Evaluation of amino acid content of GEM germplasm

GEM Cooperator's report
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Summary
Amino Acid content is an important quality trait in grain used for animal feed. We analyzed the amino acids Methionine (M), Tryptophan (W) and Lysine (K) in GEM germplasm produced in the 2006 growing season in Ames, Iowa. Two experiments were carried out. The first was a screening experiment to identify GEM material with unusual amino acid composition. GEM accessions with Amino Acid content similar to high M and K checks were identified in two-year evaluations. In four year evaluations, the high amino acid checks were superior to the GEM accessions. The second experiment is an evaluation of hybrids based on GEM germplasm. This experiment was produced at two locations and will be repeated next year.

Protocol
Grain samples were hand harvested and shelled in bulk. Protein, oil and starch were determined by Susan Duvick using NIR spectroscopy. Grain samples were then ground to a fine powder. The amino acids M, W and K were analyzed using high-throughput microbial screening methods developed in our laboratory (Scott et al., 2004; Darrigues et al., 2005). Each sample was analyzed in triplicate. An index value was calculated with M, W and K each weighted equally and the mean value of the experiment equal to 1. Each amino acid was analyzed on a per mass basis and on a per protein basis. ANOVA was used to determine that the variation among entries was statistically significant ($P<.05$) in each experiment. Mean values of each entry were compared using pair-wise Student's T tests. High check samples were B45o2, a mutant inbred line with exceptional W content and High lysine content and B101, an inbred line with high methionine content. B73, Mo17 and B73xMo17 were included as normal checks. In the hybrid trials, it should be noted that while B101 is a high methionine check inbred, the high methionine trait in this line exhibits unusual inheritance and is often not present in hybrid combinations containing B101.

Results
The results of two year evaluations (2005, 2006) and four year (2003-2006) evaluations of GEM germplasm are presented in the attached tables, followed by two-location, one year analysis of GEM hybrids. Values in tables are in g AA/ 100g grain. The values for lysine are considerably lower than values obtained by other methods, however based on check results the ranking of samples is probably still good. In the four year evaluations, DKXL212:N11a-139 (which originated in Jim Hawk's program at U of Delaware) was the highest GEM line in the overall quality index due to its good methionine and lysine content. In the two year evaluations Major Goodman's lines derived from XL370 and XL380 did well overall. A trend is emerging in which GEM lines derived from 50%

exotic breeding crosses involving Brazilian tropical hybrids (for example XL370, XL380 and XL212) are among the best for amino acid levels.

Recommendations

Over the past 5 years we have screened a large amount of GEM germplasm and identified germplasm that is marginally better than commercial germplasm. In order to develop germplasm with substantially improved amino acid content, I propose the following approach: Screening remains important; however I suggest that it must be accompanied by the following additional activities: 1. Recurrent selection within GEM germplasm accessions to develop improved inbred lines. 2. Recombination between GEM germplasm accessions to produce synthetic populations specifically designed for improved amino acid content. 3. Evaluation of the amino acid content of hybrid combinations. Implementing these suggestions will require an increased effort in this area; however the result is likely to be superior to results obtained from screening alone.

References

Scott, M. P., S. Bhatnager, et al. (2004). "Tryptophan and methionine levels in quality protein maize breeding germplasm." Maydica **49**: 303-311.

Darrigues, A., C. Buffard, et al. (2005). "Variability and genetic effects for tryptophan and methionine in commercial maize germplasm." Maydica **50**(2): 147-156.

Four Year Evaluations:

Methionine

B101	A			0.1879862
DKXL212:N11a-139-1-1-B-B-B		B		0.16287889
CUBA117:S15-372-1-B-B-B		B		0.15363763
B73		B		0.15286668
AR16035:S02-450-1-B-B-B-B		B		0.14642064
FS8B(S):S0316-814-1-B-B		B		0.14540697
B45 o2			C	0.11686598
B73 x Mo17-B			C	0.11421111
FS8B(T):N1802-382-1-B-B			C	0.11330305
Mo17			C	0.09650203

Tryptophan

B45 o2	A		0.16774086
FS8B(S):S0316-814-1-B-B		B	0.11480016
FS8B(T):N1802-382-1-B-B		B	0.11111858
B101		B	0.10441095
B73		B	0.10356111
DKXL212:N11a-139-1-1-B-B-B		B	0.10285354
Mo17		B	0.09760135
CUBA117:S15-372-1-B-B-B		B	0.0975791
AR16035:S02-450-1-B-B-B-B		B	0.09751587
B73 x Mo17-B		B	0.09722297

Lysine

B45 o2	A			0.13109522
Mo17	A	B		0.11627822
DKXL212:N11a-139-1-1-B-B-B	A	B	C	0.10564622
FS8B(T):N1802-382-1-B-B		B	C	0.09466896
B101			C	0.08555753
CUBA117:S15-372-1-B-B-B			C	0.08477804
B73 x Mo17-B			C	0.08260734
AR16035:S02-450-1-B-B-B-B			C	0.08125639
FS8B(S):S0316-814-1-B-B			C	0.0807326
B73			C	0.07809486

Four Year Evaluations (Continued)

Index

B45 o2	A			1.35724201
DKXL212:N11a-139-1-1-B-B-B		B		1.15230533
B101		B		1.13368383
FS8B(S):S0316-814-1-B-B		B	C	1.04646009
CUBA117:S15-372-1-B-B-B		B	C	1.02727607
Mo17		B	C	1.02238666
B73		B	C	1.01707107
FS8B(T):N1802-382-1-B-B		B	C	1.01628865
AR16035:S02-450-1-B-B-B-B		B	C	0.99545646
B73 x Mo17-B			C	0.92393031

Protein

AR16035:S02-450-1-B-B-B-B	A					14.4869633
FS8B(S):S0316-814-1-B-B	A	B				14.0454133
B73 x Mo17-B	A	B				13.8243722
B73	A	B	C			13.5462116
DKXL212:N11a-139-1-1-B-B-B	A	B	C	D		13.2524633
Mo17	A	B	C	D		12.8563613
B101	A	B	C	D		12.8364633
CHIS740:S1411a-783-2-B-B-B		B	C	D		12.6868169
FS8B(T):N1802-382-1-B-B			C	D	E	11.9076972
CUBA117:S15-372-1-B-B-B				D	E	11.6638846
B45 o2					E	10.6984633

Methione/Protein

B101	A							0.01476167
CHIS740:S1411a-783-2-B-B-B	A	B						0.01333702
CUBA117:S15-372-1-B-B-B		B	C					0.01259462
B73			C	D				0.01160776
DKXL212:N11a-139-1-1-B-B-B			C	D				0.01101066
B45 o2				D				0.01073632
FS8B(S):S0316-814-1-B-B				D	E			0.01051782
AR16035:S02-450-1-B-B-B-B				D	E			0.01039116
FS8B(T):N1802-382-1-B-B					E	F		0.00900752
B73 x Mo17-B						F	G	0.00806051
Mo17							G	0.00740579

Four Year Evaluations (continued)

Tryptophan/Protein

B45 o2	A			0.01715333
FS8B(T):N1802-382-1-B-B		B		0.00936938
FS8B(S):S0316-814-1-B-B		B	C	0.00830333
CUBA117:S15-372-1-B-B-B		B	C	0.00826019
B101		B	C	0.00783253
CHIS740:S1411a-783-2-B-B-B		B	C	0.00766003
B73		B	C	0.00727974
DKXL212:N11a-139-1-1-B-B-B		B	C	0.00721298
AR16035:S02-450-1-B-B-B-B		B	C	0.00720927
Mo17		B	C	0.00719573
B73 x Mo17-B			C	0.00656535

Lysine/Protein

B45 o2	A		0.01524767
Mo17		B	0.00969404
DKXL212:N11a-139-1-1-B-B-B		B	0.00831539
FS8B(T):N1802-382-1-B-B		B	0.00750456
CUBA117:S15-372-1-B-B-B		B	0.00745212
CHIS740:S1411a-783-2-B-B-B		B	0.00699249
B101		B	0.00592502
B73		B	0.00555146
B73 x Mo17-B		B	0.00540694
FS8B(S):S0316-814-1-B-B		B	0.00534554
AR16035:S02-450-1-B-B-B-B		B	0.00520079

Index/ protein

B45 o2	A		0.14353036
CUBA117:S15-372-1-B-B-B		B	0.08712678
CHIS740:S1411a-783-2-B-B-B		B	0.08505395
B101		B	0.08456696
DKXL212:N11a-139-1-1-B-B-B		B	0.08358139
FS8B(T):N1802-382-1-B-B		B	0.08242679
Mo17		B	0.08069759
B73		B	0.07378837
FS8B(S):S0316-814-1-B-B		B	0.07365075
AR16035:S02-450-1-B-B-B-B		B	0.06923608
B73 x Mo17-B		B	0.06250643

Two Year Evaluations:

Metionine

DKXL380:S11 F2S4 2282-01)-Sib	A												0.20072609
B101	A	B											0.18078531
1881-002/98_DKXL370AN11F2S3_7521-05-B	A	B											0.17924115
1883-001/98_DKXL370AN11F2S3_7521-05-B	A	B	C										0.17742805
2258-03_XL380_S11_F2S4_71/97_Bulk/98	A	B	C	D	E	F	G	H					0.17594183
1895-001/98_DKXL370AN11F2S3_7521-29-B	A	B	C	D									0.1756462
UR11003:S0302-1011-001-B-B-B	A	B	C	D	E								0.17485601
1883-002/98_DKXL370AN11F2S3_7521-05-B	A	B	C	D	E	F							0.17419722
1886-003/98_DKXL370AN11F2S3_7521-05-B	A	B	C	D	E	F	G						0.1690743
CHIS740:S1411a-783-2-B-B-B		B	C	D	E	F	G	H					0.16409317
B73		B	C	D	E	F	G	H	I				0.15450705
CH05015:N1204-057-001-B-B-B		B	C	D	E	F	G	H	I				0.15205515
AR16035:S02-450-1-B-B-B-B			C	D	E	F	G	H	I	J			0.14462607
FS8B(S):S0316-814-1-B-B				D	E	F	G	H	I	J	K		0.14145011
CUBA117:S15-372-1-B-B-B					E	F	G	H	I	J	K		0.140734
DKXL212:N11a-139-1-1-B-B-B						F	G	H	I	J	K		0.1398598
XL370A:S11 F2S4 2228-03)-Sib-B-B-B							G	H	I	J	K		0.13768388
DREP150:N2011d-624-1-B-B								H	I	J	K	L	0.13381629
MDI022:N2120-253-001-B-B									I	J	K	L	0.12234646
AR17056:N2035-421-001-B-B										J	K	L	M	0.11684662
B45 o2											K	L	M	0.10756462
B73 x Mo17-B											K	L	M	0.10704322
FS8B(T):N1802-382-1-B-B												L	M	0.09952796
Mo17													M	0.08398588

Two Year Evaluations (continued)

Tryptophan

B45 o2	A		0.17508379
FS8B(T):N1802-382-1-B-B		B	0.10785148
FS8B(S):S0316-814-1-B-B		B	0.10554663
UR11003:S0302-1011-001-B-B-B		B	0.1013529
2258-03_XL380_S11_F2S4_71/97_Bulk/98		B	0.10029079
1895-001/98_DKXL370AN11F2S3_7521-29-B		B	0.0988245
AR17056:N2035-421-001-B-B		B	0.09836391
1883-002/98_DKXL370AN11F2S3_7521-05-B		B	0.09672205
DKXL380:S11 F2S4 2282-01)-Sib-B-B-B		B	0.09462218
AR16035:S02-450-1-B-B-B-B		B	0.09372279
1886-003/98_DKXL370AN11F2S3_7521-05-B		B	0.09279471
1881-002/98_DKXL370AN11F2S3_7521-05-B		B	0.09266474
XL370A:S11 F2S4 2228-03)-Sib-B-B-B		B	0.09171558
B101		B	0.09123178
1883-001/98_DKXL370AN11F2S3_7521-05-B		B	0.09013726
DKXL212:N11a-139-1-1-B-B-B		B	0.08962725
CUBA117:S15-372-1-B-B-B		B	0.08868912
B73		B	0.08825852
DREP150:N2011d-624-1-B-B		B	0.08787375
CHIS740:S1411a-783-2-B-B-B		B	0.08728875
CH05015:N1204-057-001-B-B-B		B	0.08710915
MDI022:N2120-253-001-B-B		B	0.08677067
Mo17		B	0.08650861
B73 x Mo17-B		B	0.08618465

Two Year Evaluations (continued)
Lysine

B45 o2	A					0.15531255
Mo17	A	B				0.12980457
MDI022:N2120-253-001-B-B	A	B	C			0.12696419
1883-002/98_DKXL370AN11F2S3_7521-05-B	A	B	C	D		0.11968624
DKXL212:N11a-139-1-1-B-B-B		B	C	D	E	0.10825124
DREP150:N2011d-624-1-B-B		B	C	D	E	0.10155995
2258-03_XL380_S11_F2S4_71/97_Bulk/98		B	C	D	E	0.09827935
1886-003/98_DKXL370AN11F2S3_7521-05-B		B	C	D	E	0.09788448
1895-001/98_DKXL370AN11F2S3_7521-29-B		B	C	D	E	0.0978403
FS8B(T):N1802-382-1-B-B		B	C	D	E	0.09160315
1883-001/98_DKXL370AN11F2S3_7521-05-B		B	C	D	E	0.08995274
CUBA117:S15-372-1-B-B-B		B	C	D	E	0.08803623
CHIS740:S1411a-783-2-B-B-B			C	D	E	0.0860177
DKXL380:S11 F2S4 2282-01)-Sib-B-B-B			C	D	E	0.0853582
AR17056:N2035-421-001-B-B				D	E	0.08435934
UR11003:S0302-1011-001-B-B-B				D	E	0.08361457
CH05015:N1204-057-001-B-B-B				D	E	0.08253724
1881-002/98_DKXL370AN11F2S3_7521-05-B				D	E	0.08087652
AR16035:S02-450-1-B-B-B-B				D	E	0.07813826
FS8B(S):S0316-814-1-B-B					E	0.07716178
B101					E	0.07628714
B73 x Mo17-B					E	0.07455877
XL370A:S11 F2S4 2228-03)-Sib-B-B-B					E	0.07206828
B73					E	0.07132576

Two Year Evaluations (continued)
Index

B45 o2	A					1.45891059
1883-002/98_DKXL370AN11F2S3_7521-05-B		B				1.2173673
2258-03_XL380_S11_F2S4_71/97_Bulk/98		B	C	D		1.14451937
1895-001/98_DKXL370AN11F2S3_7521-29-B		B	C			1.13729248
DKXL380:S11 F2S4 2282-01)-Sib-B-B-B		B	C			1.13151786
1886-003/98_DKXL370AN11F2S3_7521-05-B		B	C	D		1.10255004
MDI022:N2120-253-001-B-B		B	C	D		1.09283403
UR11003:S0302-1011-001-B-B-B		B	C	D		1.08477621
1883-001/98_DKXL370AN11F2S3_7521-05-B		B	C	D		1.08098989
DKXL212:N11a-139-1-1-B-B-B		B	C	D		1.06611559
1881-002/98_DKXL370AN11F2S3_7521-05-B		B	C	D		1.05590273
B101		B	C	D	E	1.0359858
CHIS740:S1411a-783-2-B-B-B		B	C	D	E	1.02404122
DREP150:N2011d-624-1-B-B		B	C	D	E	1.01854122
Mo17		B	C	D	E	1.01301542
FS8B(S):S0316-814-1-B-B			C	D	E	0.99260203
CUBA117:S15-372-1-B-B-B			C	D	E	0.98164534
CH05015:N1204-057-001-B-B-B			C	D	E	0.98061735
AR16035:S02-450-1-B-B-B-B			C	D	E	0.96613593
FS8B(T):N1802-382-1-B-B			C	D	E	0.96054469
B73			C	D	E	0.94378829
AR17056:N2035-421-001-B-B			C	D	E	0.94106904
XL370A:S11 F2S4 2228-03)-Sib-B-B-B				D	E	0.91818781
B73 x Mo17-B					E	0.83824083

Evaluation of GEM Hybrids, two locations, 2006:

Methionine

(DKXL380:S11 F2S4 2282-01)-Sib-B-B/LH123)-B	A							0.16276289
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/LH123)	A	B						0.15758718
(XL370A:S11 F2S4 2228-03)-Sib-B-B/LH123)-B		B	C					0.15214095
(DKXL380:S11 F2S4 2282-01)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B		B	C					0.15058915
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/DKXL212:N11a-139-001		B	C					0.15053947
(B101/LH123)-B		B	C	D				0.14835019
(LH119/LH123)-B			C	D				0.14544291
(B101/DKXL212:N11a-139-001-001-B-B-B-B)-B		B	C	D	E			0.1439554
(LH119/DKXL212:N11a-139-001-001-B-B-B-B)-B		B	C	D	E	F		0.14371127
B14Ao2 x A619o2				D	E	F		0.13904401
(XL370A:S11 F2S4 2228-03)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B					E	F		0.13376763
(DKB844:S1601-289-001-B-B-B-B/AR17056:N2025-574-001-B-B-B)-B					E	F	G	0.1314618
(AR17056:N2025-574-001-B-B-B/DKB844:S1601-289-001-B-B-B-B)-B						F	G	0.12994769
(B73xMo17)-B							G	0.12380876

Evaluation of GEM Hybrids, two locations, 2006:

Tryptophan

B14Ao2 x A619o2	A			0.18192461
(B101/DKXL212:N11a-139-001-001-B-B-B-B)-B		B		0.13807763
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/DKXL212:N11a-139-001			C	0.12006742
(XL370A:S11 F2S4 2228-03)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B			C	0.11881471
(XL370A:S11 F2S4 2228-03)-Sib-B-B/LH123)-B			C	0.11744381
(DKXL380:S11 F2S4 2282-01)-Sib-B-B/LH123)-B			C	0.11742169
(DKB844:S1601-289-001-B-B-B-B/AR17056:N2025-574-001-B-B-B)-B			C	0.11699528
(AR17056:N2025-574-001-B-B-B/DKB844:S1601-289-001-B-B-B-B)-B			C	0.11656227
(B73xMo17)-B			C	0.11637441
(B101/LH123)-B			C	0.11526989
(LH119/DKXL212:N11a-139-001-001-B-B-B-B)-B			C	0.11518329
(DKXL380:S11 F2S4 2282-01)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B			C	0.11344642
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/LH123)			C	0.11293487
(LH119/LH123)-B			C	0.10928126

Evaluation of GEM Hybrids, two locations, 2006:
Lysine

(B101/DKXL212:N11a-139-001-001-B-B-B-B)-B	A	B							0.10596703
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/DKXL212:N11a-139-001	A								0.10579968
(DKXL380:S11 F2S4 2282-01)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B		B	C						0.09811785
(XL370A:S11 F2S4 2228-03)-Sib-B-B/DKXL212:N11a-139-001-001-B-B-B-B)-B			C	D					0.09320618
B14Ao2 x A619o2				D	E				0.0904214
(DKXL380:S11 F2S4 2282-01)-Sib-B-B/LH123)-B					E	F			0.08589209
(B101/LH123)-B					E	F			0.08567253
(LH119/DKXL212:N11a-139-001-001-B-B-B-B)-B				D	E	F	G		0.08515007
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B/LH123)					E	F			0.0847639
(XL370A:S11 F2S4 2228-03)-Sib-B-B/LH123)-B						F			0.08280725
(B73xMo17)-B						F	G		0.0808635
(DKB844:S1601-289-001-B-B-B-B/AR17056:N2025-574-001-B-B-B)-B							G	H	0.07470213
(AR17056:N2025-574-001-B-B-B/DKB844:S1601-289-001-B-B-B-B)-B								H	0.07133172
(LH119/LH123)-B								H	0.07123107

Evaluation of GEM Hybrids, two locations, 2006:
Index

B14Ao2 x A619o2	A					1.1396234
(B101 / DKXL212:N11a-139-001-001	A	B				1.09212099
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib)-B / DKXL212:N11a-139-001		B	C			1.05847993
(DKXL380:S11 F2S4 2282-01) / DKXL212:N11a-139-001		B	C	D		1.01220101
(DKXL380:S11 F2S4 2282-01)-Sib-B-B / LH123)			C	D		1.00474739
(2258-03_XL380_S11_F2S4_71/97_Bulk/98-sib) / LH123)				D		0.97678987
(XL370A:S11 F2S4 2228-03)-Sib / DKXL212:N11a-139-001				D		0.96984749
(XL370A:S11 F2S4 2228-03)-Sib-B-B / LH123)-B				D		0.9690905
(B101 / LH123)-B				D		0.96539289
(LH119 / DKXL212:N11a-139-001-001				D	E	0.95265043
(B73xMo17)-B					E	0.89449258
(DKB844:S1601-289-001 / AR17056:N2025-574-001					E	0.89050585
(LH119 / LH123)-B					E	0.8887745
(AR17056:N2025-574-001 / DKB844:S1601-289-001-					E	0.8732936