009
	Total		.100		.252		.028
X4041	Grain	6.5	.049	21.0	.157	1.0	.009
	Leaves	7.5	.120	19.0	.051	9.0	.025
	Stems	7.5	.030	13.0	.043	2.0	.009
	Total		.099		.251		.043
Pioneer 866	Grain	6.5	.035	20.0	.105	1.0	.006
	Leaves	8.0	.014	19.5	.033	8.5	.014
	Stems	12.0	.037	16.5	.051	2.5	.008
	Total		.086		.189		.028
Taylor-Evans Bird-a-boo	Grain	6.0	.041	17.5	.117	0.5	.003
	Leaves	7.5	.015	17.5	.034	8.5	.017
	Stems	8.5	.033	12.0	.046	1.0	.004
	Total		.089		.197		.024
Mucho	Grain	7.0	.058	20.5	.170	1.0	.008
	Leaves	7.5	.016	21.0	.044	7.5	.016
	Stems	10.5	.051	20.0	.103	3.0	.013
	Total		.125		.317		.037
Exp.18114	Grain	6.0	.041	17.0	.115	0.0	.000
	Leaves	7.0	.015	19.5	.042	6.5	.014
	Stems	8.0	.042	15.5	.065	2.5	.014
	Total		.098		.222		.028
Exp.20107	Grain	6.5	.044	19.0	.128	0.5	.004
	Leaves	7.5	.014	21.5	.040	7.5	.014
	Stems	8.5	.039	17.5	.077	2.0	.009

Table 7: Part Three. Continued Page 2.

Company and variety	Plant part	Copper p.p.m.	Copper lb/A.	Zinc p.p.m.	Zinc lb/A.	Boron p.p.m.	Boron lb/ .
Taylor-Evans							
Exp.18105	Grain	7.0	.056	19.0	.154	2.0	.016
	Leaves	8.5	.025	19.0	.056	8.5	.026
	Stems	12.5	.060	14.5	.073	3.0	.015
	Total		.147		.283		.057
Exp.11105	Grain	6.5	.049	17.0	.129	1.0	.007
	Leaves	8.5	.025	20.5	.060	8.5	.025
	Stems	11.5	.058	14.0	.072	1.5	.008
	Total		.132		.261		.040
Others RS610	Grain	6.0	.046	17.5	.133	0.0	.000
	Leaves	9.0	.016	21.5	.038	8.5	.015
	Stems	9.5	.045	16.5	.086	3.0	.014
	Total		.107		.257		.029
Corn	Grain	6.0	.042	18.0	.126	1.0	.007
US13	Leaves	9.0	.032	17.0	.058	9.5	.033
	Stems	8.5	.038	7.5	.034	3.5	.016
	Total		.112		.218		.056
Average	Grain	6.5	.045	19.1	.135	0.8	.007
	Leaves	7.9	.018	20.0	.044	8.3	.019
	Stems	10.1	.043	16.0	.065	2.3	.010
	Total		.106		.244		.036
C.V. (%)	Grain	6.7	22.1	12.3	25.1	65.4	68.9
	Leaves	9.8	19.9	14.5	25.6	9.1	21.6
	Stems	18.6	26.0	18.1	17.6	22.2	28.9
	Total		21.0		19.0		22.2
L.S.D. (.05)	Grain	0.9	.022	5.1	.073	1.1	.083
	Leaves	1.7	.008	6.3	.024	1.6	.009
	Sters	4.1	.024	6.3	.025	1.1	.006
	Total		.049		.100		.166

(1) Threshed grain was used for the grain analysis from two reps. Total fertilizer applied: 275 lb. N, 56 lb. phosphate, and 333 lb. potash per acre.

Simple Methods for Determining Lysine and Tryptophan in Sorghum

E. T. Mertz and R. Jambunathan
Department of Biochemistry
Purdue University
Lafayette, Indiana

Simple methods for determining lysine and tryptophan in high lysine and normal maize have been developed recently by our research group (S. S. Subramanian, R. Jambunathan, J. H. Concon and E. T. Mertz, Federation Proceedings (FASEB) 29, March, 1970)*. These methods require essentially complete separation of protein from the starch in the ground maize kernel. This is accomplished with a simple extraction procedure in which the finely ground sample is suspended first in a small amount of 70% ethanol and then treated with a larger volume of dilute (0.5%) sodium hydroxide solution. Under these conditions, more than 90% of the protein of the maize kernel goes into solution, leaving the starch and fiber as a residue.

When this method was applied to sorghum samples, only one-half to two-thirds of the nitrogen of the grain was solubilized, as shown in Table I. The protein that was solubilized carried a higher percentage of the lysine of the grain than that portion which remained behind. Because of this the colorimetric method for lysine gave values which were several-fold higher than those obtained on the whole kernel using the Spinco Automatic Amino Acid Analyzer (see columns 4 and 5, Table I). The tryptophan values were in the normal range except in the case of sorghum sample 640-341, a highly pigmented sample, where the tryptophan value was exceptionally high due to color interference (column 6, Table I).

Eight modifications of the simple extraction method were tested in an effort to increase the amount of sorghum protein solubilized. The most effective of these modifications raised the percent solubilized by only 8%. From these studies we have concluded that the alcohol-alkali solubilization method, which is so effective with maize, cannot be used successfully with sorghum.

In our Report Number 4 for the period January 1, 1968 to December 31, 1968, we showed that 88 to 97.5% of the nitrogen of nine sorghum endosperm samples was recovered as soluble nitrogen using the Mertz copper method (Mertz, E. T., Lloyd, H. E. and Bressani, R. Cereal Chem. 35, 146 (1958)). Five hundred milligram portions of two of the finely ground samples listed in Table I were therefore suspended in 20 ml of water with 150 milligrams of copper sulphate pentahydrate and 21 milligrams of sodium sulfite. The pH was then adjusted to 11.6 with 2% sodium hydroxide solution, and the mixture stirred for three hours under a nitrogen atmosphere. The mixture was then centrifuged, the supernatant saved, and the residue washed by stirring for 15 minutes with 10 ml of a solution of 0.075% copper sulphate pentahydrate and .001% sodium sulfite. The supernatant and the washing were combined and this solution used to determine protein recovery and lysine and trypotophan levels.

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*Copy attached

In Table II it can be seen that 92% of the protein was extracted by the copper reagent in both samples, compared with 61% on sample 640-341 and 52% on sample 640-644 using the alcohol-alkali extraction procedure (Table I). The lysine value obtained with the copper reagent agrees quite well with the amino acid analyzer value on sample 640-341 (Table II). The lysine value on sample 640-644 is closer to the analyzer value (1.9 compared with 2.6) than was observed with the alcohol-alkali method (Table I), but is still somewhat low. This may be due to the fact that the colorimetric procedure measures available (or exposed) lysine in the sorghum proteins instead of total lysine as measured by the ion-exchange method. The tryptophan method using the copper extraction procedure gave values similar to those obtained with the alcohol-alkali solubility method in the case of 640-644, and a lower value on sample 640-341, the pigmented sample. However, the color of this sample was still too high to give a satisfactory value for tryptophan.

These data suggest that on non-pigmented sorghum samples useful lysine and tryptophan values can be obtained using copper extraction with simple colorimetric procedures. In tryptophan assays, additional study is needed to determine how to eliminate the interference of the pigments in highly pigmented samples of sorghum. Our research will continue on the development of simplified methods for sorghum.

Conclusions. Available lysine in sorghum can be determined with a satisfactory degree of precision using a combination of the Hertz copper extraction method and a colorimetric procedure for estimation of lysine. The cooper extraction method can also be used successfully in combination with a colorimetric method for tryptophan provided the sorghum is not highly pigmented.

TABLE I

Lysine and Tryptophan Levels in Proteins
Extracted by the Alcohol-Alkali Method

Sample	Protein in Kernel (N x 6.25)	Protein Recovered in Extract (%)	Lysine C*	Lysine S*	Tryptophan C
640-264	17.2	68	3.8	1.3	1.2
640-341	9.1	61	2.3	1.3	5.2
640-644	12.9	52	3.5	2.6	1.2

*C = colorimetric method. S = ion-exchange method. Lysine and tryptophan values in grams per 100 grams of protein (N x 6.25)

TABLE II

Lysine and Tryptophan Levels in Proteins
Extracted by the Copper Method

Sample	Protein Recovered in Extract (Copper Method %)	Lysine C*	Lysine S*	Tryptophan C
640-341	92.0	1.5	1.3	2.7
640-644	92.0	1.9	2.6	1.0

*C = colorimetric method. S = ion-exchange method. Lysine and tryptophan values in grams per 100 grams of protein (N x 6.25)

SIMPLE METHODS FOR DETERMINING LYSINE AND TRYPTOPHAN IN HIGH LYSINE AND NORMAL MAIZE.

S. S. Subramanian*, R. Jambunathan*, J. M. Concon* and E. T. Mertz.

Purdue Univ., Lafayette, Ind. 47907 and

Univ. of Kentucky, Lexington, Ky. 40506.

Plant breeders incorporating the opaque-2 and floury-2 genes into locally adapted varieties of maize need rapid inexpensive methods for lysine and tryptophan. By combining a simple extraction procedure devised by one of us (J.M.C.) with published colorimetric methods, both amino acids can be determined with adequate precision. One gram of maize is ground in a Wiley mill through a 20 mesh sieve. The powder is placed in a micro ball mill (Wig-L-Bug, Crescent Dental Mfg. Co. Chicago) for 3 minutes, suspended in 20 volumes of acetone, and passed once through a 150 mesh sieve. The suspension is filtered, and the residue air-dried. To 500 mg of residue add 0.7 ml of 70% ethanol (v/v). Mix 5 min. (Vortex-Position 6). Add 5 ml 0.5% NaOH, mix again (Pos. 6-3 min., Pos. 2-12 min.). Angle centrifuge to obtain clear supernatant. Use 0.1 ml supernatant for lysine detn. (Kakade and Liener, Anal. Biochem. 27, 273 (1969)). Use 0.5 ml supernatant for tryptophan detn. (Opienska-Blauth et al, Anal. Biochem. 6, 69 (1963)). With these procedures, normal maize gave 2.7 gm lysine/100 gm protein (ion-exchange 2.75), Indiana opaque-2 gave 4.2 gm lysine (ion-exchange 4.2), Columbian opaque-2 gave 4.6 gm lysine (ion-exchange, 5.3). Tryptophan values were 0.5, 1.0, and 1.1 resp. for these samples. (Supported by USDA Grant No. 12-14-100-7984 (71) and USDA Contract No. 12-14-100-9507 (71), Peoria, Ill.).