Evaluation of Midwestern and Southern Switchgrass Cultivars and Germplasm For Biomass Production in the Northeast

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Introduction

The potential for switchgrass to be used as a lignocellulosic biofuel crop as well as for direct combustion has received much attention and research because of its wide adaptability and high yields. Evaluation of switchgrass cultivars across similar plant hardiness zones and ecoregions has shown the potential to move high productive cultivars developed in the Midwest to the East. The idea of moving switchgrass cultivars and germplasm one plant hardiness zone North as a strategy to improve yields is well documented. The above two concepts about the adaptability of switchgrass formed the rationale to look at breeding lines and cultivars from the Midwest and Southern U.S. to be used in the Northeastern U.S. Switchgrass Breeding lines are being developed to be used for hybrid populations between the Lowland populations selected from 'Kanlow' and upland types selected from 'Summer'. Typically lowland switchgrasses like Kanlow are tetraploid. Summer switchgrass is unusual in that it is an upland tetraploid not the typical octoploid of most upland types. This allows breeding between those two populations and cultivars. Some of the breeding lines and experimental hybrids are being evaluated at the Big Flats Plant Materials Center. The experimental hybrids were crossed in a greenhouse. Some of the breeding lines being evaluated represent work being done to select for late flowering upland types and earlier flowering lowland types with good compositional qualities and yield to be used to synchronize flowering times for field hybrid population seed production.

Materials and Methods

Two studies were conducted at the Big Flats Plant Materials Center in Corning, NY (latitude 45° 07' 30") on a Unadilla silt loam soil. The soil pH was 5.7 with medium phosphorus and potassium soil test values. The first study established on 5/22/09 evaluated 13 lines (See Tables 1 and 2) developed by Dr. Ken Vogel from the USDA-NRCS Central-East Regional Biomass Center, Lincoln Nebraska being evaluated for use in a hybrid population breeding system. It consists of selections from Summer switchgrass with an origin of Southeast Nebraska and Kanlow with an origin of East-Central Oklahoma. The second study established on 5/21/10 (Table 3) evaluated 4 lines developed by Dr. Michael Casler USDA-ARS U.S. Dairy Forage Research Center, Madison Wisconsin and lines from Oklahoma State University Stillwater Oklahoma developed by Dr. Charles Taliaferro and recently released cultivars 'Bomaster' and 'Timber' this material was compared with Kanlow and 'Cave-In-Rock'. Both studies were seeded in 5 by 20 ft plots in a completely randomized design replicated 4 times at a rate of 11 lb/ac bulk seed using a Brillion seeder. No fertilizer was applied at any time during the studies The plots were burned in the fall for maintenance. The plots were harvested with a Carter harvester on 10/20/10 and 10/18/11 for the 2009 planted study and on 10/18/11 for the 2010 study. The samples were dried in a forced air oven and dry matter was calculated.

Figure 1. Switchgrass Breeding Lines of Ken Vogel's plots Planted 5/22/09 Photo 8/29/10

Table 1. Ken Vogel's Breeding Lines

Kanlow
NE SUMMER Elite late mat. selection PC
K x S HP1 C1 High Yield PC
S x K HP1 C1 High Yield PC
NE Summer late mat. high vigor selection PC
Kanlow N1 Syn 2 increase
Kanlow N1 NETO3 Index selection PC
S x K HP1 C1 High NETO2 index PC
CIR HYD-HDMD C3 PC
Kanlow N1 NETO2
K x S HP1 C1 high NETO2 index PC
Kanlow N1 early mat-High yield PC
Kanlow N1 late mat-High yield PC
NE Late Syn HYLD-HDMD C4 Syn 2

Table 3. Plant Material for 2010 Study

- 'Timber' Switchgrass- (cv from Cape may PMC)
- 'Bomaster' Switchgrass- (cv from North Carolina State University)
- 'Kanlow' Switchgrass- (cv from Kansas State, SCE-07-PAVI-ZK, Lot # SWK-6185-S)
- 'Cave-In-Rock'- (cv from Elsberry Plant Materials Center, Mo., SFO-06-PAVI-Z)
- SW-385 St. Croix- upland accession from northern Wisconsin[1]
- SW 1655-7- clone synthetic selected for rust resistance[1]
- SW 1656- a late flowering upland selection from unknown sources[1]
- SW 1657- high yielding broad-based upland population from many sources[1]
- NL94-1- another breeding line from Oklahoma State University
- NL94-2001-1- breeding line for Oklahoma State University

[1] Seed provided by Dr. Michael Casler U.S. National Forage and Dairy Lab, Madison, Wi.

Table 2. Definitions of Ken Vogel's Breeding Line Names

- K= Cultivar 'Kanlow' population
- S= Cultivar 'Summer' population
- K x S or S x K population crosses the first letter is the male population
- HP1 = hybrid population 1 cycle of selection
- C=breeding cycle generations of selection
- PC= polycross, interpollination in isolation of selected plants
- Kanlow N1= populations based on 1 cycle of selection from the base cultivar 'Kanlow'
- Syn= Synthetic, a group of selected populations
- NET02 & NET03 = Nebraska ethanol index selection indices used for different composition factors (i.e. high IVDMD and low lignin) and yield
- CIR HYD-HDMD C3 = 'Cave-In-Rock' high yield - high in vitro dry matter digestibilty (IVDMD) breeding cycle 3
- NE Late Syn = a synthetic based on upland populations adapted to the Central Great Plains selected for late flowering

Results and Discussion

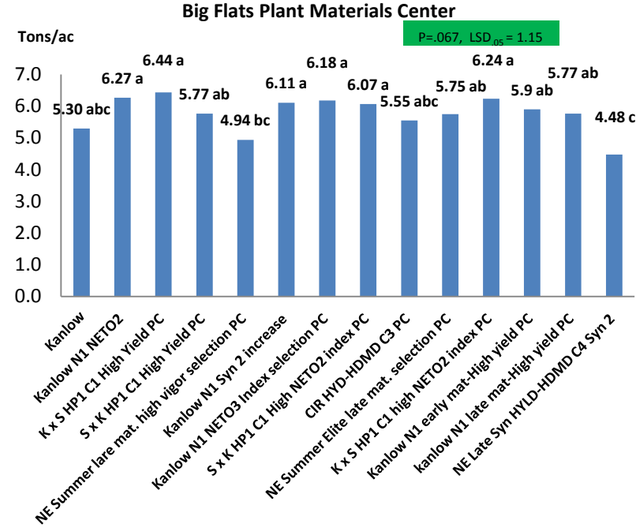
All fields established well with good uniform stands allowing for reasonable yield comparisons (Figure 1). For the study evaluating Ken Vogels breeding lines, in the second year after establishment, 2010 (Figure 2), there was no significant differences between the hybrid population lines compared to the improved parent breeding lines developed from Kanlow with yields of 4.41 and 4. 54 t/ac respectively . The upland parent populations developed from cv Summer had lower yields (3.29 t/ac) compared to the average of the lowland parent and hybrid populations (4.52 t/ac) or the Kanlow (4.86 t/ac) . The improved Cave-In-Rock line yielded 3.50 t/ac.

In the third year after establishment, 2011 (Figure 3), there was an overall average yield increase from 4.10 to 5.76 t/ac as expected as the stand reaches maturity. There was no statistical yield increase from the hybrid population lines compared to the improved breeding lines developed from Kanlow with yields of 6.13 and 6.05 t/ac respectively. There was a trend toward higher yield from the K x S crosses compared to the S x K crosses with yields of 6.34 and 5.92 t/ac respectively.

The yield of Kanlow from a cultivar evaluation at Cornell University without fertilizer (Table 4) had the same yield as this study, 5.3 t/ac. There was a significant increase in their Kanlow yield when fertilized. The addition of fertilizer a typical practice should be used to evaluate these hybrids to compare differences when the plots are fertilized. The male parent population of Kanlow used in this study had no further selection it is likely that using the improved male parents evaluated in this study will improve the hybrid populations yield over the lowland parents. The Summer population used in this study was not improved. Its origin of southeast Nebraska should increase the winter hardiness of the hybrid populations compared to Kanlow germplasm alone.

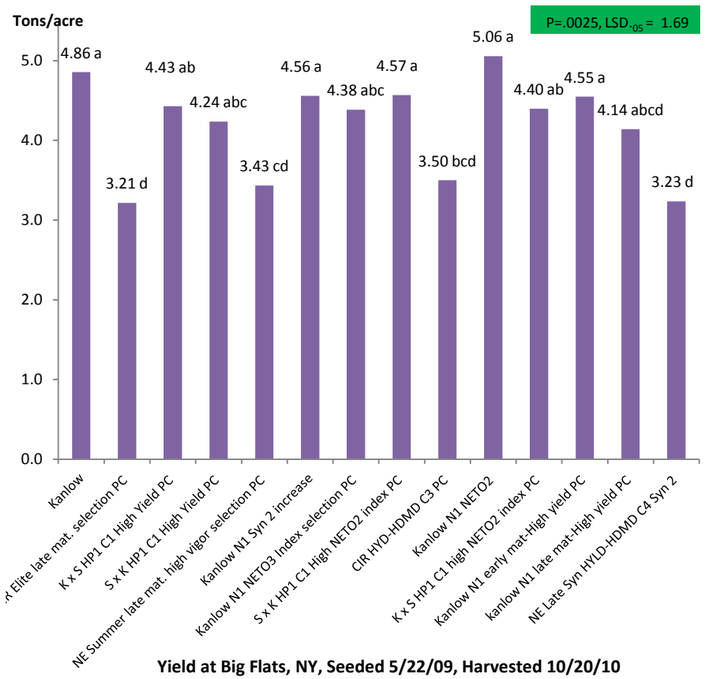
The second study is only in its second year and the yields represent only the second year following establishment. Two breeding lines of Casler's, and Timber exceeded the yield of Kanlow although there were no statistical differences. The Bomaster was significantly lower than Timber. Since both came from similar starting material further evaluation of the data revealed one data point was very low and when removed brought the yield in line with Kanlow and NL_94-1 with 3.93 t/ac (Figure 4). This preliminary information shows the applicability of some of the cultivars and breeding lines for the Northeast.

Figure 3. Switchgrass Breeding Lines of Ken Vogel's at Big Flats Plant Materials Center



Yield at Big Flats, NY Seeded 5/21/10, Harvested 10/18/11

Figure 2. Switchgrass Breeding Lines of Ken Vogel at Big Flats Plant Materials Center 2010 Yield



Yield at Big Flats, NY, Seeded 5/22/09, Harvested 10/20/10

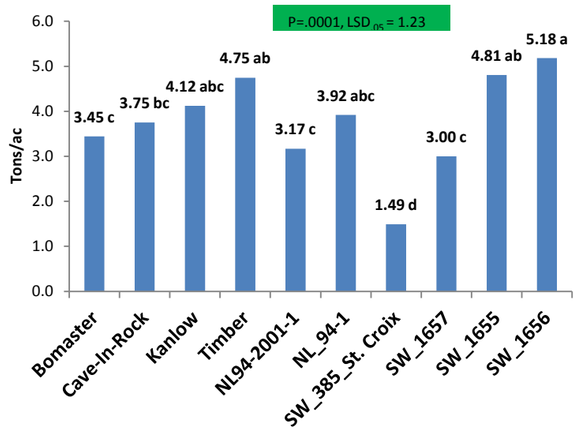
Table 4. Cornell Warm Season Grass Yield Trial with and without Nitrogen Fertilizer 2011[1]

Variety	Species	Ithaca Tompkins Co. 10/18/11 Yield (No N) t/ac	Ithaca Tompkins Co. 10/18/11 Yield (N) t/ac	4 site Average 2011 Yield (No N)* t/ac
Bonanza	big bluestem	2.04	0.58	2.24
Goldmine	big bluestem	0.88	1.91	1.45
Niagara	big bluestem	3.86	3.18	3.45
Pawnee	big bluestem	1.72	1.70	1.85
Atlantic	coastal panic grass	3.71	4.76	2.23
Pete	e.gamagrass	2.91	3.49	1.81
Blackwell	switchgrass	5.02	5.33	4.43
Carthage	switchgrass	4.04	6.01	3.46
Cave-in-rock*	switchgrass	4.86	5.77	4.56
Cave-in-rock	switchgrass	4.72	6.27	4.38
Forestburg	switchgrass	2.11	2.98	2.19
Kanlow	switchgrass	5.30	7.78	2.53
Pathfinder	switchgrass	1.43	3.46	1.83
Shawnee	switchgrass	5.03	5.43	4.63
Shelter	switchgrass	4.92	5.62	4.26
Sunburst	switchgrass	2.26	3.34	2.44
Trailblazer	switchgrass	2.91	2.45	2.59
Nebraska 28	switchgrass	1.85	1.09	2.44
Nebraska 54	indiangrass	2.34	1.68	2.16
Rumsey	indiangrass	2.40	2.02	2.46
Mix 1	Cave-in-Rock/Bonanza	4.65	6.32	4.36
Mix 2	Sunburst/Niagara	4.25	3.43	3.59
Mix 3	Cave-in-Rock/Pete	4.98	5.34	4.51
Mix 4	Niagara/Pete	3.85	3.78	3.16
Grand Total		3.42	3.91	3.04

*Cave-in-Rock lot no. 07-338 was stratified prior to planting

[1] Hilary Mayton, Cornell University, NY Farm Viability Grant

Figure 4. Switchgrass Breeding Lines of Casler and Oklahoma State and Released Cultivars 2011 Yield



Yield at Big Flats, NY, Seeded 5/22/09, Harvested 10/18/11

References

Casler, M.D., K.P. Vogel, C.M. Taliaferro, and R.L. Wynia. 2004 . Latitudinal adaptation of switchgrass populations. Crop Sci. 44:293-303.

Vogel, K.P. and R.B. Mitchell. 2008. Heterosis in Switchgrass: biomass yield in Swards. Crop Sci. 48: 2159-2164.