Growth Potential and Unique Quality Characteristics of Fall-Grown Cereal-Grain Forages in Central Wisconsin

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Introduction

Cereal grains are used commonly for fall, winter and spring grazing throughout the Southern Great Plains, but these forages have not been evaluated extensively as fall forage options for dairy and beef producers in the north-central U.S. Studies were conducted to determine if beef and dairy producers could use cereal-grain forages to extend the fall grazing season, minimize supplemental hay or silage feeding, or to provide an additional forage option for silage. These management strategies could be applied routinely, or specifically following summer drought.

Research has suggested that selection of cultivars exhibiting at least some stem elongation following late-summer establishment will provide a 2:1 yield advantage over cultivars that remain vegetative (entirely leaf), such as wheat. Furthermore, physiological development of tillers during cooler fall temperatures may offer potential for unique quality characteristics, such as reduced concentrations of lignin and greater forage digestibility.

Approach

These studies looked at both yield and quality characteristics of different species and varieties of cereal grains when planted in mid-August and harvested on various dates. Four varieties of spring oat (Ogle, Drumlin, Vista and ForagePlus), two varieties of winter wheat (Hopewell and Kaskaskia), and one variety of triticale (Trical 2700) were established in replicated plots on August 11, 2006, and August 13, 2007, at Prairie du Sac, WI. Forages were no-till seeded into residual cereal-grain stubble and fertilized at planting with a single application of ammonium nitrate at 50 lbs N/ac. Forages were harvested on three dates (~September 15, October 7 and November 1) during 2006 and 2007. In addition to determining yield, samples were retained and evaluated for a variety of forage quality characteristics at the U.S. Dairy Forage Research Center Laboratory-Marshfield, WI.

Forage Yield

Yields of DM are summarized in Figure 1, and they represent the average of both 2006 and 2007 production years. On all harvest dates, oat varieties maintained an approximate 2:1 advantage in yield over wheat with triticale being intermediate. These differences are largely related to growth habit; oat and triticale varieties jointed and exhibited elongating stems following an early-August planting date, while wheat varieties remained completely vegetative. Across the four oat varieties (Figure 2), yields were greatest for the earliest maturing variety (Ogle; 4,730 lbs/ac), and least for the latest maturing variety (ForagePlus; 3,741 lbs/ac). Other oat varieties produced intermediate yields.

Interpretation of these data requires some additional caution. First, fall yields of cereal-grain forages vary substantially from one year to the next. This occurs, in part, because weather patterns can be somewhat erratic during late-summer. Maximum yields will be obtained when soil conditions permit quick germination and emergence. Mild temperatures during late-October also may permit continued accumulation of DM, especially for cultivars that mature more slowly. *However, independent studies initiated in Marshfield during 2007 have indicated that the yield relationships for oat that are described in Figure 2 are essentially reversed with earlier (mid-July) planting dates.* Early-maturing oat varieties often exhibit accelerated developmental rates under high summer temperatures and also tiller poorly, resulting in poor yields of DM. With mid-July or very early-August planting dates throughout central Wisconsin, late-maturing varieties, such as ForagePlus, are likely to provide much better fall yields than grain-type oat cultivars; these yields have ranged as high as 7,200 lbs/ac in replicated plots established at Marshfield, WI.

Effects of Lignification

Lignin is a complex entity that is essential to plant growth and structure. Its function can be viewed in much the same way as steel reinforcement rods within concrete; generally, it is essential for upright growth, and for supporting the weight of a filling seed head. Unfortunately, lignin is completely indigestible and is a significant impediment to utilization of cell wall by ruminants. Table 1 summarizes the relationships between cell wall (NDF), lignin, and TDN for generic cereal-grain silages harvested traditionally during late-spring or summer (NRC, 2001). It is important to note that these plants matured physiologically during a time period when both day length and temperature were increasing. Generally, these factors combine to increase deposition of lignin. For the forages described in Table 1, concentrations of lignin ranged from 5.5-6.5% of total forage DM, which represented about 10% of the cell wall (NDF).

Figure 1. *Yield response for 4 oat, 2 wheat, and 1 triticale cultivar established in early-August and harvested on 3 dates in the fall of 2006 and 2007. Data averaged over 2 years.*

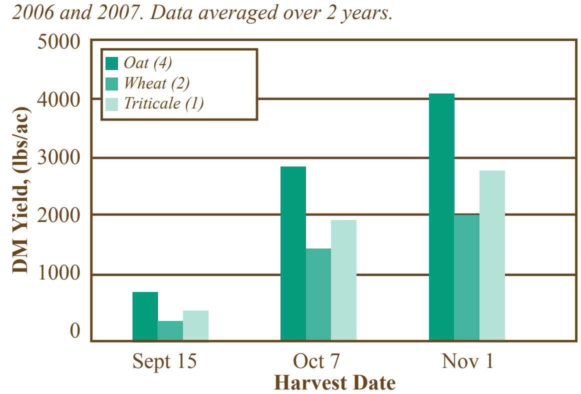
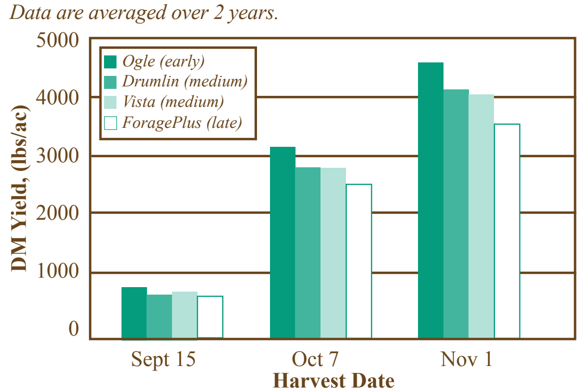


Figure 2. *Yield response for early-, medium-, and late-maturing oat cultivars established in early-August and harvested on 3 dates. Data are averaged over 2 years.*



To contrast these quality characteristics with those of fall-grown cereals, consider similar assessments for Kaskaskia wheat, Ogle oat, ForagePlus oat, and Trical 2700 triticale harvested from the replicated plots during 2006 and 2007 (Table 2). Concentrations of lignin exceeded 2.0% of DM only for Ogle oat harvested on ~November 1 (2.3% of DM). For that forage, tillers had matured to the early heading stage during 2007, which was more advanced than observed for any other cultivar within the trial. This contributed to elevated concentrations of lignin in these fall-grown plants. Averaged over all forages, lignin comprised about 2.0% of NDF, which was only ~21% of that summarized for silages harvested in spring or summer (Table 1). As a result of these striking differences, the energy density (TDN) of fall-grown cereal grains was substantially greater than described for the silages summarized in Table 1, ranging from 63.3-68.9% over the two year trial.

Table 1. *Concentrations of NDF, lignin and TDN for generic cereal-grain silages harvested at the heading stage of growth during late-spring or summer (NRC, 2001).*

Silage Type	NDF	Lignin		TDN
	%DM	%DM	%NDF	%DM
Oat	60.6	5.5	9.1	56.8
Barley	56.3	5.6	9.9	60.2
Triticale	59.7	5.8	9.7	57.2
Wheat	59.9	5.8	9.7	57.2

Other Considerations

In addition to the relatively high concentrations of TDN observed for fall-grown cereal grains, another interesting characteristic for these forages is the relative stability of TDN estimates across harvest dates. While there are many factors that contribute to this unique observation, two factors summarized in Table 3 are especially unique. First, as a result of the relatively low concentrations of lignin, fiber digestibilities are relatively consistent and do not display the dramatic reductions typically associated with maturing plants. This is especially true until the seedhead becomes visible. Secondly, a normal defense mechanism used by cereal-grain plants to resist freezing/winterkill is the accumulation of soluble material within plant cells. Much of this is sugar. This occurs for wheat, which remains vegetative and survives the winter, as well as for oat, which will joint, elongate, and ultimately die. As a result, the normal effects of maturity are offset for fall-grown cereal grains by both extensive and stable digestibilities of forage fiber, as well as accumulations of sugar.

Table 2. *Concentrations of NDF, lignin and TDN for fall-grown cereal-grains harvested near Prairie du Sac, WI, during 2006-2007. Data averaged over 2 years.*

Forage	Harvest Date	NDF	Lignin		TDN
		%DM	%DM	%NDF	%DM
Kaskaskia Wheat	Sept 15	40.6	0.7	1.7	67.0
	Oct 7	46.4	1.1	2.4	66.5
	Nov 1	45.8	0.9	2.0	69.3
Ogle Oat	Sept 15	42.0	0.7	1.7	67.2
	Oct 7	55.2	1.7	3.1	63.3
	Nov 1	55.1	2.3	4.2	64.8
ForagePlus Oat	Sept 15	39.4	0.4	1.0	67.8
	Oct 7	50.1	0.9	1.8	65.4
	Nov 1	49.5	0.9	1.8	68.0
Trical 2700 Triticale	Sept 15	40.6	0.6	1.5	68.9
	Oct 7	49.3	0.8	1.6	66.1
	Nov 1	49.7	0.8	1.6	67.5

Management Implications

1. Generally, selection of cereal-grain cultivars, such as oat, that exhibit stem elongation or heading following fall establishment will deliver a 2:1 advantage in yields of DM over wheat cultivars that remain vegetative.
2. With establishment dates timed to ~August 10, fall forage yield can be improved even further by selecting grain-type oat cultivars that typically exhibit early heading dates when established traditionally in the spring.
3. Forage-type oat cultivars that consistently out-yield grain types following spring establishment often mature slowly, and their fall growth may be limited by cold temperatures. However, forage-oat cultivars will likely out-yield grain types if establishment occurs earlier, during July or very early August.
4. Another advantage of selecting elongating cultivars for fall forage production is that concentrations of TDN are relatively high, and often remain stable throughout the late-fall. Within this context, harvest decisions can be more flexible, and based on factors such as maximization of yield, suitability of weather, or simple convenience, rather than the growth stage of the forage plant.
5. For the dairy industry, a one-time harvest as oat silage could be utilized routinely, or as an emergency measure following summer drought. However, there would be essentially no regrowth of oat following such a harvest, nor would oat be expected to survive winter.
6. Within a grazing context, selection of elongating cultivars generally will provide yield advantages, regardless of grazing date, but these advantages must be weighed against poor potential for regrowth during the fall, and a near certainty of subsequent winterkill.

Table 3. *Fiber digestibilities and concentrations of digestible nonfiber carbohydrate (mainly sugar) harvested from fall-grown cereal-grain forages. Data averaged over 2*

Forage	Harvest Date	Fiber Digestibility[1]	Digestible Nonfiber Carbohydrate[2]
		%NDF	%DM
Kaskaskia Wheat	Sept 15	75.3	14.4
	Oct 7	76.8	13.5
	Nov 1	77.5	25.1
Ogle Oat	Sept 15	75.7	12.6
	Oct 7	67.2	14.2
	Nov 1	64.0	22.0
ForagePlus Oat	Sept 15	76.4	13.5
	Oct 7	74.9	16.8
	Nov 1	74.0	23.2
Trical 2700 Triticale	Sept 15	78.0	15.8
	Oct 7	78.8	12.8
	Nov 1	77.5	18.2

[1] Determined by 48-hour in vitro digestibility of NDF.
[2] Determined as described by NRC (2001).

References: NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC.