

# **DEVELOPMENT OF INBREDS, HYBRIDS, AND ENHANCED GEM BREEDING POPULATIONS WITH SUPERIOR SILAGE YIELD AND NUTRITIONAL VALUE**

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## **Overview:**

Close to 6.6% of the 37.5 million hectares of corn harvested in the U.S. were dedicated to silage in 2007 (USDA, 2008). Wisconsin is the major silage-producing state in the U.S. with approximately 300 thousand hectares of silage harvested in 2007, representing approximately 12% of the total number of corn hectares harvested in the U.S. and more than 20% of the area harvested in the state of Wisconsin that year (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 2008, 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 2008 trials focused primarily of the advanced-generation inbred testing and some re-testing of different GEM materials.

## **2008 Field Trials:**

Two trials involving GEM materials (08GEM1 and 08GEM2) were planted in 2008 at two WI locations, Madison (May 6<sup>th</sup>) and Arlington (May 27<sup>th</sup>). Trials were planted in triplicates in each of the locations with an average planting density of 32,800 plants/acre. Very wet conditions affected both locations during the month of May. The Madison location recovered fairly well and yields reflect that fact. The Arlington location, on the other hand, had water standing in portions of the field for longer periods of time. A substantial amount of nitrogen leaching (yellowing of plants) was therefore observed later in the season. Overall plant standability was above average this year, therefore no lodging information was collected in

neither location. The Madison trials were harvested on September 10<sup>th</sup>. The Arlington trials were harvested on October 3<sup>rd</sup>. For a detailed description of these trials please see <http://cornbreeding.wisc.edu>.

## **08GEM1**

Trial **08GEM1** consisted of the silage evaluation of advanced inbred lines from the GEM program derived from the AR16026:S1719-052-2-B-B-B population. Trial GEM1 included 25 inbreds each crossed to Holdens tester LH287 and/or WI inbred line W604S. Eight different hybrids were also included as checks (Table 1).

**08GEM1 highlights (Table 1):** Of the 44 hybrids evaluated, the forage yield of 16 of those exceeded the average yield of the checks excluding F2F633 (9.57 tons/acre). Due to the wet conditions present at the Arlington location early in the season, materials didn't mature appropriately and dry matter contents for that location were in many instances below acceptable threshold (< 35%) for southern WI. Of these 16 highest yielding hybrids, only three presented dry matter content below 35% at the Madison location. Lines AR16026:S1719-052-2-B-B-B-13-1, AR16026:S1719-052-2-B-B-B-20-1, AR16026:S1719-052-2-B-B-B-16-1, AR16026:S1719-052-2-B-B-B-5-1 and AR16026:S1719-052-2-B-B-B-9-1 crossed by testers LH287 and/or W604S were amongst the highest-yielding hybrids of the trial with yields that exceeded the average trial yield by 4 to 6%. Quality evaluation will be performed for 21 of the 44 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. W604S was released by the UW Corn Silage Breeding program in 2003 and was developed from the Wisconsin Quality Synthetic (WQS) population after the second cycle of selection. WQS is composed of approximately 50% Lancaster background and 50% broad-based high-quality germplasm from northern temperate regions. After quality evaluation analysis is completed, decisions will be made as to which lines from 08GEM1 merit further evaluation.

## **08GEM2**

Trial **08GEM2** consisted of the silage evaluation of advanced inbred lines from the GEM program derived from AR17056:N2025-508-1-B-B-B-B, DK212T:N11a12-122-1-B-B and FS8B(T):N11a-322-1-B-B. Trial 08GEM2 included 13 inbreds each crossed to Holdens' tester LH244. This trial also included seven hybrid checks (Table 2).

**08GEM2 highlights (Table 2):** Of the 13 hybrids evaluated, the forage yield of only four of those exceeded the average of the trial. Due to the poor field conditions early on in the season at the Arlington location, maturity measurements at this location might not be representative, therefore maturity discussion is solely based on results from the Madison location. Maturity appears to be an issue with some of these hybrids. The percentage dry matter content for three (all entries from AR17056:N2025-508-1-B-B-B-B) of the seven highest yielding hybrids (yield above trial average of 8.96 tons/acre) ranged from 34.4 to 35.6% with the other four being above the acceptable threshold of 35%. The average dry matter content for checks (excluding F2F633) was 40.1%. Quality evaluation will be performed for 7 of the 13 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.

### **2008 Nursery Activities:**

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. 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 this 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 that will be testcrossed next summer for evaluation during summer 2010.

In our 2008 breeding nursery, approximately 75 new GEM families (derived from GUAT209:S1308a-135, GUAT209:S1308a-084, GUAT209:S1308a-013 and DK2888:N11a08a:440) were crossed to appropriate testers as well as self-pollinated for further advancement. Approximately 40 promising more advanced lines derived from breeding crosses AR17056:N2025-508 and DK212T:N11a12-122 were also topcrossed to inbred tester LH244 for 2009 evaluations. We were unsuccessful crossing the most promising  $S_3$  families from GQS C0 during our 2007 summer nursery. These crosses were repeated this summer for approximately 30 of those promising lines and hybrids will be evaluated in summer 2009. Testers were W604S and LH287.

We have also added five new GEM bulk populations to our 2008 nursery for inbred line development. These bulks were derived from GUAT209:S1308a-120, GUAT209:S1308a-104, CUBA164:S2008c-289, BVIR155:S2012-029 and AR16021:S0908a-075.

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 GEM1 trial in 2008. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with “\*” will be analyzed for nutritional quality.

08 No.	Entry	Madison		Arlington		Mean		For Quality Evaluation
		Dry matter	Yield	Dry matter	Yield	Dry matter	Yield	
		%	t/a	%	t/a	%	t/a	
1	AR16026:S1719-052-2-B-B-B-10-1 X LH287	37.52	10.14	32.12	8.80	34.82	9.47	
2	AR16026:S1719-052-2-B-B-B-10-1 X W604S	35.52	8.96	32.44	9.03	33.98	8.99	
3	AR16026:S1719-052-2-B-B-B-11-1 X LH287	37.42	10.29	35.06	8.62	36.24	9.46	
4	AR16026:S1719-052-2-B-B-B-11-1 X W604S	35.84	9.07	31.16	7.73	33.50	8.40	
5	AR16026:S1719-052-2-B-B-B-12-1 X LH287	40.72	9.67	32.16	9.07	36.44	9.37	*
6	AR16026:S1719-052-2-B-B-B-12-1 X W604S	37.83	10.13	31.63	9.06	34.73	9.60	*
7	AR16026:S1719-052-2-B-B-B-13-1 X LH287	34.74	10.98	30.30	9.02	32.52	10.00	*
8	AR16026:S1719-052-2-B-B-B-14-1 X LH287	35.33	10.06	34.06	8.98	34.69	9.52	
9	AR16026:S1719-052-2-B-B-B-14-1 X W604S	34.69	8.32	33.41	8.67	34.05	8.50	
10	AR16026:S1719-052-2-B-B-B-15-1 X LH287	31.42	9.48	31.43	9.46	31.42	9.47	*
11	AR16026:S1719-052-2-B-B-B-15-1 X W604S	37.57	10.39	32.01	8.83	34.79	9.61	*
12	AR16026:S1719-052-2-B-B-B-16-1 X LH287	35.90	10.41	31.92	9.60	33.91	10.00	*
13	AR16026:S1719-052-2-B-B-B-16-1 X W604S	39.37	10.80	33.04	8.75	36.20	9.77	*
14	AR16026:S1719-052-2-B-B-B-16-2 X LH287	39.23	9.93	34.10	9.27	36.66	9.60	*
15	AR16026:S1719-052-2-B-B-B-17-1 X LH287	38.81	10.14	34.31	8.79	36.56	9.47	*
16	AR16026:S1719-052-2-B-B-B-17-1 X W604S	37.75	9.95	31.61	8.74	34.68	9.34	*
17	AR16026:S1719-052-2-B-B-B-18-1 X LH287	37.85	9.57	32.42	9.18	35.13	9.37	
18	AR16026:S1719-052-2-B-B-B-19-1 X LH287	37.01	9.82	31.39	8.24	34.20	9.03	
19	AR16026:S1719-052-2-B-B-B-19-1 X W604S	34.50	9.87	34.34	9.35	34.42	9.61	
20	AR16026:S1719-052-2-B-B-B-20-1 X LH287	41.61	10.45	32.67	9.27	37.14	9.86	*
21	AR16026:S1719-052-2-B-B-B-2-1 X LH287	40.37	10.44	30.82	7.79	35.59	9.12	
22	AR16026:S1719-052-2-B-B-B-2-1 X W604S	38.77	8.70	32.08	8.89	35.43	8.79	
23	AR16026:S1719-052-2-B-B-B-21-1 X LH287	34.42	9.75	32.61	8.66	33.52	9.21	
24	AR16026:S1719-052-2-B-B-B-21-1 X W604S	36.93	9.05	32.74	8.48	34.84	8.76	
25	AR16026:S1719-052-2-B-B-B-22-1 X LH287	35.81	9.45	33.12	9.19	34.46	9.32	*
26	AR16026:S1719-052-2-B-B-B-22-1 X W604S	36.38	10.72	34.24	9.01	35.31	9.87	*
27	AR16026:S1719-052-2-B-B-B-23-1 X LH287	36.78	9.25	30.25	8.67	33.52	8.96	
28	AR16026:S1719-052-2-B-B-B-23-1 X W604S	36.14	9.52	30.53	8.85	33.33	9.19	
29	AR16026:S1719-052-2-B-B-B-24-1 X LH287	39.59	10.18	31.73	9.29	35.66	9.74	
30	AR16026:S1719-052-2-B-B-B-24-1 X W604S	36.46	9.23	30.44	8.84	33.45	9.03	
31	AR16026:S1719-052-2-B-B-B-25-1 X LH287	41.03	9.55	31.57	8.99	36.30	9.27	
32	AR16026:S1719-052-2-B-B-B-26-1 X LH287	39.62	9.49	31.95	8.79	35.78	9.14	
33	AR16026:S1719-052-2-B-B-B-26-1 X W604S	38.85	9.23	33.39	9.91	36.12	9.57	
34	AR16026:S1719-052-2-B-B-B-3-1 X LH287	35.03	9.09	30.64	9.02	32.84	9.06	*
35	AR16026:S1719-052-2-B-B-B-3-1 X W604S	35.79	10.21	32.58	9.78	34.18	9.99	*
36	AR16026:S1719-052-2-B-B-B-4-1 X LH287	39.78	9.97	33.14	8.63	36.46	9.30	
37	AR16026:S1719-052-2-B-B-B-5-1 X LH287	36.46	10.86	32.48	9.46	34.47	10.16	*
38	AR16026:S1719-052-2-B-B-B-5-1 X W604S	36.47	10.19	30.84	8.92	33.65	9.56	*
39	AR16026:S1719-052-2-B-B-B-6-1 X LH287	35.67	10.58	28.35	9.11	32.01	9.85	
40	AR16026:S1719-052-2-B-B-B-6-1 X W604S	34.17	8.72	29.77	8.98	31.97	8.85	
41	AR16026:S1719-052-2-B-B-B-7-1 X LH287	37.00	9.72	33.35	9.22	35.17	9.47	*
42	AR16026:S1719-052-2-B-B-B-7-1 X W604S	36.88	10.43	32.95	9.21	34.91	9.82	*
43	AR16026:S1719-052-2-B-B-B-9-1 X LH287	35.22	10.13	32.24	9.48	33.73	9.81	*
44	AR16026:S1719-052-2-B-B-B-9-1 X W604S	34.47	10.75	30.41	9.33	32.44	10.04	*
45	W604S X LH244	37.12	9.68	35.67	9.35	36.40	9.51	*
46	34R67	37.59	10.48	31.98	9.01	34.78	9.75	*
47	W605S X LH244	33.93	10.70	33.45	9.75	33.69	10.23	*
48	W605S X LH332	34.02	10.47	32.29	8.65	33.15	9.56	*
49	34R67	33.74	9.57	32.27	9.27	33.00	9.42	*
50	33T55	36.85	10.65	31.21	8.91	34.03	9.78	*
51	F2F633 (BMR3)	29.88	8.48	24.59	6.75	27.23	7.61	*
52	N48V8 (LFY)	41.77	9.25	32.92	8.22	37.35	8.73	*
	Mean	36.80	9.86	32.08	8.94	34.44	9.40	
	CV (%)	6	9	6	7	6	8	
	LSD (0.05)	3.78	1.49	3.22	1.01	3.44	0.90	
	Mean of all GEM1 testcrosses	37.02	9.86	32.13	8.98	34.57	9.42	
	Mean of experimental entries (21) for quality evaluation	36.88	10.19	32.29	9.17	34.58	9.68	
	Mean of checks (w/o F2633)	36.43	10.11	32.83	9.02	34.63	9.57	

Table 2. Forage yield evaluation for GEM2 trial in 2008. Forage yield was evaluated at Madison and Arlington, WI. Entries marked with “\*” will be analyzed for nutritional quality.

08 No.	Entry	Madison		Arlington		Mean		For Quality Evaluation
		Dry matter	Yield	Dry matter	Yield	Dry matter	Yield	
		%	t/a	%	t/a	%	t/a	
1	AR17056:N2025-508-1-B-B-B-B-2 X LH244	34.68	11.58	26.12	6.88	30.40	9.23	*
2	AR17056:N2025-508-1-B-B-B-B-9 X LH244	35.97	10.70	26.08	8.21	31.02	9.45	*
3	AR17056:N2025-508-1-B-B-B-B-15 X LH244	34.41	11.08	26.15	6.36	30.28	8.72	*
4	AR17056:N2025-508-1-B-B-B-B-16 X LH244	36.22	11.13	27.16	7.82	31.69	9.47	*
5	AR17056:N2025-508-1-B-B-B-B-18 X LH244	34.98	11.40	27.57	7.18	31.28	9.29	*
6	DK212T:N11a12-122-1-B-B-8 X LH244	42.88	10.18	27.89	5.75	35.39	7.97	
7	DK212T:N11a12-122-1-B-B-9 X LH244	44.15	9.52	28.23	5.21	36.19	7.36	
8	DK212T:N11a12-122-1-B-B-21 X LH244	40.83	10.24	29.58	7.25	35.20	8.75	
9	DK212T:N11a12-122-1-B-B-22 X LH244	39.23	10.28	29.44	7.63	34.33	8.95	
10	FS8B(T):N11a-322-1-B-B-2 X LH244	39.27	10.40	28.39	7.27	33.83	8.83	
11	FS8B(T):N11a-322-1-B-B-3 X LH244	37.47	10.85	28.04	7.07	32.75	8.96	*
12	FS8B(T):N11a-322-1-B-B-6 X LH244	38.98	11.35	29.74	7.82	34.36	9.59	*
13	FS8B(T):N11a-322-1-B-B-11 X LH244	40.68	8.88	28.24	6.64	34.46	7.76	
14	W604S X LH244	41.37	10.08	29.89	8.48	35.63	9.28	*
15	W605S X LH244	36.69	11.34	29.32	8.30	33.00	9.82	*
16	34R67	39.59	11.44	32.91	7.40	36.25	9.42	*
17	W605S X LH332	35.92	11.05	30.64	8.27	33.28	9.66	*
18	34R67	38.65	11.26	30.82	8.36	34.73	9.81	*
19	F2F633 (BMR3)	35.76	8.89	23.08	5.93	29.42	7.41	*
20	N48V8 (LFY)	48.51	10.65	33.67	8.32	41.09	9.49	*
	Mean	38.81	10.62	28.65	7.31	33.73	8.96	
	CV (%)	7	10	6	14	7	11	
	LSD (0.05)	4.43	1.67	5.10	1.69	4.28	1.17	
	Mean of all GEM2 testcrosses	38.44	10.58	27.89	7.01	33.17	8.80	
	Mean of experimental entries (7) for quality evaluation	36.10	11.16	27.27	7.33	31.68	9.24	
	Mean of checks (w/o F2633)	40.12	10.97	31.21	8.19	35.66	9.58	

**Reference:**

USDA - United States Department of Agriculture. National Agricultural Statistics Service. 2008. Crop Production 2007 Summary. (<http://www.scribd.com/doc/2095432/USDA-2007-Crop-Production>)