Wheat Residue Yield and Composition for Estimation of Biofuel Feedstock Potential

Mark Marsalis[1], Sangamesh Angadi[1], Rex Kirksey[1], Robert Hagevoort[1], and Mick O'Neill[2]

[1] NMSU Agricultural Science Center at Clovis;
[2] NMSU Agricultural Science Center at Farmington;
New Mexico State University, Las Cruces, NM

INTRODUCTION

New Mexico Wheat Production:

- Semi-arid and arid environments; annual precipitation <450 mm yr $^{-1}$
- Characterized mostly by irrigated agriculture with diminishing water resources or low-input, non-irrigated systems
- Over 180,000 ha of wheat planted in the state each year
- Large amounts of biomass remain after grain harvest (Fig. 1)
- Wheat stover poses a problem in intensively managed, double-cropping systems prior to planting annual summer crops
- Current value of wheat straw hay is low where residue is harvested

Biofuel Prospects:

- No new crops identified for the region as having strong potential (Fig. 2)
- Wheat stover remaining after grain harvest may present a cellulosic source for biofuel conversion facilities
- Economic value of wheat residue may be increased if energy value is adequate and if biofuel marketing options exist
- Appropriate quality parameters for estimating biofuel potential of cellulosic sources are still in question

Fig. 1. Wheat residue after harvest with combine.

Fig. 2. Geographic suitability of different biomass crops in the United States (DOE, 2006).

OBJECTIVES

1. Evaluate the suitability of post-harvest wheat residue harvested from irrigated systems for use as a biofuel feedstock.
2. Estimate dry matter yield of residue of different varieties of winter wheat at two climatically different locations.
3. Measure concentrations of several cell wall components and fiber digestibility to estimate, in general, conversion potential of wheat biomass.

For more information:
Mark Marsalis: marsalis@nmsu.edu
Ph: 575-985-2292 Ext.123

MATERIALS AND METHODS

Field Procedures

Locations:	Clovis, NM Farmington, NM
Years:	2008 and 2009
Varieties Used:	Jackpot, Kharkof, Scout 66, TAM 107, Trego
Seeding Dates:	2007 – Oct. 30 (Clovis) & Sept. 25 (Farmington) 2008 – Oct. 30 (Clovis) & Sept. 24 (Farmington)
Harvest Dates:	2008 – July 1 (Clovis) & July 30 (Farmington) 2009 – June 19 (Clovis) & Aug. 11 (Farmington)
Plot size:	Clovis: 10.5 m^2 ; 11 rows ; 14.0 cm between rows Farmington: 9.3 m^2 ; 6 rows ; 25.4 cm between rows
Seeding Rate:	Clovis, 106 kg ha^{-1}; Farmington, 112 kg ha^{-1}
Irrigation:	Clovis: 676 mm (2008) ; 447 mm (2009) Farmington: 605 mm (2008) ; 711 mm (2009)
Fertilizers:	Clovis: 195 kg N ha^{-1}, 56 kg P ha^{-1}, 8 kg S ha^{-1}, and 1 kg Zn ha^{-1} Farmington: 165 kg N ha^{-1}, 54 kg P ha^{-1}, 64 kg K ha^{-1}, 17 kg S ha^{-1}, and 2 kg Zn ha^{-1}
Experimental Design:	Randomized Complete Block with 3 replications

Harvest Management

- 0.6 m^2 of planted plot area hand-clipped and separated into heads and stalks
- Wheat heads threshed and chaff collected separately from grain
- Stalks and chaff composited to give total residue weight
- Residue material dried at 55°C for 72 hr to determine dry matter (DM) yield

Plant Composition Analyses

- Residue was ground to pass a 1-mm sieve for fiber analysis
- Chemical analyses determined proportions of cellulose, hemicellulose, acid detergent lignin (ADL), and *in vitro* neutral detergent fiber digestibility (NDFD, 48-hr)
- Concentrations multiplied by DM yield to give yield per ha of each fiber parameter

RESULTS

- All varieties yielded greater than 8 Mg ha^{-1} of DM; Kharkof and Jackpot differed in DM yield from one year to the next. All other varieties had similar yields both within and across years (Table 1).
- All yield components, except lignin yield, were greater at Farmington than Clovis (Table 2). Greater than 3.5 Mg ha^{-1} of cellulose was harvested.
- In vitro NDFD was similar between locations; however, varieties differed in IVNDFD and ranged from 38 to 43 g 100 g^{-1} NDF. No apparent correlations were observed between DM yield and IVNDFD.
- Lignin comprised as much as 5% of total DM yield on average and was not different between locations or among varieties.

Table 1. Dry matter yield of five varieties of irrigated winter wheat residue harvested for biomass at two locations in New Mexico.

	Year		
Variety	2008	2009	P < 0.05
	Mg ha^{-1}		
Kharkof	8.3 ^{b}	10.9 ^{a}	*
Scout 66	8.4 ^{b}	8.8 ^{b}	NS
TAM 107	9.2 ^{ab}	8.7 ^{b}	NS
Trego	9.4 ^{ab}	8.4 ^{b}	NS
Jackpot	10.5 ^{a}	8.4 ^{b}	*

$^{*, NS}$ Indicates difference between means across years (P < 0.05).
$^{a, b}$ Indicates difference between means within a year (P < 0.05).

Table 2. Production parameters and fiber composition of irrigated winter wheat residue harvested for biomass at two locations in New Mexico averaged over two years and five varieties.

	Location		
Parameter	Clovis	Farmington	SE†
	Mg ha^{-1}		
Dry Matter Yield	7.8	10.4 ***	0.3
Cellulose Yield	3.2	4.1 **	0.2
Hemicellulose Yield	1.9	2.6 ***	0.1
Lignin Yield	0.44	0.49	0.04
NDFD‡ Yield	2.3	3.1 ***	0.1
	g 100g^{-1}		
ADF‡	50.7	46.9 *	0.8
NDF‡	74.2	72.1 **	0.3
Cellulose	41.4	39.2 *	0.6
Hemicellulose§	23.5	25.2	0.9
Lignin¶	6.0	4.6	0.5
IVNDFD$^{\#}$	40.0	42.2	1.2

† SE = standard error of the mean, n = 30 for all means; ‡ ADF = acid detergent fiber, NDF = neutral detergent fiber, NDFD = neutral detergent fiber digestibility; § Calculated as (NDF - ADF); ¶ Acid detergent lignin; $^{\#}$ IVNDFD = In vitro NDFD (48-hr; g 100g-1 NDF); *,**,*** Indicates difference between location means (P < 0.05; 0.01; and 0.001, respectively).

SUMMARY

- Large amounts of dry matter can be harvested for biofuel feedstock from irrigated wheat systems in NM; however, when digestible fiber yield (NDFD) is used as an indicator, potentially less than one-third of this material may be fermentable and contribute to energy production.
- Milder spring temperatures and greater overall irrigation amount at Farmington compared to Clovis may have contributed to higher yields without reduced fiber digestibility.
- Other factors such as soil erosion and water retention should be considered in these systems as removal of surface residue will affect subsequent crop productivity and environmental quality.