DEVELOPMENT OF MAIZE INBREDS, HYBRIDS, AND ENHANCED GEM BREEDING POPULATIONS FOR SUPERIOR SILAGE, BIOFEEDSTOCK YIELD, AND COMPOSITIONAL ATTRIBUTES

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Overview:

The production of silage represents the second most important use of corn in the U.S. after grain production. Approximately 7.1% of the 34.2 million hectares of corn harvested in the U.S. in 2008 were dedicated to silage. It is worthwhile noting also that, although the total acreage of corn harvested in U.S. in 2008 declined slightly from the previous year (37.5 million hectares in 2007), the proportion of silage harvested presented a positive trend from 6.6% in 2007 (USDA, 2009).

Wisconsin is the major silage-producing state in the U.S. with approximately 350 thousand hectares harvested in 2008. This represents close to 15% of the total number of corn hectares harvested for silage in the U.S. and approximately 23% of the area harvested in the state of Wisconsin in 2008 (USDA, 2008).

In the early 1990's, motivated by the realization of the substantial economic and nutritional benefits of improving forage quality, primarily corn for silage, the University of Wisconsin (UW) Corn Silage Breeding Program was initiated to enhance both nutritional value and forage yield of corn. This was the first corn silage breeding program in the U.S. focused on the development of corn varieties for biomass production, currently used for animal feed and this program remains the only public program of its kind in the country. The UW Corn Silage Breeding Program has been incorporating new sources of germplasm from the GEM project for a number of years as a means to enhance primarily forage yield but also compositional quality.

The biomass quality properties of corn required for animal nutrition have been found to be parallel to the desired traits to be selected for corn to be used as a feedstock for energy bioconversion. Therefore, the high forage yield and highly fermentable cell wall carbohydrate composition of the populations and crosses involving germplasm developed by the UW Corn Silage Breeding Program have shown promise for developing lignocellulosic biofeedstocks for ethanol production.

In 2009, The UW Corn Silage Breeding Program continued to evaluate silage yield and nutritive value of the most productive GEM crosses identified in grain yield evaluations conducted over the past several years by the GEM project throughout the U.S. Corn Belt. If any of these crosses have high dry matter yield and good nutritional quality in our UW trials, the respective GEM parent or breeding population is included in the UW inbred development nursery for further inbreeding and selection. The 2009 trials focused primarily of the advanced-generation inbred testing and some re-testing of different GEM materials.

2009 Field Trials:

Five trials involving GEM materials (09AR16026, 09AR17056, 09DK212T, 09DK888, 09GUAT209) and one involving lines derived from GQS C0 were planted in 2009 at two WI locations, Madison (May 6th and 12th) and Arlington (June 1st). Trials were planted in triplicates in each of the locations with an average planting density of 32,800 plants/acre. Temperatures after planting were slightly below normal for both locations, but percent emergence did not appear to be affected by it. July of this year was the coldest July on record for our locations in the state of Wisconsin. Some lodging was observed primarily at the Arlington location. A very cool and wet Fall season provided for a very difficult and late harvesting season this year. A detailed trial description for 2009 will soon become available through our web site at http://cornbreeding.wisc.edu.

09AR16026

Trial **09AR16026** consisted of the silage re-evaluation of seven advanced inbred lines from the GEM program derived from the AR16026:S1719-052-2-B-B-B population testcrossed by Holdens tester LH287 and three advanced inbred lines from GEM population FS8B(T):N11a-322-1-B-B testcrossed by Holdens testers LH244 and LH332. Seven different hybrids were also included as checks (Table 1).

09AR16026 highlights (Table 1): Of the 13 hybrids evaluated, the forage yield of eight of those exceeded the average yield of the checks excluding F2F633 (8.40 tons/acre). Due to the wet and cold Fall, moisture content for some of the materials was below the acceptable threshold (< 35%) for southern WI. Yields for the AR16026:S1719-052-2 populations were in general lower than expected. On the other hand, two of the three FS8B(T):N11a-322-1 lines had high forage yields and acceptable moisture content. Quality evaluation will be performed for 9 of the 13 hybrids evaluated for yield. It is worthwhile noting that the highest yielding check of this trial was W605S x LH244. Inbred W605S was released by the UW Corn Silage Breeding program in 2004 and was developed from the GEM breeding population AR17026:N1019. After quality evaluation analysis is completed, decisions will be made as to which lines from 08AR16026 merit further evaluation.

09AR17056

Trial **09AR17056** consisted of the silage re-evaluation of advanced inbred lines from the GEM program derived from AR17056:N2025-508-1-B-B-B-B. Trial 09AR17056 included 17 inbreds each crossed to Holdens' tester LH244. This trial also included eight hybrid checks (Table 2).

09AR17056 highlights (Table 2): Of the 17 hybrids evaluated, the forage yield of six of those exceeded the average of the trial. Maturity appears to be an issue with some of these hybrids. The percentage dry matter content for the AR17056:N2025-508-1-B-B-B-B testcrosses were more than four percentage units below the check average. The dry matter content of the six highest yielding hybrids (yield above check average of 8.20 tons/acre) ranged from 33.3 to 37.4%. Three of them were below and three above the acceptable range for our region (>35%). The average dry matter content

for checks (excluding F2F633) was 38.8%. Quality evaluation will be performed for eight of the 17 hybrids evaluated for yield in this trial to determine merit for further evaluation.

09DK212T

Trial **09DK212T** consisted of the silage evaluation of advanced inbred lines from the GEM program derived from DK212T:N11a12-122-1-B-B. Trial 09AR212T included 19 inbreds each crossed to Holdens' tester LH244. Hybrid FS8B(T):N11a-322-1-B-B-15-1-1 crossed by Holdens inbreds LH244 and LH332 was also included in the trial as entries 20 and 21. This trial also included eight hybrid checks (Table 3).

09DK212T highlights (Table 3): Due to excessive lodging problems at our Arlington location data presented and discussed in this report refers only to our West Madison location. Of the 19 DK212T hybrids evaluated, the forage yield of seven of those exceeded the average of the checks without including F2F633 (9.93 tons/acre). The percentage dry matter content for the DK212T testcrosses was appropriate for our conditions. Quality evaluation will be performed for 11 of the 21 hybrids and those would include the two FS8B(T):N11a-322 hybrids evaluated for yield in this trial to determine merit for further evaluation.

09DK888

Trial **09DK888** consisted of the silage evaluation of 19 inbred lines from the GEM program derived from population DK888:N11a08a:440-001-B crossed to Holdens' tester LH244. This trial also included eight hybrid checks (Table 4).

09DK888 highlights (Table 4): Due to excessive lodging at our Arlington location data presented and discussed in this report refers only to our West Madison location. Fifteen of the 19 DK888 hybrids evaluated in this trial exceeded the average forage yield of the checks without including F2F633 (10.05 tons/acre). The highest yielding hybrid in this trial yielded approximately 22% more than the average check (except F2F633). The percentage dry matter content for the DK888 testcrosses was slightly below ideal for our conditions (>35%). The average dry matter content for the set of experimental testcrosses was four percentage units below the check average (excluding F2F633). Quality evaluation will be performed for 12 of the 19 hybrids evaluated for yield in this trial to determine merit for further evaluation.

09GUAT209

Trial **09GUAT209** consisted of the silage evaluation of 57 inbred lines from the GEM program derived from population GUAT209:S1308a-135-001-B, GUAT209:S1308a-084-001-B and GUAT209:S1308a-013-001-B crossed to Holdens' tester LH279. This trial also included eight hybrid checks (Table 5).

09GUAT209 highlights (Table 5): Nine of the 57 GUAT209 hybrids evaluated in this trial exceeded the average forage yield of the checks without including F2F633 (9.28 tons/acre). The percentage dry

matter content for the GUAT209 testcrosses was well within the ideal conditions for our area (>35%). Quality evaluation will be performed for 27 of the 57 hybrids evaluated for yield in this trial to determine merit for further evaluation.

09GQSC0

In 2005, a new breeding population derived from GEM-derived sources of germplasm was initiated. This population is designated the GEM Quality Synthetic (GQS). GQS is approximately 75% Stiff Stalk. The aim is to create inbred lines from GQS that produce silage hybrids with high forage yield as well as superior nutritional quality when crossed to inbred lines from our non-Stiff Stalk Wisconsin Quality Synthetic (WQS) breeding population. Trial **09GQSC0** consisted of the silage evaluation of 31 advanced inbred lines from the GQS C0 population crossed to Holdens' tester LH287 and W604S. This trail also included eight hybrid checks (Table 6).

09GQSC0 highlights (Table 6): Five of the 62 GQS C0 hybrids evaluated in this trial exceeded the average forage yield of the checks without including F2F633 (9.05 tons/acre). The percentage dry matter content for the GQS C0 testcrosses was well within the ideal conditions for our area (>35%). Quality evaluation will be performed for 15 of the 62 hybrids evaluated for yield in this trial to determine merit for further evaluation.

Nutritional evaluations will include assessment of neutral detergent fiber (NDF), *in vitro* true digestibility (IVTD), *in vitro* NDF digestibility (IVNDFD), crude protein (CP), and starch concentration. Based on these values, milk/ton of forage and milk/acre will be estimated based on MILK2006, which uses forage composition (NDF, IVTD, IVNDFD, CP, and starch) to estimate potential milk production per ton of forage. Forage yield is then used to estimate potential milk per acre. Nutritional evaluation will be completed in approximately one month and the results posted on our web site.

2009 Nursery Activities:

The breeding population GQS is being advanced using a second generation (S_2) top-cross selection method. Briefly, inbreds derived from succeeding cycles of improvement are developed and released. Population improvement and inbred development occur simultaneously. S_2 families derived from GQS are initially screened for general agronomic adequacy and are then top-crossed to elite commercial lines from complementary heterotic groups during the following year. The following summer, top-crosses are grown to estimate forage yield and quality of whole-plant compositional characteristics such as fiber, digestibility, protein, and starch at silage harvesting time. Twenty S_2 families are selected based on a performance index (MILK2006) that comprises silage yield and compositional quality.

During summer 2007 the top 20 selected families from Cycle 0 (GQS C0) of this population were recombined to give rise to GQS C1. During the winter nursery of 2007/8 20 GQS HS families derived from the intermating process conducted in summer 2007 were sent to our winter nursery in Puerto Rico for selfing. At least 20 self-pollinations were conducted for each of the HS families.

Ten S_1 families were derived from each of the 20 HS families. These approximately 200 S_1 families were planted in our summer nursery last year. Later this summer about half of these S_1 families were eliminated based on agronomic appearance. Three to four self-pollinations were done in each row, but only two ears were harvested from each row at the end of the season. This produced a total of 200 S_2 lines. These 200 S_2 lines were testcrossed in 2009 by inbred line W604S for evaluation during summer 2010.

In our 2009 breeding nursery, approximately 70 new GEM families (derived from GUAT209:S1308a-120-001-B-B, GUAT209:S1308a-104-001-B-B, CUBA164:S2008c-289-001-B-B, BVIR155:S2012-029-001-B-B and AR16021:S0908a-075-001) were crossed to appropriate testers as well as self-pollinated for further advancement. Promising advanced lines derived from breeding crosses were also topcrossed to appropriate inbred testers for 2010 evaluations.

We have also added five new GEM bulk populations to our 2009-10 winter nursery for inbred line development. These bulks were derived from PASCO14:N0424-078-001-B-B, DKXL212:S0912-012-001, DKXL212:S0912-117-001, SCROGP3:N2017-003-001, SCROGP3:N2017-172-001, UR11002:N0308b-086-001 and DK888:N11(95)-B-027-001-015-B.

All activities of the UW silage and biofeedstock breeding program, including nurseries and yield trials, are available through our web site. For additional information please visit: (http://cornbreeding.wisc.edu).

Table 1. Forage yield evaluation for 09AR16026 trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			Arlington			Mean			
		Dry	Stalk		Dry	Stalk		Dry	Stalk		For Quality
09 No.	Entry	matter	lodging	Yield	matter	lodging	Yield	matter	lodging	Yield	Evaluation
		%	0 - 10	t/a	%	0 - 10	t/a	%	0 - 10	t/a	
1	AR16026:S1719-052-2-B-B-B-13-1-1-1 X LH287	33.51	0.00	9.94	.	.	.	.	.	.	
2	AR16026:S1719-052-2-B-B-B-15-1-1-1 X LH287	35.93	0.00	9.44	42.31	2.33	4.53	39.12	1.17	6.99	
3	AR16026:S1719-052-2-B-B-B-16-1-1-1 X LH287	35.83	0.00	8.80	46.40	0.67	6.62	41.12	0.33	7.71	
4	AR16026:S1719-052-2-B-B-B-20-1-1-1 X LH287	35.94	0.00	10.13	43.51	0.67	7.56	39.72	0.33	8.84	*
5	AR16026:S1719-052-2-B-B-B-22-1-1-1 X LH287	36.16	0.00	10.11	39.43	1.02	7.04	37.79	0.51	8.58	*
6	AR16026:S1719-052-2-B-B-B-3-1-1-1 X LH287	34.43	0.00	9.90	45.85	4.00	6.92	40.14	2.00	8.41	
7	AR16026:S1719-052-2-B-B-B-5-1-1-1 X LH287	39.42	0.00	11.68	43.89	1.00	7.23	41.66	0.50	9.46	*
8	FS8B(T):N11a-322-1-B-B-15-1-1 X LH244	35.05	0.00	10.31	37.60	0.33	7.81	36.33	0.17	9.06	*
9	FS8B(T):N11a-322-1-B-B-15-1-1 X LH322	37.48	0.00	10.36	37.72	0.00	6.35	37.60	0.00	8.36	*
10	FS8B(T):N11a-322-1-B-B-3-1-1 X LH244	35.97	0.00	10.96	36.41	1.00	6.20	36.19	0.50	8.58	*
11	FS8B(T):N11a-322-1-B-B-3-1-1 X LH332	33.58	0.00	8.81	36.29	0.67	6.10	34.93	0.33	7.46	*
12	FS8B(T):N11a-322-1-B-B-6-1-1 X LH244	33.74	0.00	10.71	38.41	1.33	7.32	36.07	0.67	9.01	*
13	FS8B(T):N11a-322-1-B-B-6-1-1 X LH332	34.83	0.00	10.82	38.83	0.33	7.60	36.83	0.17	9.21	*
14	W604S X LH244	41.66	0.00	8.73	43.02	2.67	5.58	42.34	1.33	7.15	*
15	W604S X LH332	36.35	0.00	10.09	36.62	1.67	6.22	36.48	0.83	8.15	*
16	W605S X LH244	35.21	0.00	10.17	44.39	0.67	6.46	39.80	0.33	8.32	*
17	W605S X LH332	36.08	0.00	11.67	40.12	0.00	7.62	38.10	0.00	9.65	*
18	34R67	36.28	0.00	11.08	46.78	0.00	7.19	41.53	0.00	9.13	*
19	F2F633	32.25	0.00	8.75	35.68	3.00	5.64	33.97	1.50	7.19	*
20	N48V8	38.19	0.00	9.22	41.33	0.00	6.79	39.76	0.00	8.01	*
	Mean	35.89	0.00	10.08	40.77	1.12	6.67	38.39	0.56	8.38	
	CV (%)	6	.	10	9	130	22	8	186	14	
	LSD (0.05)	3.36	0.00	1.61	1.62	2.39	2.38	5.29	1.68	1.40	
	Mean of all AR16026 testcrosses	35.89	0.00	10.08	40.77	1.12	6.67	38.39	0.56	8.38	
	Mean of experimental entries (9) for quality evaluat	35.80	0.00	10.43	39.12	0.71	7.02	37.46	0.35	8.73	
	Mean of checks (w/o F2633)	37.29	0.00	10.16	42.04	0.83	6.64	39.67	0.42	8.40	

Table 2. Forage yield evaluation for 09AR17056 trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			Arlington			Mean			
09 No.	Entry	Dry matter	Stalk lodging	Yield	Dry matter	Stalk lodging	Yield	Dry matter	Stalk lodging	Yield	For Quality Evaluation
		%	0 - 10	t/a	%	0 - 10	t/a	%	0 - 10	t/a	
1	AR17056:N2025-508-1-B-B-B-B-1-1-1 X LH244	39.40	0.00	9.65	35.49	0.00	6.87	37.44	0.00	8.26	*
2	AR17056:N2025-508-1-B-B-B-B-2-1-1 X LH244	33.80	0.00	9.53	34.61	0.67	6.28	34.20	0.33	7.91	
3	AR17056:N2025-508-1-B-B-B-B-3-1-1 X LH244	34.11	0.00	9.60	32.53	0.00	7.14	33.32	0.00	8.37	*
4	AR17056:N2025-508-1-B-B-B-B-4-1-1 X LH244	33.32	0.00	10.12	34.05	1.33	6.27	33.68	0.67	8.19	*
5	AR17056:N2025-508-1-B-B-B-B-5-1-1 X LH244	33.59	0.00	9.67	36.62	0.00	6.61	35.11	0.00	8.14	*
6	AR17056:N2025-508-1-B-B-B-B-6-1-1 X LH244	33.80	0.00	10.55	37.21	0.33	6.84	35.50	0.17	8.70	*
7	AR17056:N2025-508-1-B-B-B-B-6-2-1 X LH244	35.03	0.00	9.65	36.06	0.33	5.75	35.54	0.17	7.70	
8	AR17056:N2025-508-1-B-B-B-B-8-1-1 X LH244	34.00	0.00	9.29	35.51	0.00	5.97	34.76	0.00	7.63	
9	AR17056:N2025-508-1-B-B-B-B-8-2-1 X LH244	34.48	0.00	10.41	32.69	0.00	6.26	33.58	0.00	8.34	*
10	AR17056:N2025-508-1-B-B-B-B-9-1-1 X LH244	34.93	0.00	9.47	30.68	0.67	4.94	32.81	0.33	7.20	
11	AR17056:N2025-508-1-B-B-B-B-12-1-1 X LH244	33.39	0.00	10.39	34.81	1.33	6.00	34.10	0.67	8.20	*
12	AR17056:N2025-508-1-B-B-B-B-13-1-1 X LH244	32.89	0.00	10.26	32.20	0.00	5.83	32.54	0.00	8.05	
13	AR17056:N2025-508-1-B-B-B-B-14-1-1 X LH244	32.76	0.00	10.24	34.68	0.33	5.89	33.72	0.17	8.07	
14	AR17056:N2025-508-1-B-B-B-B-15-1-1 X LH244	36.13	0.00	10.22	35.51	2.00	5.69	35.82	1.00	7.96	
15	AR17056:N2025-508-1-B-B-B-B-16-1-1 X LH244	35.46	0.00	8.51	34.48	0.33	6.44	34.97	0.17	7.48	
16	AR17056:N2025-508-1-B-B-B-B-17-1-1 X LH244	36.33	0.00	9.90	37.95	2.00	6.13	37.14	1.00	8.01	
17	AR17056:N2025-508-1-B-B-B-B-18-1-1 X LH244	35.74	0.00	10.38	35.54	1.33	6.78	35.64	0.67	8.58	*
18	W604S X LH244	33.90	0.00	9.24	40.90	0.33	6.59	37.40	0.17	7.91	*
19	W604S X LH332	42.18	0.00	9.57	35.72	0.00	7.68	38.95	0.00	8.63	*
20	W605S X LH244	37.28	0.00	10.89	38.12	0.33	6.01	37.70	0.17	8.45	*
21	W605S X LH332	36.96	0.00	10.44	38.95	0.00	7.10	37.95	0.00	8.77	*
22	34R67	38.40	0.00	11.02	45.53	0.00	7.29	41.97	0.00	9.15	*
23	33T55	35.64	0.00	10.09	41.63	0.33	7.41	38.64	0.17	8.75	*
24	F2F633	34.19	0.00	8.80	34.97	2.67	5.36	34.58	1.33	7.08	*
25	N48V8	36.60	0.00	5.91	41.89	1.00	5.64	39.24	0.50	5.78	*
	Mean	35.37	0.00	9.75	36.33	0.61	6.35	35.85	0.31	8.05	
	CV (%)	6	.	8	6	211	19	6	297	13	
	LSD (0.05)	3.34	0.00	1.34	3.87	2.12	1.96	4.66	1.06	1.18	
	Mean of all AR17056 testcrosses	34.66	0.00	9.87	34.74	0.63	6.22	34.70	0.31	8.05	
	Mean of experimental entries (8) for quality evaluat	34.73	0.00	10.10	34.87	0.54	6.60	34.80	0.27	8.35	
	Mean of checks (w/o F2633)	37.28	0.00	9.59	40.39	0.29	6.81	38.84	0.14	8.20	

Table 3. Forage yield evaluation for 09DK212T trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			For
		Dry	Stalk		Quality
09 No.	Entry	matter	lodging	Yield	Evaluation
		%	0 - 10	t/a	
1	DK212T:N11a12-122-1-B-B-2-1-1 X LH244	.	.	.	
2	DK212T:N11a12-122-1-B-B-3-1-1 X LH244	41.96	0.00	10.02	*
3	DK212T:N11a12-122-1-B-B-3-2-1 X LH244	39.85	0.00	9.97	*
4	DK212T:N11a12-122-1-B-B-3-3-1 X LH244	41.69	0.00	9.49	
5	DK212T:N11a12-122-1-B-B-5-1-1 X LH244	37.45	0.00	9.26	
6	DK212T:N11a12-122-1-B-B-7-1-1 X LH244	36.84	0.00	10.80	*
7	DK212T:N11a12-122-1-B-B-7-2-1 X LH244	38.53	0.00	10.65	*
8	DK212T:N11a12-122-1-B-B-8-1-1 X LH244	40.27	0.00	9.11	
9	DK212T:N11a12-122-1-B-B-9-1-1 X LH244	43.26	0.00	9.39	
10	DK212T:N11a12-122-1-B-B-9-2-1 X LH244	45.24	0.00	8.36	
11	DK212T:N11a12-122-1-B-B-11-1-1 X LH244	36.47	0.00	10.14	*
12	DK212T:N11a12-122-1-B-B-12-1-1 X LH244	34.32	0.00	9.31	
13	DK212T:N11a12-122-1-B-B-13-1-1 X LH244	38.40	0.00	10.43	*
14	DK212T:N11a12-122-1-B-B-16-1-1 X LH244	36.45	0.00	9.70	*
15	DK212T:N11a12-122-1-B-B-16-2-1 X LH244	35.03	0.00	11.75	*
16	DK212T:N11a12-122-1-B-B-17-1-1 X LH244	36.85	0.00	9.68	*
17	DK212T:N11a12-122-1-B-B-19-1-1 X LH244	37.25	0.00	8.02	
18	DK212T:N11a12-122-1-B-B-21-1-1 X LH244	37.52	0.00	9.25	
19	DK212T:N11a12-122-1-B-B-22-1-1 X LH244	36.68	0.00	9.40	
20	FS8B(T):N11a-322-1-B-B-15-1-1 X LH244	37.70	0.00	10.15	*
21	FS8B(T):N11a-322-1-B-B-15-1-1 X LH322	38.76	0.00	10.30	*
22	W604S X LH244	43.52	0.00	7.90	*
23	W604S X LH332	42.53	0.00	9.80	*
24	W605S X LH244	37.93	0.00	11.32	*
25	W605S X LH332	36.91	0.00	10.15	*
26	34R67	34.25	0.00	10.83	*
27	33T55	36.12	0.00	10.21	*
28	F2F633	34.29	0.00	7.86	*
29	N48V8	41.64	0.00	9.32	*
	Mean	38.49	0.00	9.73	
	CV (%)	7	.	9	
	LSD (0.05)	4.60	0.00	1.36	
	Mean of all DK212T testcrosses	38.53	0.00	9.76	
	Mean of experimental entries (11) for quality evaluation	37.89	0.00	10.33	
	Mean of checks (w/o F2633)	38.98	0.00	9.93	

Table 4. Forage yield evaluation for 09DK888 trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			For
		Dry	Stalk		Quality
09 No.	Entry	matter	lodging	Yield	Evaluation
		%	0 - 10	t/a	
1	DK888:N11a08a:440-001-B-1 X LH244	.	.	.	
2	DK888:N11a08a:440-001-B-2 X LH244	34.08	0.00	9.53	
3	DK888:N11a08a:440-001-B-3 X LH244	32.63	0.00	11.83	*
4	DK888:N11a08a:440-001-B-4 X LH244	.	.	.	
5	DK888:N11a08a:440-001-B-5 X LH244	32.28	0.00	10.98	*
6	DK888:N11a08a:440-001-B-6 X LH244	31.10	0.00	10.47	
7	DK888:N11a08a:440-001-B-7 X LH244	33.48	0.00	10.78	*
8	DK888:N11a08a:440-001-B-8 X LH244	32.87	0.00	10.37	
9	DK888:N11a08a:440-001-B-9 X LH244	34.89	0.00	10.63	*
10	DK888:N11a08a:440-001-B-10 X LH244	32.37	0.00	10.71	*
11	DK888:N11a08a:440-001-B-11 X LH244	33.72	0.00	12.30	*
12	DK888:N11a08a:440-001-B-12 X LH244	32.47	0.00	10.91	*
13	DK888:N11a08a:440-001-B-13 X LH244	30.78	0.00	9.67	
14	DK888:N11a08a:440-001-B-14 X LH244	31.50	0.00	11.10	*
15	DK888:N11a08a:440-001-B-15 X LH244	32.61	0.00	11.78	*
16	DK888:N11a08a:440-001-B-16 X LH244	32.33	0.00	9.22	
17	DK888:N11a08a:440-001-B-17 X LH244	32.72	0.00	11.16	*
18	DK888:N11a08a:440-001-B-18 X LH244	30.90	0.00	9.61	
19	DK888:N11a08a:440-001-B-19 X LH244	31.64	0.00	11.16	*
20	DK888:N11a08a:440-001-B-20 X LH244	33.28	0.00	10.60	*
21	DK888:N11a08a:440-001-B-21 X LH244	34.52	0.00	9.85	
22	W604S X LH244	38.66	0.00	7.94	*
23	W604S X LH332	38.95	0.00	9.85	*
24	W605S X LH244	35.14	0.00	11.46	*
25	W605S X LH332	37.01	0.00	11.28	*
26	34R67	34.41	0.00	11.19	*
27	33T55	34.88	0.00	9.77	*
28	F2F633	32.83	0.00	9.12	*
29	N48V8	38.24	0.00	8.85	*
	Mean	33.71	0.00	10.45	
	CV (%)	4	.	7	
	LSD (0.05)	2.47	0.00	1.26	
	Mean of all DK2888 testcrosses	32.64	0.00	10.67	
	Mean of experimental entries (12) for quality evaluation	32.80	0.00	11.16	
	Mean of checks (w/o F2633)	36.76	0.00	10.05	

Table 5. Forage yield evaluation for 09GUAT209 trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			Arlington			Mean			For
		Dry	Stalk		Dry	Stalk		Dry	Stalk		Quality
09 No.	Entry	matter	lodging	Yield	matter	lodging	Yield	matter	lodging	Yield	Evaluation
		%	0 - 10	t/a	%	0 - 10	t/a	%	0 - 10	t/a	
1	GUAT209-S1308a-135-001-B-1 X LH279	34.97	0.00	11.57	40.42	0.33	7.74	37.70	0.17	9.66	*
2	GUAT209-S1308a-135-001-B-2 X LH279	.	.	.	41.26	1.33	6.29	.	.	.	
3	GUAT209-S1308a-135-001-B-3 X LH279	34.45	0.00	9.71	37.98	0.00	7.07	36.22	0.00	8.39	
4	GUAT209-S1308a-135-001-B-4 X LH279	35.12	0.00	11.09	41.65	0.33	7.91	38.38	0.17	9.50	*
5	GUAT209-S1308a-135-001-B-5 X LH279	35.69	0.00	10.93	37.40	0.00	7.46	36.55	0.00	9.20	*
6	GUAT209-S1308a-135-001-B-6 X LH279	35.79	0.00	11.15	39.51	0.00	7.60	37.65	0.00	9.38	*
7	GUAT209-S1308a-135-001-B-7 X LH279	34.69	0.00	9.45	39.34	0.00	6.72	37.02	0.00	8.08	
8	GUAT209-S1308a-135-001-B-8 X LH279	36.25	0.00	10.49	44.77	0.67	8.60	40.51	0.33	9.55	*
9	GUAT209-S1308a-135-001-B-9 X LH279	35.92	0.00	10.04	38.79	0.00	7.47	37.36	0.00	8.76	*
10	GUAT209-S1308a-135-001-B-10 X LH279	36.09	0.00	10.54	40.62	1.33	6.00	38.36	0.67	8.27	
11	GUAT209-S1308a-135-001-B-11 X LH279	37.40	0.00	9.78	39.72	0.67	6.26	38.56	0.33	8.02	
12	GUAT209-S1308a-135-001-B-12 X LH279	22.40	0.00	6.80	39.32	1.00	5.05	30.86	0.50	5.92	
13	GUAT209-S1308a-135-001-B-13 X LH279	33.31	0.00	10.86	42.34	1.00	8.21	37.83	0.50	9.54	*
14	GUAT209-S1308a-135-001-B-14 X LH279	35.41	0.00	11.35	40.45	0.00	7.67	37.93	0.00	9.51	*
15	GUAT209-S1308a-135-001-B-15 X LH279	39.15	0.00	10.59	43.29	0.17	8.16	41.22	0.08	9.37	*
16	GUAT209-S1308a-135-001-B-16 X LH279	38.34	0.00	10.77	38.26	0.00	7.28	38.30	0.00	9.02	*
17	GUAT209-S1308a-135-001-B-17 X LH279	37.59	0.00	10.96	39.92	0.00	7.45	38.75	0.00	9.21	*
18	GUAT209-S1308a-135-001-B-18 X LH279	32.87	0.00	9.49	41.46	0.67	6.55	37.16	0.33	8.02	
19	GUAT209-S1308a-135-001-B-19 X LH279	34.17	0.00	10.07	40.76	0.00	7.58	37.46	0.00	8.83	*
20	GUAT209-S1308a-135-001-B-20 X LH279	36.67	0.00	10.25	42.36	1.00	7.50	39.52	0.50	8.87	*
21	GUAT209-S1308a-135-001-B-21 X LH279	34.02	0.00	10.47	42.62	4.00	6.42	38.32	2.00	8.45	*
22	GUAT209-S1308a-135-001-B-22 X LH279	36.17	0.00	11.84	38.92	0.00	7.35	37.55	0.00	9.60	*
23	GUAT209-S1308a-135-001-B-23 X LH279	35.94	0.00	10.24	45.63	1.00	7.43	40.78	0.50	8.84	*
24	GUAT209-S1308a-135-001-B-24 X LH279	21.76	0.00	7.18	39.01	0.67	7.55	30.38	0.33	7.37	
25	GUAT209-S1308a-084-001-B-1 X LH279	36.43	0.00	8.80	43.54	0.33	6.95	39.98	0.17	7.87	
26	GUAT209-S1308a-084-001-B-2 X LH279	41.39	0.00	9.12	43.72	0.00	7.07	42.55	0.00	8.10	
27	GUAT209-S1308a-084-001-B-3 X LH279	37.24	0.00	9.03	43.06	0.33	7.03	40.15	0.17	8.03	
28	GUAT209-S1308a-084-001-B-4 X LH279	35.65	0.00	9.56	39.59	3.33	5.61	37.62	1.67	7.59	
29	GUAT209-S1308a-084-001-B-5 X LH279	36.91	0.00	8.68	42.57	2.67	5.29	39.74	1.33	6.98	
30	GUAT209-S1308a-084-001-B-6 X LH279	36.96	0.00	9.56	44.07	1.00	5.87	40.51	0.50	7.71	
31	GUAT209-S1308a-084-001-B-7 X LH279	37.91	0.00	10.26	41.67	0.33	7.16	39.79	0.17	8.71	*
32	GUAT209-S1308a-084-001-B-8 X LH279	39.39	0.00	10.34	43.50	0.33	6.13	41.45	0.17	8.24	
33	GUAT209-S1308a-084-001-B-9 X LH279	37.55	0.00	8.71	42.99	0.67	5.38	40.27	0.33	7.05	
34	GUAT209-S1308a-084-001-B-10 X LH279	34.39	0.00	9.48	42.88	3.00	5.83	38.63	1.50	7.66	
35	GUAT209-S1308a-084-001-B-11 X LH279	38.46	0.00	9.15	42.12	1.33	6.94	40.29	0.67	8.04	
36	GUAT209-S1308a-084-001-B-12 X LH279	38.97	0.00	9.60	42.26	0.00	7.21	40.62	0.00	8.41	*
37	GUAT209-S1308a-084-001-B-13 X LH279	34.99	0.00	10.23	42.30	0.00	7.22	38.64	0.00	8.73	*
38	GUAT209-S1308a-084-001-B-14 X LH279	41.50	0.00	9.37	44.31	0.67	6.73	42.90	0.33	8.05	
39	GUAT209-S1308a-084-001-B-15 X LH279	37.02	0.00	10.03	45.01	0.00	7.54	41.01	0.00	8.78	*
40	GUAT209-S1308a-084-001-B-16 X LH279	35.88	0.00	10.03	39.45	0.33	6.94	37.66	0.17	8.49	*
41	GUAT209-S1308a-084-001-B-17 X LH279	38.38	0.00	9.90	41.24	0.33	7.14	39.81	0.17	8.52	*
42	GUAT209-S1308a-084-001-B-18 X LH279	34.15	0.00	7.61	38.86	0.00	5.26	36.50	0.00	6.44	
43	GUAT209-S1308a-013-001-B-1 X LH279	34.27	0.00	10.06	39.38	0.33	6.94	36.83	0.17	8.50	*
44	GUAT209-S1308a-013-001-B-2 X LH279	34.36	0.00	10.16	42.53	0.00	7.35	38.44	0.00	8.75	*
45	GUAT209-S1308a-013-001-B-3 X LH279	36.45	0.00	9.78	42.01	0.33	7.44	39.23	0.17	8.61	*
46	GUAT209-S1308a-013-001-B-4 X LH279	36.28	0.00	10.70	45.08	0.67	7.96	40.68	0.33	9.33	*
47	GUAT209-S1308a-013-001-B-5 X LH279	34.57	0.00	10.25	35.31	0.64	5.67	34.94	0.32	7.96	
48	GUAT209-S1308a-013-001-B-6 X LH279	33.52	0.00	8.78	43.80	0.00	7.07	38.66	0.00	7.92	
49	GUAT209-S1308a-013-001-B-7 X LH279	34.86	0.00	9.37	42.13	0.00	7.27	38.49	0.00	8.32	
50	GUAT209-S1308a-013-001-B-8 X LH279	37.59	0.00	9.75	42.54	2.67	5.08	40.06	1.33	7.41	
51	GUAT209-S1308a-013-001-B-9 X LH279	34.56	0.00	8.70	40.10	1.00	5.08	37.33	0.50	6.89	
52	GUAT209-S1308a-013-001-B-10 X LH279	35.48	0.00	9.60	40.33	0.33	6.22	37.90	0.17	7.91	
53	GUAT209-S1308a-013-001-B-11 X LH279	37.18	0.00	9.89	41.77	2.00	6.08	39.47	1.00	7.99	
54	GUAT209-S1308a-013-001-B-12 X LH279	36.40	0.00	9.79	40.89	1.33	6.01	38.64	0.67	7.90	
55	GUAT209-S1308a-013-001-B-13 X LH279	32.94	0.00	8.60	39.54	0.00	7.08	36.24	0.00	7.84	
56	GUAT209-S1308a-013-001-B-14 X LH279	35.06	0.00	9.27	41.66	0.67	6.59	38.36	0.33	7.93	
57	GUAT209-S1308a-013-001-B-15 X LH279	36.79	0.00	10.64	40.27	0.00	6.44	38.53	0.00	8.54	*
58	W604S X LH244	45.89	0.00	10.49	43.73	2.33	7.01	44.81	1.17	8.75	*
59	W604S X LH332	40.99	0.00	9.57	42.95	0.33	7.31	41.97	0.17	8.44	*
60	W605S X LH244	37.30	0.00	10.65	43.26	1.00	8.65	40.28	0.50	9.65	*
61	W605S X LH332	36.27	0.00	10.92	43.23	0.67	9.02	39.75	0.33	9.97	*
62	34R67	40.76	0.00	11.71	44.75	0.00	7.71	42.76	0.00	9.71	*
63	33T55	37.15	0.00	10.73	45.19	0.00	8.55	41.17	0.00	9.64	*
64	F2F633	37.61	0.00	9.93	33.06	0.00	5.15	35.34	0.00	7.54	*
65	N48V8	40.69	0.00	9.32	47.29	0.67	8.25	43.99	0.33	8.79	*
	Mean	36.16	0.00	9.90	41.53	0.67	6.93	38.85	0.33	8.42	
	CV (%)	18	.	21	6	196	14	13	277	19	
	LSD (0.05)	10.46	0.00	3.39	4.11	2.13	1.59	5.60	1.26	1.86	
	Mean of all GUAT209 testcrosses	35.67	0.00	9.83	41.34	0.68	6.82	38.51	0.33	8.33	
	Mean of experimental entries (28) for quality evaluation	36.14	0.00	10.52	41.41	0.43	7.41	38.78	0.20	8.99	
	Mean of checks (w/o F2633)	39.86	0.00	10.49	44.34	0.71	8.07	42.10	0.36	9.28	

Table 6. Forage yield evaluation for 09GQSC0 trial in 2009. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with "*" will be analyzed for nutritional quality.

		Madison			Arlington			Mean			
		Dry	Stalk		Dry	Stalk		Dry	Stalk		For Quality
09 No.	Entry	matter	lodging	Yield	matter	lodging	Yield	matter	lodging	Yield	Evaluation
		%	0 - 10	t/a	%	0 - 10	t/a	%	0 - 10	t/a	
1	50021-1-1-1 X LH287	37.83	0.00	9.02	50.12	3.33	5.26	43.97	1.67	7.14	
2	50021-1-1-1 X W604S	44.65	0.00	10.28	46.25	4.67	6.11	45.45	2.33	8.19	
3	50021-1-1-2 X LH287	39.75	0.00	10.24	49.80	2.67	7.18	44.77	1.33	8.71	*
4	50021-1-1-2 X W604S	41.48	0.00	9.76	47.36	3.67	6.83	44.42	1.83	8.30	*
5	50021-1-2-1 X LH287	38.07	0.00	9.19	45.13	1.67	6.56	41.60	0.83	7.88	
6	50021-1-2-1 X W604S	43.11	0.00	10.64	44.90	1.00	5.57	44.01	0.50	8.10	
7	50021-1-2-2 X LH287	40.98	0.00	9.63	56.74	6.33	3.44	48.86	3.17	6.53	
8	50021-1-2-2 X W604S	45.72	0.00	10.88	50.15	5.33	5.89	47.94	2.67	8.39	
9	50021-1-2-3 X LH287	40.05	0.00	10.10	52.94	6.67	5.06	46.49	3.33	7.58	
10	50021-1-2-3 X W604S	39.47	0.00	9.75	43.84	1.33	6.58	41.66	0.67	8.17	
11	50036-2-1-1 X LH287	44.06	0.00	10.08	59.56	4.33	6.99	51.81	2.17	8.53	
12	50036-2-1-1 X W604S	47.57	0.00	9.43	52.62	3.67	4.88	50.10	1.83	7.15	
13	50036-2-1-2 X LH287	45.61	0.00	8.98	49.41	2.67	6.44	47.51	1.33	7.71	
14	50036-2-1-2 X W604S	46.21	0.00	8.85	46.93	2.33	6.40	46.57	1.17	7.62	
15	50036-2-2-1 X LH287	43.05	0.00	9.45	48.49	2.67	6.96	45.77	1.33	8.20	*
16	50036-2-2-1 X W604S	44.62	0.00	9.57	50.44	0.67	6.17	47.53	0.33	7.87	*
17	50036-2-2-2 X LH287	40.78	0.00	8.50	49.61	2.67	6.50	45.19	1.33	7.50	
18	50036-2-2-2 X W604S	44.48	0.00	8.90	54.58	4.33	6.14	49.53	2.17	7.52	
19	50072-1-1-1 X LH287	40.34	0.00	10.40	48.86	5.67	7.96	44.60	2.83	9.18	*
20	50072-1-1-1 X W604S	40.90	0.00	10.20	55.53	2.33	7.16	48.22	1.17	8.68	*
21	50072-1-1-2 X LH287	37.04	0.00	8.17	47.12	2.67	7.31	42.08	1.33	7.74	*
22	50072-1-1-2 X W604S	40.46	0.00	10.08	51.25	2.00	7.43	45.85	1.00	8.76	*
23	50072-1-1-3 X LH287	41.22	0.00	9.25	45.20	6.00	5.68	43.21	3.00	7.47	
24	50072-1-1-3 X W604S	41.41	0.00	9.66	44.14	0.33	6.96	42.77	0.17	8.31	
25	50072-1-1-4 X LH287	35.93	0.00	10.24	49.33	4.33	7.02	42.63	2.17	8.63	*
26	50072-1-1-4 X W604S	43.85	0.00	10.02	49.00	3.00	7.43	46.42	1.50	8.73	*
27	50072-1-1-5 X LH287	36.79	0.00	9.19	46.49	3.67	7.38	41.64	1.83	8.29	*
28	50072-1-1-5 X W604S	42.54	0.00	10.20	43.16	0.33	6.59	42.85	0.17	8.40	*
29	50094-1-1-1 X LH287	39.66	0.00	9.60	45.66	5.33	5.29	42.66	2.67	7.45	
30	50094-1-1-1 X W604S	41.67	0.00	8.64	48.52	5.33	4.40	45.09	2.67	6.52	
31	50094-1-1-2 X LH287	38.54	0.00	9.84	46.23	8.33	5.06	42.39	4.17	7.45	
32	50094-1-1-2 X W604S	40.87	0.00	8.04	50.97	5.67	3.49	45.92	2.83	5.76	
33	50094-1-1-3 X LH287	42.04	0.00	8.56	48.87	3.67	5.75	45.46	1.83	7.15	
34	50094-1-1-3 X W604S	43.97	0.00	8.52	50.69	3.00	5.13	47.33	1.50	6.82	
35	50114-1-1 X LH287	40.02	0.00	10.68	44.02	3.33	6.97	42.02	1.67	8.82	*
36	50114-1-1 X W604S	43.13	0.00	11.03	46.39	4.33	7.16	44.76	2.17	9.09	*
37	50120-1-1-1 X LH287	38.95	0.00	10.81	43.90	3.33	6.72	41.43	1.67	8.77	*
38	50120-1-1-1 X W604S	43.05	0.00	10.60	41.38	1.67	7.53	42.21	0.83	9.06	*
39	50120-1-1-2 X LH287	36.94	0.00	10.13	38.87	2.00	5.58	37.91	1.00	7.86	*
40	50120-1-1-2 X W604S	43.54	0.00	11.16	39.54	2.67	6.36	41.54	1.33	8.76	*
41	50148-1-1-1 X LH287	40.35	0.00	8.61	51.26	2.67	7.53	45.81	1.33	8.07	
42	50148-1-1-1 X W604S	40.99	0.00	8.75	51.44	4.67	4.46	46.21	2.33	6.60	
43	50148-1-1-2 X LH287	43.30	0.00	9.30	47.73	3.67	6.83	45.51	1.83	8.07	
44	50148-1-1-2 X W604S	41.39	0.00	8.92	53.32	5.67	5.82	47.35	2.83	7.37	
45	50156-1-1-1 X LH287	41.54	0.00	9.46	49.26	6.67	4.15	45.40	3.33	6.80	
46	50156-1-1-1 X W604S	48.33	0.00	9.43	49.47	4.00	5.32	48.90	2.00	7.37	
47	50156-1-1-2 X LH287	38.38	0.00	9.98	52.11	2.00	7.34	45.24	1.00	8.66	*
48	50156-1-1-2 X W604S	41.79	0.00	10.27	53.10	2.33	6.16	47.45	1.17	8.22	*
49	50156-1-1-3 X LH287	38.68	0.00	10.88	52.64	1.67	7.00	45.66	0.83	8.94	*
50	50156-1-1-3 X W604S	44.73	0.00	11.06	47.00	2.33	6.97	45.87	1.17	9.02	*
51	50159-1-1-1 X LH287	37.06	0.00	10.20	49.10	4.67	6.30	43.08	2.33	8.25	*
52	50159-1-1-1 X W604S	41.00	0.00	10.23	44.11	3.33	5.59	42.55	1.67	7.91	*
53	50159-1-1-2 X LH287	39.97	0.00	8.96	49.49	1.67	6.66	44.73	0.83	7.81	*
54	50159-1-1-2 X W604S	41.65	0.00	10.93	46.92	2.67	7.50	44.29	1.33	9.21	*
55	50159-1-1-3 X LH287	40.97	0.00	10.43	47.98	4.33	7.39	44.48	2.17	8.91	*
56	50159-1-1-3 X W604S	42.37	0.00	10.05	53.96	2.00	7.08	48.17	1.00	8.56	*
57	50197-1-1-1 X LH287	35.94	0.00	8.32	45.28	4.33	6.62	40.61	2.17	7.47	
58	50197-1-1-1 X W604S	39.37	0.00	10.58	45.98	6.67	3.76	42.68	3.33	7.17	
59	50197-1-1-2 X LH287	36.53	0.00	8.36	44.64	6.00	4.96	40.59	3.00	6.66	*
60	50197-1-1-2 X W604S	41.87	0.00	11.77	47.44	4.33	6.35	44.66	2.17	9.06	*
61	50197-1-1-3 X LH287	37.81	0.00	9.51	38.69	9.22	3.74	38.25	4.61	6.62	
62	50197-1-1-3 X W604S	39.14	0.00	8.68	48.15	5.67	5.31	43.64	2.83	7.00	
63	W604S X LH244	42.76	0.00	11.75	46.21	5.33	6.52	44.49	2.67	9.13	*
64	W604S X LH332	41.87	0.00	12.04	40.77	4.00	7.21	41.32	2.00	9.63	*
65	W605S X LH244	35.59	0.00	11.04	45.87	3.00	7.76	40.73	1.50	9.40	*
66	W605S X LH332	36.26	0.00	10.00	41.23	1.00	8.54	38.75	0.50	9.27	*
67	34R67	35.99	0.00	11.36	36.66	0.33	7.59	36.32	0.17	9.47	*
68	33T55	34.26	0.00	10.03	40.73	0.10	7.91	37.50	0.05	8.97	*
69	F2F633	33.59	0.00	9.37	31.97	4.72	5.76	32.78	2.36	7.57	*
70	N48V8	34.96	0.00	7.26	48.84	3.67	7.74	41.90	1.83	7.50	*
	Mean	40.70	0.00	9.80	47.50	3.60	6.30	44.10	1.80	8.05	
	CV (%)	7	.	10	11	66	20	10	93	14	
	LSD (0.05)	4.31	0.00	1.51	8.77	3.80	2.06	6.37	2.64	1.78	
	Mean of all GQSC0 testcrosses	41.19	0.00	9.73	48.28	3.70	6.16	44.73	1.85	7.94	
	Mean of experimental entries (15) for quality evalu	40.58	0.00	10.17	47.65	2.94	6.83	44.11	1.47	8.50	
	Mean of checks (w/o F2633)	37.39	0.00	10.50	42.90	2.49	7.61	40.14	1.25	9.05	

Reference:

USDA - United States Department of Agriculture. National Agricultural Statistics Service. 2009. Crop Production 2008 Summary. (http://usda.mannlib.cornell.edu/usda/current/CropProdSu/CropProdSu-01-12-2009.pdf)