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for period
January 1, 1969 to June 30, 1969

Prepared by
R. C. Pickett

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

Report for period January 1, 1968 to June 30, 1969

This report includes summary information on a 1968 M.S. thesis study by Fernando Rodriguez entitled "The Influence of Population Density on the Embryo, Seed Size, Yield and other Agronomic Characters in Sorghum bicolor (L.) Moench" and a 1968 Ph.D. thesis by Ayo Abifarin entitled "Combining Ability and Heterosis for Yield, Protein, Lysine and Certain Plant Characters in Eighteen Diverse Inbreds and Fifty-six Hybrids in Sorghum bicolor (L.) Moench". The study by Rodriguez is presented in tables 1 through 12. For best yields under good conditions populations of 170,000 to 550,000 plants per hectare should be used. Due to small seed supplies and a month of cool, wet conditions following planting the stand in this study was reduced to the range reported of 86,000 to 345,000. The general rule of significant yield increases with population (plant density) increases was true in this range. The mean for all genotypes was 6037 kg/ha for the low population and 7247 kg/ha for the high population. Seed weight decreased slightly but not significantly with the increase in population. Embryo percentage, mean weight of embryo, percent oil, percent protein, and percent lysine did not change significantly with population.

Percent oil had a range among genotypes of 3.07 to 5.28% which was highly significant and important (Table 3). The oil percentage was a good guide to embryo percentage of the whole seed which varied from 10.5 to 13% (other genotypes ranged from 9.7 to 14.1% embryo) (Table 4). The correlation of the two was r = +.75. The composition of the embryo was also important with the protein varying from 18.1 to 24.7% and the lysine varying from 5.5 to 6.5% of protein (Tables 8 and 9). In the embryo free seed the protein varied from 9.4 to 12.4% which was also a significant range (Table 6), but the lowest entry (0793)* for protein in the embryo was the highest in the embryo free seed (endosperm + seed coat). The

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*All genotypes in this report are given in Hyderabad numbers. For purposes of converting to I.S. numbers please use this table:

Hyderabad	I.S.
0793	0075
0819	2319
1884	0508

lysine in the embryo free seed ranged from 0.98 to 1.33% (Table 7). On total seed analysis 0793 and 0819 were not significantly different at 13.5 and 13.4% respectively (Table 10). On lysine, however, they are at opposite ends of the scale with 0819 at 2.12% and 0793 at 1.62% lysine (Table 11). This emphasizes the importance of embryo size and improved composition of it as a major component of nutritional quality improvement in sorghum. Apparently within the range of populations tested the main effect of population is on number of seed and not size or composition of the seeds. In studies of relationship among the characters studied, protein percentage in the embryo is significantly correlated at r = +.45 with embryo percentage of the whole seed (Table 12). The highest correlation of +.89 was of percent protein of embryo free seed with percent protein in the whole seed. The percent oil, in addition to being an excellent indication of embryo percentage, is also an indicator of highest percent protein lysine and protein in the whole seed. Oil analyses will be run on all samples from all locations this year. These determinations by nuclear magnetic resonance (NMR) are by far the least expensive at 50 cents each and should be helpful indicators of quality contributed by embryos.

Abifarin's trials (Tables 13-17 incl.) showed some very high degrees of heterosis and crosses of 14 parents on to 4 male steriles. The two highest degrees of percent heterosis for grain yield of 99.7 and 141.6% were on crosses that had yield of 17,288 and 15,893 kg/ha respectively (Table 14). The third highest yielder at 13,500 kg/ha also had a very high degree of heterosis at 79%. Nine other crosses had percent heterosis of over 50%. Heterosis for protein percent was usually negative but sometimes very relatively low as in the case of the high cross, W x 2, at -6.9 and the second highest cross, C x 5, which had the high percentage heterosis for yield, was one of the greatest negative heterosis percentages of -24.2%, while the percent heterosis for lysine percent was +.1% and +13.5% respectively. The highest protein yield per acre as well as the lysine yield were present in the highest yielding cross. The second highest yielding cross (C x 5) was exceeded in protein yield (Table 17) by eight other crosses due to its negative heterosis for protein. The grain yield was positively correlated with protein yield at

.93 and with lysine yield at .78 (Table 16). Plant height was also correlated with panicle grain weight at .91, protein yield at .79, grain yield at .76, and lysine yield at .61. Leaf number is also highly significant and positively associated with these same characters. Seed size (gm/100 seeds) had positive correlations of r = +.42 with grain yield and r = +.51 with protein yield. Days to bloom was positively associated with grain yield at r = +.69 and protein yield at r = +.64.

Thus growth per day is of constant concern but within each maturity group there are variable leaf numbers and types of plant morphology. Present evidence shows distinctly superior yield and quality combinations on some of the taller and medium to later maturity types which are 6 to 9 feet tall.

Table 1. Mean grain yield of six sorghum genotypes for three population densities (Kg/ha). 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
Martin x 0793*	7,945.86	10,150.15	8,792.96	8,962.99
0819*	7,154.66	6,870.33	7,561.01	7,195.33
RS610	6,224.79	5,286.06	6,678.44	6,396.43
Martin x 1884*	4,300.00	6,549.98	8,304.38	6,384.79
0793*	5,834.03	6,030.75	6,703.16	6,189.31
Martin B	4,764.94	4,548.33	5,445.95	4,919.74
Grand Mean	6,037.38	6,739.26	7,247.65	6,674.76

*All genotypes in this report are given in Hyderabad numbers. For purposes of converting to I.S. numbers please use this table:

Hyderabad	I.S.
0793	0075
0819	2319
1884	0508

Table 2. Mean 100 seed weight of six sorghum genotypes for three population densities (gm). 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0793	4.20	4.01	3.86	4.02
Martin x 0793	3.79	3.72	3.65	3.72
0819	3.59	3.65	3.42	3.55
Martin x 1884	2.83	3.09	2.93	2.95
RS610	2.71	2.76	2.70	2.72
Martin B	2.73	2.59	2.56	2.63
Grand Mean	3.31	3.30	3.19	3.26

Table 3. Mean percent oil in the seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	5.22	5.47	5.12	5.28
Martin B	3.53	3.52	3.42	3.49
Martin x 0793	3.40	3.50	3.42	3.44
0793	3.25	3.42	3.32	3.33
RS610	3.25	3.22	3.38	3.28
Martin x 1884	3.00	3.07	3.13	3.07
Grand Mean	3.61	3.70	3.63	3.65

Table 4. Mean embryo as percent of the whole seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	13.50	13.98	14.15	13.88
RS610	12.05	12.30	12.05	12.13
Martin B	11.25	11.45	11.77	11.49
Martin x 0793	10.85	11.35	11.50	11.23
Martin x 1884	10.90	11.10	10.65	10.88
0793	10.60	10.40	10.55	10.52
Grand Mean	11.53	11.76	11.78	11.69

Table 5. Mean weight of the embryo of six sorghum genotypes for three population densities (mg). 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	4.63	4.82	4.67	4.71
Martin x 0793	3.95	3.97	4.02	3.98
0793	4.00	4.00	3.87	3.96
RS610	2.92	3.22	3.28	3.13
Martin x 1884	3.05	3.28	3.02	3.12
Martin B	2.90	2.82	2.90	2.88
Grand Mean	3.57	3.69	3.63	3.63

Table 6. Mean percent protein in the embryo free seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0793	13.00	12.20	11.85	12.36
0819	12.28	11.80	11.03	11.70
Martin B	11.80	12.13	10.85	11.59
Martin x 0793	11.17	10.43	10.78	10.79
RS610	9.80	9.70	9.30	9.60
Martin x 1884	9.55	9.55	8.95	9.35
Grand Mean	11.27	10.97	10.47	10.90

Table 7. Mean lysine as percent of protein in the embryo free seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	1.30	1.30	1.40	1.33
Martin x 1884	1.12	1.24	1.19	1.18
Martin x 0793	1.15	1.12	1.13	1.13
RS610	1.02	1.13	1.12	1.09
0793	1.02	1.11	1.10	1.08
Martin B	0.88	0.99	1.08	0.98
Grand Mean	1.08	1.15	1.17	1.13

Table 8. Mean percent protein in the embryo of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotypes	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	23.45	25.13	25.47	24.68
Martin x 1884	20.98	21.75	25.85	22.86
RS610	22.28	22.73	23.35	22.78
Martin B	23.32	20.48	23.75	22.52
Martin x 0793	20.50	22.68	20.75	21.31
0793	16.30	19.13	19.00	18.14
Grand Mean	21.14	21.98	23.03	22.05

Table 9. Mean lysine as percent of protein in the embryo of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana

Genotypes	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
Martin B	6.60	6.87	5.95	6.47
0819	5.50	6.75	6.22	6.16
RS610	6.51	5.55	5.49	5.85
0793	6.74	5.60	4.90	5.75
Martin x 0793	5.85	5.20	6.01	5.69
Martin x 1884	5.66	5.23	5.62	5.50
Grand Mean	6.14	5.87	5.70	5.90

Table 10. Mean percent protein in the whole seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0793	13.93	13.53	13.10	13.52
0819	13.87	13.55	12.73	13.38
Martin B	13.68	13.50	12.55	13.24
Martin x 0793	12.28	11.95	12.00	12.08
RS610	11.05	11.10	10.70	10.95
Martin x 1884	10.77	10.57	10.45	10.60
Grand Mean	12.60	12.37	11.92	12.30

Table 11. Mean lysine as percent of protein in the whole seed of six sorghum genotypes for three population densities. 1968, Lafayette, Indiana.

Genotype	Population (Plants/Hectare)			
	86,450	172,900	345,800	Mean
0819	1.92	2.19	2.24	2.12
Martin x 1884	1.98	2.03	2.08	2.03
RS610	2.02	1.98	2.03	2.00
Martin x 0793	1.89	1.81	1.89	1.86
Martin B	1.77	1.78	1.94	1.82
0793	1.62	1.66	1.57	1.62
Grand Mean	1.87	1.91	1.96	1.91

Table 12. Simple correlation coefficients among 16 characters of six sorghum genotypes over three population densities. 1968, Lafayette, Indiana.

	Head exertion	Plant height	Wt. of 100 seeds	Yield	Length of flag leaf	Width of flag leaf	Embryo weight	Embryo % of whole seed	% oil in the seed	% protein in embryo free seed	% lysine in embryo free seed++	% protein in whole seed	% lysine in whole seed++	% protein in embryo	% lysine in embryo++
Panicle length	.51**	-.48**	-.47**	-.09	.54**	-.18	-.65**	-.47**	-.68**	-.48**	-.33*	-.53**	.03	-.05	-.02
Head exertion		-.50**	-.40**	-.04	.01	-.43**	-.59**	-.49**	-.69**	-.44**	-.28*	-.45**	-.21	-.05	-.22
Plant height			.75**	.44**	.10	.56**	.80**	.24	.58**	.30*	.54**	.27	.08	-.04	-.04
Weight of 100 seeds				.35*	.21	.64**	.75**	-.07	.26	.50**	.17	.45**	-.30*	-.22	-.03
Yield					.05	.17	.31*	.05	.15	-.19	.33*	-.18	.21	.07	-.09
Length of flag leaf						.64**	-.11	-.44**	-.30*	.07	-.32*	-.04	-.17	-.28*	.16
Width of flag leaf							.42**	-.15	.22	.52**	-.13	.46**	-.27	-.24	.16
Embryo weight								.56**	.67**	.34*	.47**	.39**	.12	.11	-.02
Embryo % of whole seed									.75**	-.03	.48**	.11	.51**	.45**	-.01
% oil in seed										.33*	.53*	.44**	.35*	.27	.08
% protein in embryo free seed											-.21	.89**	-.47**	-.47**	.39**
% lysine in embryo free seed++												-.13	.42**	.34*	-.34*
% protein in whole seed													-.45**	-.05	.13
% lysine in whole seed++														.26	.33*
% protein in embryo															-.63**

*Significant at the .05 level
**Significant at the .01 level
++Lysine as percent of the protein

Table [illegible] Identification of the male and female parents used in the male sterile crosses[1]

Code	1963 Hyderabad No.	I.S. No.	Group No.	Group Name	Pedigree
1	1042	2822	38	Caudatum-Kafir	Red Swazi local
2	3914	5437	38	Caudatum-Kafir	Iyungu c olam
3	922	855	28	Caffrorum-Durra	SA 1797 Gurno
4	1748	129	38	Caudatum-Kafir	Hegari 6645-11-1-1-2
5	1736	115	38	Caudatum-Kafir	DD Wh. Heg. SA 6645-4
6	5365	6974	38	Caudatum-Kafir	280 Geterita Gondalz 12
7	5300	3441	33	Caudatum	178 Abu Kudar
8	1027	8295	38	Caudatum-Kafir	E C 21496 Z-8
9	5170	3568	33	Caudatum	137 Wad Habis
10	2499	3977	22	Caffrorum	SA 9602 - 1 Short DD SS Yek
11	2191	2936	22	Caffrorum	SA 8026-2-5-2
12	2197	2942	22	Caffrorum	SA 8026-1-24-M-2
13	Unknown				Inbred Selection from CK 60xH 7910
14	Unknown				Inbred Selection from 7763/55Hx1308
15	RS 610				
16	Wheatland B line				Wheatland (W)
17	Combine Kafir 60 B line				Combine Kafir 60 (C or CK 60)
18	Redlan B line				Redline (R)
19	Martin B line				Martin (M)

[1] Most of these informations were obtained from the Indian Journal of Genetics & Plant Breeding, Vol. 27, 1967.

Table 14 Percent heterosis[1] of 56 F_1 hybrids for grain yields, protein %, lysine %, protein yield, and lysine yield

Grain yield rank	F_1 hybrid	Grain yield	Protein %	Lysine %	Protein yield	Lysine yield
1	W x 2	99.7**	-6.9	1.0	115.1*	122.0**
2	C x 5	141.6**	-24.2**	13.5*	84.4**	109.6**
3	C x 2	79.1**	-4.6	2.0	87.3**	91.1**
4	R x 7	41.8**	1.0	8.5	39.2**	60.2**
5	R x 2	38.6**	-1.9	1.0	38.3**	44.8**
6	C x 7	40.4**	1.9	5.5	44.8**	51.6**
7	R x 8	35.7**	4.6	-2.6	42.5**	41.2**
8	M x 8	35.6**	-17.6**	-1.0	48.4**	78.5**
9	R x 4	34.1**	-12.3**	10.8*	25.8**	50.5**
10	W x 5	79.2**	-21.7**	10.5	43.0**	75.2**
11	W x 8	28.1	2.6	-4.2	35.8**	28.8*
12	R x 1	27.5	4.6	-4.1	35.0**	36.7**
13	R x 5	26.8	-20.8**	4.5	12.8	24.3**
14	M x 5	86.6**	-26.1**	0.0	25.8**	55.4**
15	M x 1	67.9**	-14.1**	-7.5	43.8**	43.6**
16	R x 9	23.9	-1.9	-5.3	22.6*	27.6
17	R x 3	23.1	-9.8**	-2.2	26.1**	21.0
18	W x 4	68.5**	-16.4**	0.5	40.9**	55.6**
19	W x 1	27.0	-4.3	-5.6	35.3**	22.5
20	M x 4	59.9**	-15.5**	-14.7**	31.4**	43.5*
21	C x 8	18.6	-0.9	7.2	17.0*	26.0
22	C x 4	73.9**	-18.6**	7.4	41.7**	51.8**
23	M x 2	40.3**	-19.0**	-4.1	27.2**	48.0**
24	M x 3	61.1**	-9.8**	1.1	50.4**	55.5**
25	M x 7	18.7	-16.2**	9.5	28.6**	48.3**
26	M x 9	41.3**	-15.5**	-6.8	28.8**	48.1**
27	M x 3	49.6**	-15.5**	-5.6	26.2**	32.8
28	R x 11	11.1	-5.3	2.6	11.2	18.1
29	C x 9	37.0*	-5.6	-1.0	28.9*	28.1
30	C x 10	75.5**	-5.5	-2.3	71.3**	76.4**
31	C x 3	75.3**	-9.8*	-1.7	71.9**	69.2**
32	W x 7	11.6	-6.0	0.0	17.0*	14.7
33	C x 11	62.8*	-13.4**	6.6	39.1**	47.5*
34	W x 12	38.5	-28.0**	21.5**	35.2**	66.4**
35	W x 9	16.6	-3.0	-10.6*	22.2*	2.2
36	C x 1	-0.5	13.3**	-3.0	12.4	7.8
37	M x 11	24.8	-17.6**	-1.5	2.9	23.2

Table 14 (cont'd.)

Grain yield rank	F_1 hybrid	Grain yield	Protein %	Lysine %	Protein yield	Lysine yield
38	R x 10	-7.7	-9.2	2.7	-13.9	1.9
39	M x 14	20.5	0.7	-2.2	21.0*	33.9
40	W x 11	23.5	-22.0**	6.6	3.6	17.9
41	M x 10	18.4	-19.0**	-8.2	-3.8	19.8
42	W x 13	18.6	-4.7	1.1	12.4	26.6
43	R x 13	-12.9	-14.1**	1.6	-8.7	-11.4
44	R x 12	-15.3	-34.4**	11.4*	-18.3*	-10.5
45	R x 6	-17.2	-11.8**	3.8	-12.7	-11.4
46	C x 12	31.2	-27.4**	4.8	34.9*	45.4
47	W x 14	12.8	-8.7**	-1.1	23.0*	23.9
48	M x 12	-3.2	-24.6**	13.3*	-19.9*	0.6
49	C x 6	15.1	-7.9*	1.1	2.5	14.8
50	R x 14	-29.7*	-14.5**	0.5	-22.7*	-23.8
51	C x 13	-5.2	-2.5	-2.2	-11.9	0.0
52	W x 10	-5.1	-7.8*	-6.8	-13.5	0.6
53	M x 6	-9.5	-9.9**	10.8	-19.4*	-6.8
54	M x 13	-12.6	-5.6	14.8*	-17.2*	-2.8
55	W x 6	-11.0	-11.0**	12.7*	-13.9	-1.3
56	C x 14	-9.2	-13.0**	1.6	-11.4	0.8

[1]Heterosis = percent above better parent

[2]Yield rank: hybrids are presented in descending order of grain yields

[3]Percentage lysine is the proportion of lysine in the protein

*Significant at the .05 level

**Significant at the .01 level

Table 15 Percent heterosis[1] of 56 F_1 hybrids for grain weight per panicle, 100 seed weight, and days to half bloom

Grain yield rank[2]	F_1 hybrids	Panicle grain weight	100 seed weight	Days to half bloom
1	W x 2	43.2**	0.0	11.7**
2	C x 5	54.3*	4.2	5.5**
3	C x 2	60.0**	29.2**	6.2**
4	R x 7	60.0**	-3.8	1.1
5	R x 2	57.3**	11.5	13.0**
6	C x 7	90.4**	16.7*	-3.4**
7	R x 8	57.8**	26.9**	-0.2
8	M x 8	104.4**	23.1**	-5.8
9	R x 4	15.7	-7.7	0.5
10	W x 5	38.7	-17.9**	9.8
11	W x 8	100.9**	25.0**	-1.0
12	R x 1	56.6**	23.1**	6.2**
13	R x 5	55.8*	-11.5	5.2**
14	M x 5	75.4**	0.0	0.0
15	M x 1	81.3**	20.0**	6.2**
16	R.x 9	92.4**	3.8	-3.3*
17	R x 3	43.0	3.6	-6.4**
18	W x 4	37.2	-14.3*	1.6
19	W x 1	83.8**	21.4**	6.2**
20	M x 4	9.4	0.0	1.3
21	C x 8	67.5**	26.9**	-7.3**
22	C x 4	31.2	0.0	7.3**
23	M x 2	57.3**	30.4**	7.8**
24	M x 3	41.2	3.6	-3.1*
25	M x 7	91.2**	13.0	-1.8
26	M x 9	103.[illegible]**	4.3	-3.3
27	M x 3	38.5	16.7*	-5.9
28	R x 11	56.7**	-7.7	-3.6
29	C x 9	18.1	20.8**	-4.6**
30	C x 10	20.6	4.2	-6.6**
31	C x 3	31.8*	20.8**	-8.7**
32	W x 7	24.2**	-10.7	1.8
33	C x 11	41.3	4.2	-10.0**
34	W x 12	1.7	-17.2**	-3.2**
35	W x 9	42.0	7.1	-14.3**
36	C x 1	38.2	28.0**	5.7**
37	M x 11	36.6	0.0	-13.0*

Table 15 (cont'd)

Grain yield rank[2]	F_1 hybrids	Panicle grain weight	100 seed weight	Days to half bloom
38	R x 10	25.8	-11.5	-1.5
39	M x 14	-13.6	-4.7	-8.2**
40	W x 11	11.3	-14.3*	-4.6**
41	M x 10	27.1	4.3	-7.7**
42	W x 13	-13.3	7.1	-0.7
43	R x 13	-31.4	-3.6	-1.0
44	R x 12	3.1	-10.4	-4.2**
45	R x 6	-8.1	-7.4	-12.2**
46	C x 12	49.5*	-6.9	-10.5**
47	W x 14	3.8	-7.2	-2.3
48	M x 12	29.6	-13.8*	-8.0**
49	C x 6	15.2	-7.4	-4.8**
50	R x 14	7.7	-11.5	-2.3
51	C x 13	-21.5	-14.3*	-3.5*
52	W x 10	-1.7	-21.4	-2.9
53	M x 6	-6.2	-18.5**	-8.2**
54	M x 13	-3.8	-10.7	-2.8
55	W x 6	-24.9	-50.0*	-11.1**
56	C x 14	-11.4	-4.2	-8.2**
Means				

[1]Heterosis - percent above the better parent

[2]Grain yield rank: hybrids are presented in descending order of grain yield

*Significant at the .05 level

**Significant at the .01 level

Table 16. Intercharacter phenotypic correlation coefficient for the 56 F_1 hybrids grown in 1968[1]

Character	Leaf No.	Height	Leaf area	Panicle exertion	Panicle length	Thresher %	Panicle grain weight	100 seed weight	Protein %	Lysine %	Grain yield	Protein yield	Lysine yield
Days to bloom	.90**	.80**	.58**	-.09	-.12	.45**	.82**	.34*	-.36**	.32*	.69**	.64**	.60**
Leaf number		.82**	.45**	-.12	-.15	.54**	.84**	.46**	-.31*	.29*	.69**	.67**	.61**
Plant height			.41**	.01	-.23	.73**	.91**	.63**	-.21	.07	.76**	.79**	.61**
Leaf area				.04	.28*	.14	.47**	-.09	-.30*	.30*	.38**	.32*	.28*
Panicle exertion					.03	-.19	.13	-.14	.48**	-.18	-.12	.06	.08
Panicle length						-.32*	-.15	-.41**	-.17	.42**	-.23*	-.30*	-.08
Threshing %							.73**	.56**	-.25	-.04	.71**	.78**	.48**
Panicle grain weight								.62**	-.31*	.15	.78**	.93**	.60**
100 seed weight									.02	-.29*	.42**	.51**	.32*
Protein %										- 69**	-.48**	-.14	-.38**
Lysine %											.26	-.00	.34**
Grain yield												.93**	.78**
Protein yield													.73**

*Significant at the .05 level
**Significant at the .01 level
[1]With 54 degrees of freedom values of .264 and .342 are significant at the .05 and .01 level respectively

Table 17. Mean values of grain yields, grain weight per panicle, seed weight, % protein, % lysine, protein yield, and lysine yield for 56 F_1's grown in 1968

Hybrids	Grain yield (kg/ha)	Grain wt./ panicle (gm)	100 seed wt. (gm)	Protein %	Lysine %	Protein yield (kg/ha)	Lysine yield (kg/ha)
1 W x 2	17,288	123.7	2.8	10.8	1.98	1,876	37.3
2 C x 5	15,893	81.0	2.5	9.1	2.27	1,448	32.9
3 C x 2	15,506	108.0	3.1	10.3	2.00	1,605	32.1
4 R x 7	14,700	103.5	2.5	10.5	2.17	1,545	33.8
5 R x 2	14,358	106.2	2.9	10.6	1.98	1,535	30.4
6 C x 7	14,166	123.2	2.8	10.7	2.11	1,520	32.0
7 R x 8	14,061	100.5	3.3	11.3	1.88	1,588	29.8
8 M x 8	14,044	130.2	3.2	11.7	1.91	1,653	31.6
9 R x 4	13,900	77.2	2.4	10.0	2.26	1,396	31.6
10 W x 5	13,405	83.5	2.3	9.4	2.21	1,247	27.5
11 W x 8	13,274	128.0	3.5	11.3	1.85	1,513	27.7
12 R x 1	13,218	103.7	3.2	11.3	1.91	1,499	28.7
13 R x 5	13,141	90.7	2.3	9.5	2.09	1,252	26.1
14 M x 5	13,035	84.2	2.3	10.5	2.00	1,390	27.5
15 M x 1	12,960	120.0	3.0	12.2	1.84	1,589	29.3
16 R x 9	12,833	112.0	2.7	10.6	1.96	1,359	26.8
17 R x 3	12,758	83.2	2.9	11.0	1.81	1,400	25.4
18 W x 4	12,605	91.5	2.4	9.7	2.05	1,229	25.2
19 W x 1	12,397	121.7	3.4	11.1	1.85	1,380	25.0
20 M x 4	12,360	73.0	2.3	12.0	1.74	1,452	25.4
21 C x 8	12,289	106.7	3.3	10.6	2.07	1,304	27.1
22 C x 4	12,184	87.5	2.4	9.2	2.19	1,122	24.6
23 M x 2	12,145	106.2	3.0	11.5	1.88	1,406	26.2

Table 17. (cont'd.)

Hybrids	Grain yield (kg/ha)	Grain wt./ panicle (gm)	100 weed wt. (gm)	Protein %	Lysine %	Protein yield (kg/ha)	Lysine yield (kg/ha)
24 W x 3	12,053	85.0	2.9	11.0	1.83	1,312	24.1
25 M x 7	11,980	123.7	2.6	11.9	2.19	1,421	31.3
26 M x 9	11,864	102.0	2.4	12.0	1.93	1,423	22.4
27 M x 3	11,567	66.5	2.8	12.0	1.69	1,395	23.5
28 R x 11	11,511	91.2	2.4	10.7	2.01	1,234	24.8
29 C x 9	11,500	114.5	2.9	10.1	2.05	1,160	23.7
30 C x 10	11,311	63.0	2.5	10.3	2.14	1,180	25.4
31 C x 3	11,294	69.2	2.9	11.0	1.76	[illegible]	22.0
32 W x 7	11,262	112.7	2.5	10.9	2.00	1,228	24.2
33 C x 11	10,4[illegible]	[illegible].2	2.5	11.0	2.09	1,153	23.9
34 W x 12	10,357	61.2	2.4	11.3	2.20	1,179	25.8
35 W x 9	9,785	85.5	3.0	11.2	1.85	1,100	18.9
36 C x 1	9,707	91.5	3.2	11.9	1.93	1,147	22.0
37 M x 11	9,647	67.5	2.3	11.7	1.93	1,137	21.8
38 R x 10	9,568	73.2	2.3	9.9	2.25	[illegible]	21.4
39 M x 14	9,316	41.5	2.3	14.3	1.78	1,337	23.7
40 W x 11	9,236	67.0	2.4	9.9	2.09	903	19.1
41 M x 10	9,155	61.0	2.4	[illegible]	2.01	1,063	21.2
42 W x 13	9,034	68.5	3.0	[illegible].2	1.83	1,099	20.0
43 R x 13	9,024	54.2	2.7	11.0	1.88	1,013	18.6
44 R x 12	8,781	60.0	2.6	10.3	2.06	907	18.8
45 R x 6	8,576	53.5	2.5	11.2	1.92	969	18.6
46 C x 12	8,458	78.5	2.7	11.4	1.95	971	18.9
47 W x 14	3,441	62.5	2.6	12.6	1.80	1,073	19.2
48 M x 12	7,478	62.2	2.5	11.8	2.04	885	17.8
49 C x 6	7,415	60.5	2.5	11.7	1.88	871	16.3
50 R x 14	7,284	62.7	2.3	11.8	1.86	858	16.0

Table 17. (cont'd.)

Hybrids	Grain yield (kg/ha)	Grain wt./ panicle (gm)	100 seed wt. (gm)	Protein %	Lysine %	Protein yield (kg/ha)	Lysine yield (kg/ha)
51 R x 14	7,226	41.2	2.4	11.9	1.82	862	15.8
52 W x 10	7,097	59.2	2.2	10.7	2.04	754	15.6
53 M x 6	6,996	45.0	2.2	12.8	1.85	891	16.5
54 M x 13	6,753	46.2	2.5	13.4	1.86	915	17.2
55 W x 6	6,661	45.2	1.4	11.3	2.04	751	15.3
56 C x 14	5,854	46.5	2.3	12.0	1.89	702	13.3
RS 610	7,645	55.2		12.1	1.93	930	17.7
LSD .05 level	1,624	25.3	0.36	1.0	0.22	186	6.0
LSD .01 level	2,301	35.8	0.51	1.4	0.31	263	8.4

Table 18. Mean of the parental lines for grain yield and RS 610 and other characters

Parents	Yield (kg/ha)	Days to bloom	Leaf no.	Height (cm)	Flag leaf area	Threshing %	Panicle grain wt.	100 seed wt.	Panicle exertion	Panicle length	Protein %	Lysine %	Protein yield	Lysine yield
18	10,363	96.2	12.1	143.7	117.6	76.9	58.2	2.6	7.6	21.5	10.8	1.85	1,110	21.0
8	10,360	103.2	14.2	187.5	190.4	78.7	63.7	2.6	-3.2	21.3	10.7	1.93	1,114	21.5
7	10,090	111.5	15.5	185.0	261.8	79.9	64.7	2.2	8.5	22.9	10.4	2.00	1,050	21.1
1	9,757	96.2	12.0	166.2	146.3	80.4	66.2	2.5	1.2	21.3	10.4	1.99	1,020	20.4
2	8,658	96.2	12.0	175.0	207.1	78.2	67.5	2.3	3.0	20.4	9.9	1.96	854	16.8
9	8,394	112.2	16.0	211.2	220.6	77.5	50.2	1.7	4.6	26.2	10.7	2.07	900	18.5
19	7,729	89.5	11.7	131.2	146.0	76.0	48.0	2.3	10.5	29.6	14.2	1.60	1,105	17.7
RS610	7,645	81.5	10.5	137.5	133.1	77.6	55.2	2.4	10.8	24.4	12.1	1.93	930	17.7
13	7,620	91.2	11.7	123.7	152.6	76.3	46.5	2.8	10.4	22.3	12.8	1.62	978	15.8
16	7,480	95.2	12.5	108.7	157.1	79.0	60.2	2.8	5.6	28.7	11.6	1.81	872	15.5
4	7,005	89.2	11.7	108.7	124.8	67.2	66.7	2.1	5.0	20.0	11.3	2.04	792	16.2
6	6,652	81.5	9.7	125.0	115.1	72.7	40.7	2.7	11.2	29.6	12.7	1.67	850	14.2
5	6,579	94.5	11.5	107.5	149.2	64.8	29.7	2.1	-1.9	22.2	12.0	2.00	785	15.7
17	6,444	89.0	10.5	130.0	120.9	75.7	52.5	2.4	8.5	23.8	10.5	1.86	689	13.0
11	6,306	101.7	12.0	156.2	139.7	75.1	49.5	2.2	7.4	32.6	12.7	1.96	829	16.2
3	5,960	98.0	12.0	172.5	117.9	77.4	41.7	2.4	12.4	18.7	12.2	1.79	726	12.7
10	5,940	98.0	11.7	125.0	121.1	72.7	42.5	2.3	6.9	35.3	10.9	2.19	663	14.4
14	5,334	97.2	12.5	91.2	129.8	75.6	34.2	2.4	4.4	23.3	13.8	1.82	731	13.2
12	4,601	99.7	12.5	117.5	124.5	66.3	36.5	2.9	4.8	30.8	15.7	1.80	720	12.9
LSD .05	996	2.7	1.5	7.6	49.0	9.5	30.4	.38	5.0	5.2	1.1	0.23	112	9.5
LSD .01	1,411	3.9	2.2	10.8	69.3	13.5	43.0	.54	7.0	7.4	1.5	0.32	159	13.4