

Supporting Organic Seed Corn Production in New York

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Project Background and Justification

While organic farmers in New York grow many acres of corn, most of the seed for their crop comes from out of state. Also, very little of the seed corn in the United States is currently being grown organically. Since the new National Organic Program rules require organically grown seed, organic farmers here in New York are currently limited to relatively few outlets that are all out of state. This seed bottleneck represents a potential opportunity for organic seed corn production here in New York because seed corn can readily be grown here and because we have organic farmers here with the wherewithal to take on such enterprises. It also represents an opportunity to identify and produce varieties that are particularly well suited to New York's production conditions.

In 2003 and 2004 we carried out preliminary evaluations of several hybrids (based in part on Cornell-developed inbreds) on one organically-managed field near Penn Yan. The results provided us with a good first look at how these hybrids would do under organic management. Yields were from 140 to 180 bu/A and were comparable to commercial checks. These varieties need a fuller evaluation on organic farms: except for the single trials described above, their superiority has been demonstrated only in intensive input systems. Also, inbreds vary in their vigor and plant height. It is possible that the inbreds used to make superior hybrids might be difficult to grow under organic conditions and this has been observed especially when weed management is difficult. Evaluations of the inbreds per se and in hybrid combination are needed to assess the potential for successful hybrid seed production for those hybrids that prove themselves superior under organic conditions. We have begun the process of evaluating corn hybrids based on public lines in organic conditions, but more information is needed before we can be sure which hybrids are going to be valuable for both farmers and potential seed producers in New York.

Finally, contamination of seed from genetically engineered varieties is a constant issue in seed corn production and especially so for organic seed corn. At the December 2003 annual meeting of the Cornell Organic Production and Marketing Program Work Team, farmers specifically asked for help in avoiding pollen from genetically engineered corn. One way to do this is to convert dependable varieties to carry the gametophytic sterility gene (*Ga1s*) that was first discovered in popcorn several decades ago. This trait has been used for years by midwestern white corn growers to keep the number of yellow seeds in

their fields very low. It has been successful even though many neighboring fields contain yellow corn. Two other corn genes could be incorporated into lines for organic production to aid seed producers in keeping transgenic contamination out of their seed fields. The first is white cap (Wc1), which gives each yellow kernel a white cap on the dented portion of the kernel. Outcrossed seed would have a light yellow cap, so this trait could help seed producers to segregate ears with accidental outcrosses from seed to be sold to other organic producers. The second trait is called brown midrib (bm3) and it gives plants with the trait distinctly brown midribs on all of the lower leaves. It also makes the plants more digestible for silage purposes. Seed producers could use this trait to rogue volunteer and accidentally outcrossed plants from seed production fields prior to flowering, thereby aiding in the maintenance of genetic purity. We have begun the process of introducing these genes into several public inbred lines. However several more breeding generations are needed before these lines are available, and additional inbred and hybrid evaluation data are needed to identify those lines that are most worthy of this conversion.

Specific Objectives of this Project

1. Evaluate ten or more public corn hybrids in replicated, small plot trials on two organic fields in 2005 to augment single-location preliminary trials from the previous two years.
2. Evaluate the same hybrids on conventionally managed fields for comparison purposes.
3. Evaluate ten or more public inbreds that comprise these hybrids in organic fields in 2005.
4. Begin backcrossing the gametophytic sterility, white cap, and brown midrib traits into several public inbreds for later use in producing organically grown corn hybrids. Continue this process in three public inbreds (NY73118, ND250, SD65) for which conversion began in 2002.

Materials and Methods

Objectives 1 and 2. Evaluate ten or more public corn hybrids in replicated, small plot trials on two organic fields and on conventionally managed fields for comparison.

In spring 2005, we planted 41 field corn varieties in replicated trials at each of four locations. The locations included Penn Yan (with cooperators Klaas Martens and Mary-Howell Martens at Lakeview Organic Grain, in a certified organic field), Ketola (a Cornell-owned farm near Ithaca, in a field that is transitioning to organic management), Sackets Harbor (with cooperator Ron Robbins on a non-organic dairy farm), and in Lansing (with cooperators from Willet Dairy, a non-organic dairy farm). At each farmer-cooperator's location, the field preparation was done by the cooperator. When the rest of the field was being planted to corn by the cooperators, we simultaneously planted our yield evaluation plots using a two-row precision planter. Plot size was 1/500th of an acre

(two 17.5' long rows at 30" row spacing) and three reps were planted at each location using a randomized complete block design. All plots were planted with untreated seed.

The hybrid and open-pollinated varieties evaluated are listed in Table 1. They include three commercial hybrids for which organically produced seed is available, two of which (Brunner OR-9802 and Chemgro 5500) are considered top commercial hybrids by our organic cooperators. There are also four commercially available open-pollinated varieties, one of which (Wapsie Valley) is produced and marketed by Lakeview Organic Grain. Most of the experimental hybrids in these trials are produced from inbred parents that are either from Cornell's breeding program or are publicly available, such that they could be commercially produced without concern about patenting or other intellectual property rights issues. Four top experimental hybrids that involve commercially protected parents crossed with Cornell parents were also included, to assess the potential of these materials in case licensing of the commercial parents becomes possible.

Weed control practices were done by the farmer cooperators using basically the same practices they used for their own portion of the field. At Ketola, we carried out weed management using tine weeders and cultivators (two passes each). The very cool and dry weather during planting and early crop growth in 2005 resulted in weed control problems on one of the non-organic farms, necessitating additional chemical sprays to our plots beyond what the cooperator would normally have done. Based on past experience on organic farms, the organic plots also received extra cultivations to control weeds that spring up in alleyways and other open spaces that occur in small plot trials but not under normal production conditions. These weed control efforts resulted in excellent weed control in the Penn Yan organic site and adequate weed control at Sackets Harbor and Lansing. A persistent and uncontrollable infestation with nutsedge resulted in loss of the plots at the organically-managed site at Ketola, from which no meaningful data could have been recovered.

Table 1. Hybrid and open-pollinated field corn varieties evaluated under organic and non-organic management in summer 2005.

<u>Variety Name</u>	<u>Variety Type</u>
Brunner OR-8702	Commercial check hybrid
Brunner OR-9802	Commercial check hybrid
Chemgro 5500	Commercial check hybrid
NC + 1550	Commercial check hybrid
E95	Commercial open-pollinated variety
Green Oaxacana Dent	Commercial open-pollinated variety
Nokomis Gold	Commercial open-pollinated variety
Wapsie Valley	Commercial open-pollinated variety
45004 / LH177	Experimental hybrid
73118 / CO388	Experimental hybrid
73118 / SD65	Experimental hybrid
93-183 / LH295	Experimental hybrid
BS21/ BS22	Experimental hybrid
EX2105 (A634Ht/32311C-A)	Experimental hybrid
EX3101 (93-187/LH177)	Experimental hybrid
EX3103 (25-112//A634Ht/A641Ht)	Experimental hybrid
EX4201 (05-438//LH176/LH177)	Experimental hybrid
EX8101 (73118/LH177)	Experimental hybrid
EX8102 (A641Ht/A634Ht//32311C-A)	Experimental hybrid
PA6224 / H111	Experimental hybrid
PHB09 / LH38	Experimental hybrid
PHB47 / LH38	Experimental hybrid
PHG35 / LH145	Experimental hybrid
PHG80 / LH38	Experimental hybrid
RD3012 / 03042	Experimental hybrid
207 / RD4579 // 73118 / 93-187	Experimental double cross hybrid
73118 / 93-187 // 207 / LH82	Experimental double cross hybrid
A682 / LH38 // 73118 / 93-187	Experimental double cross hybrid
CO255 / F2 // 73118 / 93-187	Experimental double cross hybrid
CO255 / T143 // 73118 / 93-187	Experimental double cross hybrid
H111 / MS75 // SD65 / Mo42	Experimental double cross hybrid
ND240/PA409 ///(A683/RD3501)S3//NY821	Experimental double cross hybrid
ND405/PA409 // A682/NY821	Experimental double cross hybrid
W552 / 207 // 73118 / 93-187	Experimental double cross hybrid
CG CCGPA / CG SS C5	Experimental varietal hybrid
CG Syn A C8 / CG SS C5	Experimental varietal hybrid
CG Syn A C8 / CG SS C5	Experimental varietal hybrid
Wapsie Valley / CO388	Experimental varietal hybrid
BS22 (R)C7	Open-pollinated experimental population
CG SS C5	Open-pollinated experimental population
NDSAB C12	Open-pollinated experimental population

At each location, the yield trial plots were counted and thinned by hand to a density of 26,000 to 28,000 plants per acre. Notes on plant vigor, any disease or insect infestations present, staygreen, and field conditions affecting the plots were taken during the course of the growing season. Immediately prior to harvest, we counted the number of plants stalk lodged and root lodged. Plots were harvested using our plot combine that weighs and measures the moisture of the grain in each plot. Data were used to calculate grain yield at 15.5% moisture, yield:moisture ratio (a measure of the efficiency of a variety at producing grain at a given maturity; the higher the number, the more efficient the hybrid), and percentage stalk and root lodging. Data were subjected to analysis of variance and compared within and across locations.

Objective 3. Evaluate ten or more public inbreds that comprise the hybrids in organic fields.

We do not normally assess performance of inbreds, but for the purposes of this project we evaluated the parents of the experimental hybrids being tested under organic management, to determine the viability of producing commercial organic hybrid seed for sale. Parent evaluations were established in the same two organic fields where the hybrid and open-pollinated varieties were evaluated (Penn Yan and Ketola) using two replications and the same field procedures. Parents were evaluated in two separate trials: one for inbred parents (which are generally quite poor in vigor) and a separate one for line cross or variety parents (which are more vigorous than the inbred parents and would have competed unfairly with them had they been randomized together in the field). The parents in each trial are listed in Table 2. We did not have sufficient seed to test all the parents of the varieties evaluated in our variety trial, but included as many as we could. At the Penn Yan site, some hand weeding was done in the inbred parent trial due to additional weed problems that occur with the less vigorous growth of inbred parents. Again, the Ketola site yielded no meaningful data due to a severe nutsedge infestation. The inbred trial was harvested by hand as inbreds cannot be effectively machine harvested due to their poor field vigor. Data collection and analysis were similar to that done for the hybrid and open-pollinated variety trials.

Objective 4. Begin backcrossing the gametophytic sterility, white cap, and brown midrib traits into several inbreds for later use in producing organically grown corn hybrids.

Normal backcrossing techniques were used to continue incorporating gametophytic sterility (Ga1s) into public inbreds 73118 and SD65 and to begin introducing this trait into 32311C-A, LH82, A634Ht, and 93-187. Backcrosses were initiated to incorporate the white cap (Wc1) and brown midrib (bm3) traits into these same six inbreds. Crosses to advance these materials were made using traditional hand pollination in our Aurora, New York breeding nursery in summer 2005 and some of these materials are also being advanced further using a winter generation in our Homestead, Florida winter breeding nursery. For Ga1s, each plant was simultaneously pollinated with the recurrent inbred parent and with pollen from a blue corn. At harvest, ears were selected that showed few or no blue kernels, indicating that the Ga1s factor was present in the plants these ears were derived from and was acting to exclude pollen from plants not carrying the Ga1s

allele. For Wc1 and bm3, pollinations were made in summer to cross the inbred lines with a source of each of these alleles, and the resulting progeny (all of which should be carrying the desired allele) were sent to our winter nursery to make a second cross to the inbred parent.

Table 2. Parents of field corn hybrids evaluated under organic management in summer 2005.

<u>Inbred Parents Evaluated</u>	<u>Non-Inbred Parents Evaluated</u>
93-187	H111 / MS75
32311C-A	SD65 / Mo42
25-112	ND240 / PA409
A634Ht	ND405 / PA409
73118	A682 / NY821
RD3012	CO255 / F2
03042	73118 / 93-187
93-183	W552 / 207
05-438	207 / RD4579
SD65	A682 / LH38
CO388	207 / LH82
45-004	Cg Syn A C8
05-135	BS21
PHG8D	CG CC GPA
PHG35	
LH145	
PHR47	

Results

Objectives 1 and 2. Evaluate ten or more public corn hybrids in replicated, small plot trials on two organic fields and on conventionally managed fields for comparison.

Results from analysis of variance for all three locations are presented in Table 3. The coefficients of variation (C.V.s) were generally high for grain yield, due to the unusual weather conditions during the 2005 growing season. Very cool, dry weather at planting time caused erratic germination and some weed control problems. During June, July, and August it was unusually hot and dry, which caused some drought stress (particularly at Penn Yan and Lansing) and incomplete pollination. C.V.s for grain moisture were in the normal range, as this trait is less highly affected by environmental variation than is grain yield. Despite the high grain yield C.V.s, entries were a highly significant source of variation at all sites for yield, moisture, and stalk lodging.

Yield:moisture ratio is the most comprehensive way to assess varietal efficiency in terms of grain yield produced during a given maturity period. Table 4 lists the top ten varieties according to yield:moisture ratio for the organic site (Penn Yan) vs. the two non-organic sites (Sackets Harbor and Lansing). Five of the ten were unique to each growing environment, suggesting that the top hybrids identified in a non-organic system will not necessarily be the best under organic management. It is particularly notable that the very top hybrid in the non-organic sites (which yielded 30 bu/A more than the next best hybrid and had a yield:moisture ratio that was more than one unit higher than the next best

hybrid) did not even make it into the top ten at the organic site. This trend clearly needs to be verified over more environments, but two years' worth of preliminary work conducted prior to receiving this grant suggests the same thing. Among the top ten varieties at the organic site was Wapsie Valley, one of the open-pollinated varieties. No open-pollinated varieties were among the top ten at the non-organic sites.

Table 3. Significance levels from analysis of variance for field corn varieties evaluated at one organic location and two non-organic locations for grain yield (bu/A), grain moisture at harvest (%), and stalk lodging (%) with three replications per location.

Source	df	<u>Penn Yan</u>			<u>Sackets Harbor</u>			<u>Lansing</u>		
		Grain Yield	Grain Mois.	Stalk Lodging	Grain Yield	Grain Mois.	Stalk Lodging	Grain Yield	Grain Mois.	Stalk Lodging
Reps	2	*				**			**	
Varieties	40	**	**	**	**	**	**	**	**	**
C.V.		31.8	5.9		22.5	3.6		25.1	4.7	

*, ** Significant at the $p \leq 0.05$ and $p \leq 0.01$ levels, respectively.

Table 4. Top ten field corn varieties from organic vs. non-organic sites based on yield:moisture ratio. Data are based on three replications each at one organic and two non-organic locations.

<u>Rank</u>	<u>Organic Site</u>	<u>Non-organic Sites</u>
1	PHG35 / LH145	Chemgro 5500
2	EX2105	RD3012 / 03042
3	Brunner OR-9802	EX4201
4	EX3101	Brunner OR-9802
5	RD3012 / 03042	EX2105
6	73118 / 93-187 // 207 / LH82	93-183 / LH295
7	W552 / 207 // 73118 / 93-187	73118 / 93-187 // 207 / LH82
8	Wapsie Valley	PHB47 / LH38
9	73118 / SD65	EX8102
10	93-183 / LH295	PHB09 / LH38

Mean trait values at the organic site at Penn Yan for all the varieties tested are presented in Table 5. Close examination of this data confirms that PHG35/LH145 is a very promising hybrid, with excellent stalk and root quality and good staygreen score. (Staygreen was evaluated on a 1 to 5 scale, where 1 represented a plant that was completely dead and dry and 5 a plant that was still very green. Plants rated 3 or 4 tended to have a fair amount of green leaf area but dry husks, indicating mature ears, and were considered most desirable.) EX2105, which is a cross between A634Ht and 32311C-A, also performed better than the top commercial check hybrid, Brunner OR-9802, although it appeared to have a root lodging problem. Among those hybrids that

were certainly competitive with Brunner OR-9802 were EX3101 (a cross between 93-187 from Cornell and LH177, a private commercial inbred) and RD3012/03042 (both Cornell-developed inbreds).

Table 5. Hybrid and open-pollinated variety means from evaluation under organic management at Penn Yan, New York in summer 2005.

Variety Name	Grain Yield, bu/A	Grain Moisture, %	Yield: Moisture Ratio	Lodging, %		Staygreen, 1 to 5 Scale
				Root	Stalk	
CG Syn A C8 / CG SS C5	76.2	17.1	4.5	16	11	1.7
Brunner OR-9802	123.7	17.4	7.1	4	4	3.0
45004 / LH177	79.5	17.5	4.5	11	8	3.0
EX3101	124.5	17.6	7.1	6	6	2.3
EX3103	83.6	17.6	4.8	15	6	2.3
EX8101	82.9	17.6	4.7	14	16	2.3
73118 / SD65	106.9	17.6	6.1	1	16	1.0
Brunner OR-8702	57.5	17.6	3.3	14	8	1.3
CG CCGPA / CG SS C5	80.7	17.7	4.6	8	15	1.0
CG SS C5	80.3	17.8	4.5	8	1	2.0
EX2105	126.7	17.9	7.1	15	1	4.0
EX8102	98.6	18.1	5.5	20	5	3.0
NDSAB C12	67.4	18.4	3.7	11	17	1.3
CG Syn A C8 / CG SS C5	51.4	18.6	2.8	56	8	1.7
93-183 / LH295	111.5	18.7	6.0	7	2	4.0
Wapsie Valley	119.5	18.9	6.3	20	37	1.0
RD3012 / 03042	123.3	19.0	6.6	1	8	1.0
EX4201	94.0	19.4	4.9	3	1	4.0
Chemgro 5500	110.3	19.5	5.9	7	1	4.3
207 / RD4579 // 73118 / 93-187	84.2	19.6	4.3	5	5	2.7
PHG35 / LH145	133.5	19.7	7.1	3	2	4.0
73118 / CO388 (CC1102)	97.5	19.9	4.9	6	3	3.3
Green Oaxacana Dent	67.1	20.1	3.5	47	67	2.0
W552 / 207 // 73118 / 93-187	129.0	20.4	6.3	14	5	2.3
ND240/PA409 ///(A683/RD3501)S3//NY821	70.7	20.7	3.4	31	10	1.7
CO255 / T143 // 73118 / 93-187	77.5	21.2	3.7	19	42	1.3
CO255 / F2 // 73118 / 93-187	65.1	21.3	3.1	10	48	1.0
E95	116.1	21.4	5.4	7	59	2.3
Wapsie Valley / CO388	82.4	21.5	3.8	20	7	3.0
A682 / LH38 // 73118 / 93-187	101.2	22.0	4.6	20	6	2.7
ND405/PA409 // A682/NY821	68.9	22.0	3.1	42	33	3.0
H111 / MS75 // SD65 / Mo42	67.9	22.1	3.1	4	2	3.0
NC + 1550	71.3	22.1	3.2	10	0	3.7
BS22 (R)C7	101.9	22.2	4.6	30	4	2.0
Nokomis Gold	79.1	22.5	3.5	37	9	2.7
73118 / 93-187 // 207 / LH82	148.4	22.6	6.5	11	9	2.7
PHB09 / LH38	86.4	22.7	3.8	10	0	3.0
PHB47 / LH38	88.7	22.9	3.9	54	2	4.0
BS21/ BS22	87.1	22.9	3.8	12	9	2.0
PHG80 / LH38	127.7	22.9	5.6	6	1	4.3
PA6224 / H111	105.0	23.3	4.6	18	5	4.0
Means	94.0	20.0	4.8	16	12	2.6

Two double crosses also performed quite well, and would have the advantage that seed of a double cross is much less costly to produce than seed of single cross hybrids. The open-pollinated variety Wapsie Valley had good yield but considerable lodging problems, probably exacerbated because the optimum plant density for this variety is lower than that used in our trials. Several additional hybrids were better than Chemgro 5500, which was the top hybrid (by a considerable margin) in the non-organic sites.

Mean trait values averaged across the two non-organic sites (Sackets Harbor and Lansing) for all the varieties tested are presented in Table 6. As noted above, Chemgro 5500 was considerably better than the next best hybrid in terms of yield and yield:moisture ratio. The second ranking hybrid was RD3012/03042, which also performed well at the organic site. EX4201 looked good at these non-organic sites, but it performed rather poorly in the organic site. (EX4201 is a cross between 05-432, developed at Cornell, and LH176/LH177, which is a line cross between private commercial inbreds.)

Objective 3. Evaluate ten or more public inbreds that comprise the hybrids in organic fields.

Analysis of variance for the parents of the parents tested revealed high C.V.s for grain yield as were seen in the variety trials (Table 7). The grain moisture C.V. was also exceptionally high for the inbred trial, probably due to very variable seed set and maturity among these poor vigor materials. Despite the high C.V.s, parents were a significant source of variation for grain yield and grain moisture in both the inbred and non-inbred parent trials, and for stalk lodging as well in the inbred parent trial. Clearly there is significant variation in the yield potential and agronomic quality of these parents when grown under organic management, and this type of variation would strongly affect the viability of producing commercial, organic hybrid seed on these different parents.

Table 8 shows the mean trait values for the inbred parents. With a mean yield of about 24 bu/A (compared to the hybrids and open-pollinated varieties, which had a mean yield of 94 bu/A at this same location), the poor vigor that inbreds are known for is clearly apparent. Grain moistures varied dramatically among these inbreds, ranging from 13.8% to 51.7%, the latter being way too wet to be usable for seed production in this environment. The hot dry summer of 2005 was an ideal year for getting grain to mature and dry, so inbreds that were still high in grain moisture at harvest time this year would be way too late maturing in a wetter year. Among the best yielding inbreds were PHB47 (a bit late maturing but very high yield), 73118, 93-183 (also late maturing), LH145, and PHG8D (late maturing). Of these higher yielding inbred parents, the LH145, 73118, and 93-183 were parents of some of the top ten performing varieties at this same site. Klaas Martens has indicated that with at least 25 bu/A parent yields, it would be economically viable to produce hybrid field corn seed. Nine of the 17 inbred parents tested had yields at least this high, including at least one parent of each of the top three performing experimental hybrids.

Table 6. Hybrid and open-pollinated variety means from evaluation under non-organic management at Sackets Harbor and Lansing, New York in summer 2005.

Variety Name	Grain Yield, bu/A	Grain Moisture, %	Yield: Moisture Ratio	Lodging, %	
				Root	Stalk
EX3103	95.7	17.1	5.6	6	6
EX8102	117.8	17.7	6.7	4	10
EX2105	127.6	17.8	7.3	0	8
CG CCGPA / CG SS C5	74.7	17.8	4.2	1	30
RD3012 / 03042	151.5	17.9	8.4	1	14
CG Syn A C8 / CG SS C5	67.8	17.9	3.8	2	23
ND240/PA409 ///(A683/RD3501)S3//NY821	112.3	18.0	6.2	7	33
EX3101	107.8	18.1	6.0	0	15
207 / RD4579 // 73118 / 93-187	116.9	18.1	6.5	1	19
Brunner OR-9802	133.6	18.1	7.5	1	11
93-183 / LH295	126.4	18.2	7.0	0	8
CG Syn A C8 / CG SS C5	84.4	18.3	4.6	3	27
73118 / CO388 (CC1102)	114.0	18.3	6.2	0	25
73118 / SD65	70.8	18.4	3.9	0	41
73118 / 93-187 // 207 / LH82	125.7	18.4	6.9	0	21
Wapsie Valley	92.9	18.5	5.1	4	44
Brunner OR-8702	51.2	18.6	2.8	6	28
EX8101	109.1	18.7	6.0	6	16
CG SS C5	68.5	18.7	3.6	4	9
W552 / 207 // 73118 / 93-187	119.2	18.9	6.3	1	32
EX4201	154.2	18.9	8.2	0	2
Chemgro 5500	184.5	18.9	9.7	1	3
A682 / LH38 // 73118 / 93-187	114.1	19.0	6.0	3	17
Wapsie Valley / CO388	116.3	19.3	6.1	2	14
Green Oaxacana Dent	100.9	19.4	5.2	13	36
PHB09 / LH38	128.6	19.4	6.7	9	7
H111 / MS75 // SD65 / Mo42	101.4	19.4	5.3	4	26
ND405/PA409 // A682/NY821	98.5	19.5	5.1	17	36
PHB47 / LH38	135.1	19.9	6.8	0	20
BS22 (R)C7	109.2	20.2	5.4	1	12
E95	95.0	20.4	4.7	5	24
Nokomis Gold	104.9	20.6	5.2	7	16
PHG80 / LH38	130.3	20.6	6.3	2	7
BS21/ BS22	83.1	21.3	3.9	1	17
Means	109.5	18.8	5.9	3	19

Table 7. Significance levels from analysis of variance for field corn inbred and non-inbred parents evaluated at Penn Yan, New York for grain yield (bu/A), grain moisture at harvest (%), and stalk lodging (%).

Source	df	Inbred Parents			df	Non-inbred Parents		
		Grain Yield	Grain Mois.	Stalk Lodge		Grain Yield	Grain Mois.	Stalk Lodge
Reps	1	**	**		1			
Parents	16	*	**	**	13	*	**	
C.V.		41.6	19.3			22.7	4.5	

*, ** Significant at the $p \leq 0.05$ and $p \leq 0.01$ levels, respectively.

Table 8. Means for inbred parents of hybrids evaluated under organic management in Penn Yan, New York in summer 2005.

Inbred	Grain Yield, bu/A	Grain Moisture, %	Yield: Moisture Ratio	Lodging, %		Stay-green, 1-5 scale	Early Vigor, 1-3 scale
				Root	Stalk		
73118	36.4	13.8	2.7	0	29	1.0	1.5
25-112	30.5	14.8	2.1	29	0	1.5	2.0
45-004	24.2	15.4	1.6	2	14	1.0	2.5
LH145	34.8	17.8	2.0	0	22	1.0	2.0
RD3012	16.7	21.0	0.8	0	32	1.0	2.0
05-135	16.7	21.2	0.8	0	41	2.0	1.0
32311C-A	26.1	24.8	1.1	0	0	1.5	2.5
PHB47	48.3	32.7	1.5	46	0	4.0	1.0
93-187	24.4	33.2	1.0	1	0	1.0	2.5
05-438	7.5	33.6	0.2	0	0	2.0	1.0
SD65	22.2	34.9	0.8	1	3	1.0	1.0
93-183	36.1	35.1	1.2	4	0	2.0	1.5
PHG8D	32.8	36.5	0.9	3	0	3.5	1.5
A634Ht	17.0	39.1	0.5	3	2	1.5	2.0
CO388	7.1	40.3	0.2	0	0	2.0	1.0
03042	2.2	43.8	0.1	0	2	1.0	2.0
PHG35	18.1	51.7	0.3	1	2	5.0	2.0
Means	23.6	30.0	1.0	5	9	1.9	1.7

Mean trait values for non-inbred parents are shown in Table 9. These parents, which are mostly single crosses or open-pollinated varieties themselves, showed yields similar to those of the variety trial, which was expected. Any of the parents evaluated in this trial would yield enough to allow for economically viable seed production, although some showed significant lodging problems. In general, their grain moisture values indicated acceptable maturity in this environment. The highest yielding single cross parent, which

also had no lodging and good early maturity, was 207/LH82 – one of the parents of the highest performing double cross in the variety trial at Penn Yan.

Table 9. Means for non-inbred parents of hybrids evaluated under organic management in Penn Yan, New York in summer 2005.

Parent Name	Grain Yield, bu/A	Grain Moisture, %	Yield: Moisture Ratio	Lodging, %		Stay-green, 1-5 scale
				Root	Stalk	
CO255 / F2	59.0	17.2	3.4	41	30	1.0
CG CC GPA	67.2	17.2	3.9	20	8	1.0
73118 / 93-187	74.6	17.5	4.3	6	34	1.5
Cg Syn A C8	63.5	17.7	3.6	30	5	1.0
ND240 / PA409	101.1	18.7	5.4	48	11	1.5
207 / LH82	157.8	19.0	8.4	0	0	3.5
207 / RD4579	90.8	19.2	4.7	1	7	3.0
BS21	117.5	19.8	5.9	6	5	2.0
A682 / LH38	141.6	20.1	7.0	13	5	2.0
ND405 / PA409	91.8	20.5	4.5	99	4	2.0
H111 / MS75	119.3	20.6	5.8	10	3	4.0
SD65 / Mo42	79.9	21.7	3.7	6	8	1.5
W552 / 207	90.4	22.1	4.1	37	10	3.5
A682 / NY821	107.4	22.5	4.8	63	24	2.5
Means	97.3	19.5	5.0	27	11	2.1

Objective 4. Begin backcrossing the gametophytic sterility, white cap, and brown midrib traits into several inbreds for later use in producing organically grown corn hybrids.

Crosses were made as described under the methods section for this objective. For Ga1s conversions, we now have progenies with four backcrosses to 73118, three backcrosses to SD65, and one backcross to 32311C-A, LH82, A634Ht, and 93-187. For Wc1 and bm3 conversions, all progenies are either initial crosses or have one backcross completed. Typically, five or six backcrosses are required to fully recover the phenotype of the recurrent inbred parents, so this work will need to be continued before finished products are available. With the option to carry out two breeding generations per year and predicting (conservatively) that six backcrosses will be needed, the first products will be available after the 2006-2007 winter growing season and the ones that have just been initiated will not be available until after the 2008-2009 winter growing season.

Conclusions

Based on the limited data possible to generate in one field season, it does indeed appear that the best performing field corn varieties under organic management are not the same as those that would have been selected based on evaluations under non-organic conditions. Preliminary data from evaluations of varieties at Lakeview Organic Grain in Penn Yan in 2003 and 2004 suggests the same conclusion. However, identifying the best varieties will require continued testing under organic conditions and ideally will include a greater number of environments (year-location combinations). The most promising varieties identified are of considerable interest to organic growers, as evidenced by questions and inquiries after M. Smith presented results from this work at the NOFA-NY conference in Syracuse on 28 January 2006.

Our work includes the only data we are aware of evaluating performance of parent inbreds and varieties on organic fields in New York. Results of these parent evaluations revealed a number of parents that yielded enough grain (seed) to consider acceptable for economically viable commercial organic hybrid seed production. Based on this work, Lakeview Organic Grains is ready to do pilot production of one or more of Cornell's experimental hybrids in the 2006 growing season.

Introducing genes like Ga1s, Wc1, and bm3 into parents of these elite hybrids will take a number of additional breeding generations. Nonetheless, progress has been made at moving these genes into a series of inbreds that we picked (based only on preliminary data) because they were parents of hybrids that seemed promising for organic management. A number of these inbreds were among the top performing varieties in our trials, suggesting that we made our initial choices well. Based on the data gathered through this project, we will probably initiate conversions of a few more parents that were involved in highly productive hybrids. Moving these genes into hybrid parents will ultimately give organic field corn producers something they have long desired – a means to reduce the chances of contamination of their organic crop with genetically engineered traits.

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