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FINAL STUDY REPORT
Big Flats Plant Materials Center, Corning, New York

Yield Comparison of Switchgrass Hybrids

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ABSTRACT

The potential for switchgrass (*Panicum virgatum* L.) as a lignocellulose biofuel crop as well as for direct combustion has received much attention and research because of its wide adaptability and high yields. Switchgrass breeding lines were developed for producing hybrid populations between the lowland populations selected from 'Kanlow' and upland types selected from 'Summer'. Objective of this study was to evaluate the yield potential of hybrid switchgrass populations in the northeastern region of the U.S. Replicated plots of 13 experimental strains of switchgrass were established at the USDA NRCS Big Flats Plant Materials Center, near Corning, NY. Hybrid populations and parental breeding lines produced similar yields averaging 5.1 to 5.5 tons/acre over 3 years. Strain K x S HP1 C1 high NETO2 index PC, released as 'Liberty', was among the highest biomass producer at the Big Flats Plant Materials Center and at other sites in the Great Plains. Additional testing of Liberty is needed to determine the area of adaptation for conservation plantings in the northeastern States.

INTRODUCTION

The potential for switchgrass as a lignocellulose biofuel crop as well as for direct combustion has received much attention and research because of its wide adaptability and high yields (Casler and Smart, 2013). 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 (Casler et al., 2015). 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. as potential use in the northeastern U.S. (Casler et al., 2012). Switchgrass breeding lines are being developed for use in producing hybrid populations between the lowland populations selected from 'Kanlow' and upland types selected from 'Summer'. The objective of this study is to evaluate yield potential of switchgrass hybrids, developed by Ken Vogel, in the Northeast US and compare our yields to 5 other test areas.

MATERIALS AND METHODS

Evaluation plots 13 experimental strains of switchgrass were obtained from USDA-Agriculture Research Service (via Ken Vogel) and established 22 May 2009 at the USDA NRCS Big Flats Plant Materials Center, near 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 levels. Switchgrass was seeded in 5 by 20 ft plots in a randomized complete block design, replicated 4 times, at a rate of 11 lb/acre bulk seed, using a Brillion seeder. No fertilizer was applied at any time during the study. The plots were burned in the fall for maintenance of yearly residue. A Carter harvester (Carter MFG Co, Brookston, IN) was used to harvest each plot on 20 October 2010, 18 October 2011, and 26 October 2012, respectively. Samples were collected from each switchgrass dried in a forced air oven to determine dry matter yield.

These plots were evaluated from 2009-2012, for their potential use in a hybrid population breeding system. The long-term objective was to develop a perennial biomass energy crop, which produced high yields that was adapted to plant hardiness zones 4, 5, and 6.

RESULTS AND DISCUSSION

All fields established well with good uniform stands allowing for reasonable yield comparisons (Table 1). In the second year after establishment, there were no significant differences between the hybrid population lines compared to the improved parent breeding lines developed from Kanlow with yields of 4.4 and 4.5 tons/acre, respectively. The upland parent populations developed from Summer had lower yields (3.3 tons/acre) compared to the average of the lowland parent and hybrid populations (4.5 tons/acre) or the Kanlow (4.7 tons/acre) . 'Cave-In-Rock' yielded 3.5 tons/ac.

Table 1: Yield of hybrid and parental switchgrass USDA-NRCS, Big Flats, NY 2010-2012

Breeding Line	2010	2011	2012	Ave BFPMC (2010-2012)
	----------tons/acre----------			
Kanlow N1 NETO2	5.1	6.3	6.1	6.2
K x S HP1 C1 high NETO2 index PC	4.4	6.2	6.1	6.2
Kanlow N1 early mat-High yield PC	4.6	5.9	6.2	6.1
K x S HP1 C1 High Yield PC	4.4	6.4	5.8	6.1
S x K HP1 C1 High NETO2 index PC	4.6	6.1	5.7	5.9
Kanlow N1 Syn 2 increase	4.6	6.1	5.5	5.8
Kanlow N1 NETO3 Index selection PC	4.4	6.2	5.4	5.8
Kanlow	4.9	5.3	5.3	5.3
Kanlow N1 late mat-High yield PC	4.4	5.8	5.3	5.5
NE Late Syn HYLD-HDMD C4 Syn 2	3.2	4.5	4.9	4.7
S x K HP1 C1 High Yield PC	4.2	5.8	4.9	5.3
NE SUMMER Elite late mat. selection PC	3.2	5.8	5.5	5.6
CIR HYD-HDMD C3 Polycross	3.5	5.6	4.8	5.2
NE Summer late mat. high vigor selection PC	3.4	4.9	5.2	5.1
Mean	**4.2**	**5.8**	**5.5**	**5.1**

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 digestiblilty (IVDMD) breeding cycle 3

NE Late Syn = a synthetic based on upland populations adapted to the Central Great Plains selected for late flowering

** 'Liberty' switchgrass

In the third year after establishment, when the stand reached maturity, there was an overall average yield increase from 4.1 to 5.8 tons/acre. There was no statistical yield (no shown here) increase from the hybrid population lines compared to the improved breeding lines developed from Kanlow with yields of 6.1 and 6.1 tons/acre respectively. There was a trend toward higher yield from the K x S crosses compared to the S x K crosses with yields of 6.3 and 5.9 tons/ac respectively.

'Liberty' switchgrass (Reg. No. CV-271, PI 669371) (Vogel, et al 2014) was released as a high-yielding lowland-type cultivar adapted to the Midwest and adjacent areas, where it can be grown as a biomass energy crop. Selection was based on high biomass yields, seedling vigor, and reduced biomass acid detergent lignin concentration (NETO2) for improved conversion efficiency to liquid fuels (Vogel et al. 2014). These experimental strains were tested at 6 sites: Mead, NE, DeKalb, IL, Arlington, WI, Marshfield, WI, Spooner, WI, and at the USDA NRCS Big Flats Plant Materials Center.

Based on the results seen at all locations, strain K x S HP1 C1 high NETO2 index PC ('Liberty') switchgrass was among the highest biomass producer at all sites, after 3 years (Table 2). Even though other cultivars and experimental strains produced higher biomass yields, their winter survival was significantly lower (not shown here). In NY and NE, there was no significant differences between the hybrid population lines compared to the improved parent breeding lines developed from 'Kanlow'. The upland parent populations developed from Summer had lower yields compared to the average of the lowland parent and hybrid populations or the Kanlow. At the Wisconsin sites, the Summer populations and Summer and Kanlow experimental strains produced more biomass and had higher winter survival than the Kanlow improved selections. At the Illinois site, K x S HP1 C1 high NETO2 index PC ('Liberty') was significantly higher in yield than the rest of the strains, producing 7.31 tons/acre. The other lines at the Illinois sites produced similar yields, but 'Kanlow' produced the lowest yield of 4.10 tons/acre.

CONCLUSION

A new lowland-type switchgrass cultivar, 'Liberty' has shown to be adapted to USDA hardiness zones 4, 5, and 6 in the U.S. Great Plains and Midwest. It is as a high-yielding biomass type lowland cultivar with potential adaptation in the northeastern climate as indicated by the yields at the USDA-NRCS Big Flats, New York Plant Materials Center. Additional evaluation studies should be conducted in the northeast to further document its area of adaptation and use for other conservation planting.

Table 2. Yield comparison of the 13 experimental switchgrass breeding lines at 6 sites (n/a-no data).

Cultivar/Experimental Strain	Big Flats, NY	Mead, NE*	DeKalb, IL*	Arlington, WI*	Marshfield, WI*	Spooner, WI*	Ave. all sites
	----------tons/acre----------						
S x K HP1 C1 High NETO2 index PC	5.87	8.30	n/a	n/a	n/a	n/a	7.08
K x S HP1 C1 high NETO2 index PC**	6.15	8.07	7.31	4.06	4.06	5.58	5.87
K x S HP1 C1 High Yield PC	6.11	8.16	5.80	4.10	4.77	5.71	5.78
S x K HP1 C1 High Yield PC	5.33	8.07	5.75	4.86	4.77	5.75	5.76
NE SUMMER Elite late mat. selection PC	5.63	5.89	n/a	n/a	n/a	n/a	5.76
CIR HYD-HDMD C3 Polycross	5.18	5.98	5.26	5.80	5.62	4.59	5.41
NE Summer late mat. high vigor selection PC	5.09	5.75	4.64	3.39	3.79	4.24	4.48
Kanlow N1 NETO2	6.19	9.01	5.80	2.50	1.87	1.29	4.44
Kanlow N1 late mat-High yield PC	5.54	8.88	5.62	2.50	2.45	1.12	4.35
NE Late Syn HYLD-HDMD C4 Syn 2	4.68	5.84	4.73	3.57	3.26	3.84	4.32
Kanlow N1 NETO3 Index selection PC	5.77	8.43	5.53	1.87	1.69	1.38	4.11
Kanlow N1 Syn 2 increase	5.82	8.34	4.68	2.23	1.61	1.25	3.99
Kanlow N1 early mat-High yield PC	6.05	8.12	4.73	2.77	1.34	0.67	3.94
Kanlow	5.30	8.34	4.10	2.05	1.43	1.12	3.72
ave all lines	**5.62**	**7.66**	**5.33**	**3.31**	**3.06**	**3.04**	**4.67**

** 'Liberty' switchgrass (new release)

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