Effect of Species and Maturity on Small Grain Silage Yield and Quality

Abigail M. Sartin
Kallie J. Calus
Morgan T. Grabau
Alyssa K. Kuhn
Mary E. Drewnoski
Daren D. Redfearn

Summary with Implications

A study was conducted to determine the effect of species and maturity on yield and nutritive value of winter-hardy small cereal grains used for silage. Three species were evaluated: cereal rye, winter triticale, and winter wheat at four different stages of maturity: boot, pollination, milk, and soft dough. As species matured, yield increased across all stages, but crude protein (CP) and digestible organic matter (DOM) decreased, except at soft dough where there was a slight increase in DOM. Crude protein was greatest at the boot stage at 17.7% and least at soft dough at 9.8%. When comparing species, rye and triticale resulted in greater nutrient yield per acre. If high quality forage is the goal, harvesting at pollination appeared to increase yield without sacrificing a significant amount of nutritive value compared to boot. For maximized yield, harvesting at soft dough is a better option.

Introduction

Cover crops are useful for sequestering nutrients and improving soil structure, but they can also be used as a forage source to help offset costs and generate additional revenue. Cereal rye is the most commonly planted winter hardy cover crop, but other common options include winter wheat and winter triticale. The harvest window for winter-hardy cereal silage is from early May until late June in the Midwest, offering the unique opportunity for a double cropping system with a summer cash crop. Since yields increase, but nutritive value declines as forage matures, the ideal harvest timing will vary for operations based on the quality of silage needed and timing of subsequent planting. It has also been observed that the different winter hardy small cereals differ in the timing at which they reach the various stages of maturity. Thus, species selection may impact yield, nutritive value, and window of harvest. Therefore, the objective of this study is to evaluate the silage yield and nutritive value of winter wheat, cereal rye, and winter triticale at 4 different maturity stages.

Procedure

In this two-year study, twenty 11 x 80-foot plots located on East Campus at the University of Nebraska-Lincoln were drilled in late October with Arapahoe winter wheat, VNS cereal rye, or NT11406 winter triticale in year 1 and Rymin cereal rye, NT1140 triticale, or Arapahoe wheat in year 2. In the spring, plants were observed regularly for maturity progression and harvested at 4 target stages: boot (majority of heads close to showing), pollination (heads are out and pollinating, yellow anthers visible), milk (white milky substance produced when seed is squeezed), and soft dough (white dough-like substance produced when seed is squeezed). All treatments were fertilized with 60 pounds of nitrogen per acre in the form of ammonium nitrate (NH_4-NO_3). Plots were set up as a randomized complete block design with four blocks (location) and the three species randomly assigned within block to a plot. Within each plot, there was a split plot design of the four harvest timings being randomly assigned to one quarter of the plot. Prior to harvest at each stage, biomass samples were cut at a height of 2 inches by hand to calculate yield. A 5 x 40-foot area of forage was cut with a Carter harvester within each plot at each stage and allowed to wilt, targeting 30–35% dry matter. Once cut the dry matter content was measured using a Koster moisture tester; 30 minutes to an hour later another sample was taken and dry matter content was determined to evaluate the rate of drying and determine an estimated target wilting time. For longer wilt times, this procedure was repeated until it was estimated that the target dry matter was achieved. Samples of the wilted material were taken, and buckets (5 gallon) were then packed and ensiled for 45 days in a non-temperature-controlled storage shed before being opened and sampled. The top 6 inches of material were removed and discarded. The remaining ensiled sample was mixed, and a subsample was obtained. Samples were sent to Dairyland Labs to be analyzed for pH using an Orion pH electrode and fermentation end products via high-performance liquid chromatography (HPLC). Samples were then dried at 60°C and analyzed for crude protein (combustion method) and shipped back to the UNL ruminant nutrition lab where in vitro organic matter digestibility (IVOMD) was measured by incubating samples in buffered rumen fluid for 48 hr. Digestible organic matter (DOM), a proxy for TDN, was calculated by multiplying the IVOMD by the organic matter content of the sample.

Dry matter yield (lbs/ac), CP (% of DM), DOM (% of DM), CP and DOM yield (lb/ac), DM content of plants when cut (DM at harvest), DM content of silage post fermentation, pH, and fermentation end products (lactic, butyric, and acetic acid and ammonia) were all analyzed using the mixed procedure of SAS. Effect of timing of harvest, species, and species by harvest interaction were tested as fixed effects. Year was considered random. When interaction was not significant, it was removed from the model.

Results

The dates at which each species reached these maturity stages are shown in Table 1. All species progressed from boot to soft dough over the time period of about a month. From year 1 to year 2, timing of

Table 1. Harvest dates of winter hardy small cereals species based on achieving the target maturity stage.

	Year 1		
	Rye	Wheat	Triticale
Boot	5/18/20	5/23/20	5/18/20
Pollination	6/1/20	ND[1]	5/29/20
Milk	6/9/20	6/8/20	6/9/20
Soft Dough	6/22/20	6/16/20	6/22/20
	Year 2		
Boot	5/5/21	5/13/21	5/11/21
Pollination	5/12/21	5/24/21	5/24/21
Milk	6/11/21	6/7/21	6/8/21
Soft Dough	6/15/21	6/14/21	6/21/21

[1]The pollination stage of wheat was missed; therefore, no date is available.

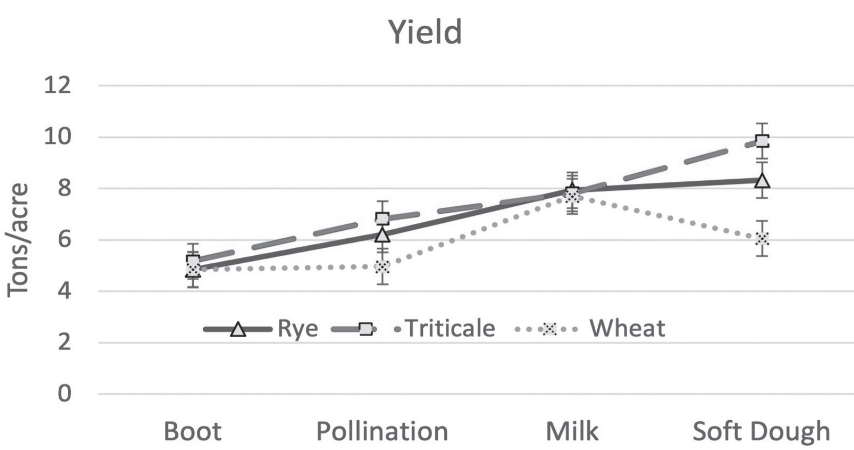

Figure 1. Dry matter yield of wheat, rye, and triticale across 4 stages: boot, pollination, milk, and soft dough. Yield increased for each species across stage except for wheat, which declined at soft dough. Species x Stage $P = 0.03$, Species $P < 0.01$, Stage $P < 0.01$

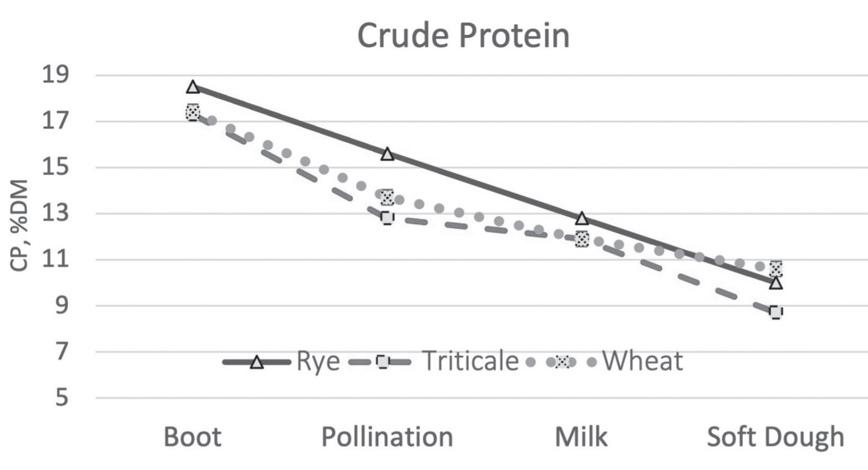

Figure 2. Crude protein as a percent of dry matter of wheat, rye, and triticale across 4 stages. Crude protein declined with maturity across all species. Species x Stage $P < 0.01$, Species $P < 0.01$, Stage $P < 0.01$

harvest for each species varied, likely due to difference in the varieties used. In year 1, rye and triticale were harvested on similar dates and reached boot stage earlier compared to wheat. However, wheat progressed through later stages quickly resulting in wheat reaching milk at the same time as the rye and triticale. The increased rate of maturing for wheat resulting in it reaching soft dough earlier than rye and triticale. In year 2, rye reached boot and pollination earlier than triticale and wheat which had similar timing for these stages. Wheat and triticale also had similar timing at which they reached milk and were about a week earlier than rye. Rye and wheat reached soft dough at the same time and was about a week earlier then triticale. Overall, the window of harvest is slightly shorter for wheat than for rye and triticale.

As the small cereals matured the DM content when cut increased ($P < 0.01$) at 17, 21, 30, and 41% DM for boot, anthesis, milk and soft dough, respectively. Similarly, dry matter yield (Figure 1) increased across all stages, except for wheat, where there was a significant decline at soft dough, likely due to senescence of the lower leaves. Yield of rye and triticale did not differ ($P > 0.05$) except at soft dough where triticale was greater ($P < 0.01$) than rye. Triticale yield was greater ($P < 0.01$) than wheat at pollination and soft dough, with rye being greater ($P \leq 0.05$) than wheat at pollination and soft dough.

Crude protein (Figure 2) decreased ($P < 0.01$) with maturity across all species. Among species, rye was greater ($P \leq 0.01$) than triticale at boot, pollination, and soft dough, but was not different ($P \geq 0.10$) from wheat at boot, milk, and soft dough. At boot, pollination, and milk triticale was not different from wheat ($P \geq 0.07$). Triticale was less than wheat at soft dough ($P < 0.01$).

In terms of DOM (Figure 3), rye and wheat did not differ statistically ($P > 0.05$) but were greater ($P < 0.01$) than triticale. Across species, boot stage had the greatest average DOM concentration at 57.5% and milk had the lowest at 49.3%.

When comparing nutrient yield per acre in terms of energy (DOM) and CP (Figure 4), rye and triticale had greater ($P \leq 0.05$) nutrient yields than wheat with triticale having a slightly greater DM yield with slightly lower energy and protein content

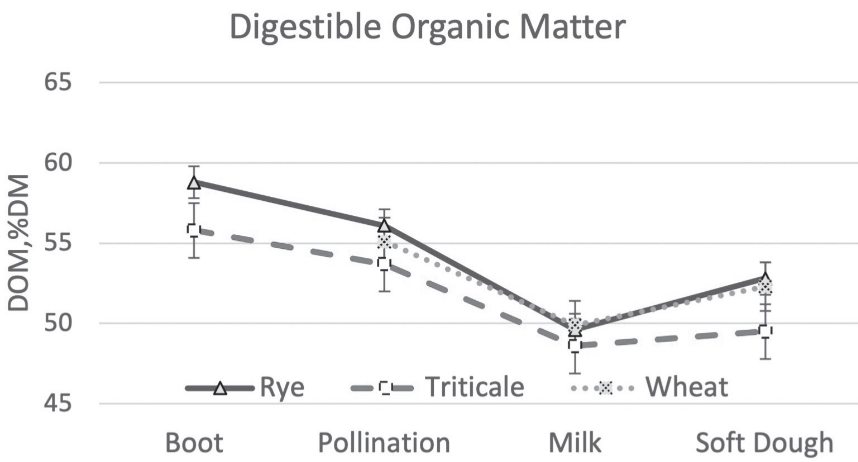

Figure 3. Digestible Organic Matter (DOM), which is a proxy for TDN, as a percent of dry matter for wheat, rye, and triticale across 4 stages. DOM decreased with maturity across species, except at soft dough where there was slight increase, likely due to the formation of the seed head. Species x Stage $P = 0.80$, Species $P < 0.01$, Stage $P < 0.01$.

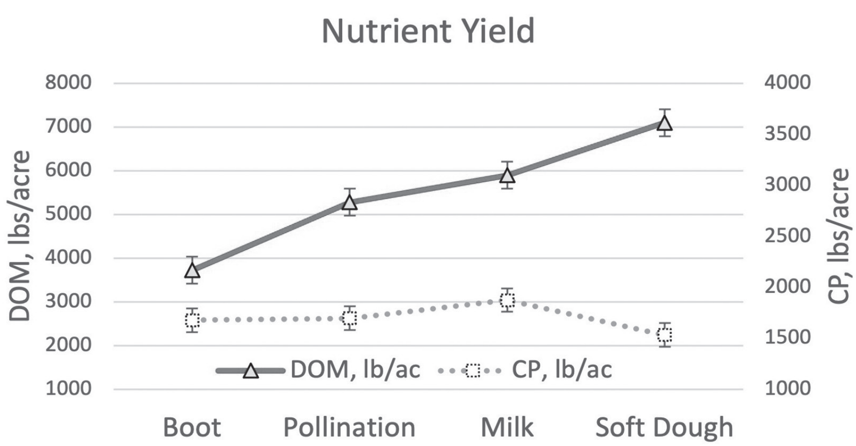

Figure 4. Nutrient yield per acre across 4 stages for all three species: wheat, rye, and triticale. DOM is represented on the left axis and CP on the right axis. Stage DOM $P < 0.01$, Stage CP $P = 0.10$

Table 2. Effect of maturity stage on DM content and the resulting fermentation profile of small cereal grain silage fermented for 45 days.

	Typical Values	Boot	Anthesis	Milk	Soft Dough	SEM	*P*-value
DM, %	-	23d	27c	31b	37a	1.1	<0.01
pH	4.3–4.7	4.3d	4.6b	4.4c	4.6a	0.11	0.01
Lactic Acid, % DM	6.0–10.0	8a	4b	5b	3b	2.6	<0.01
Butyric Acid, % DM	0.5–1.0	0.03	0.35	0.02	0.02	0.18	0.24
Acetic Acid, %DM	1.0–3.0	1.6a	1.6a	1.1b	0.6c	0.67	<0.01
Total Acid, %DM	-	9a	6a	6a	4b	3.2	<0.01
Ammonia, %CP	8.0–12.0	6.1	7.5	3.1	4.7	1.6	0.17

while rye had lesser yields with a slightly greater energy and protein content. There was no difference ($P = 0.10$) for CP yield across stages of maturity, however there was an effect of harvest maturity on DOM yield (Figure 4). The DOM yield increased from boot to pollination ($P = 0.05$), but pollination and milk did not differ ($P = 0.08$) and increased ($P < 0.01$) again at soft dough.

There were significant species by harvest interactions for pH, lactic acid, and total acid content. However, these differences were minor and inconsistent. Stage of harvest (Table 2) significantly affected the DM content, pH, lactic acid, acetic acid, and total acids content of the silage. The milk and soft dough stages did not require wilting prior to packing. However, despite wilting at boot and anthesis the silage DM content increased with maturity. Despite wilting, boot stage was still below the target DM content when packed. Despite this there was not an effect ($P = 0.24$) of stage on butyric acid content, suggesting that clostridial fermentation did not occur. In fact, boot stage appeared to have the best fermentation profile, obtaining a lower pH and greater lactic acid content than the later stages. There appeared to be only minor differences among the other stages.

Conclusion

These data suggest that planting rye or triticale results in the best nutrient yield per acre. If high quality forage is an operation's goal, harvesting at the pollination stage results in increased yield compared to boot without sacrificing a significant amount of nutritive value. For maximal energy yield per acre, waiting until soft dough may be the best option.

Abigail M. Sartin, graduate student

Kallie J. Calus, graduate student

Morgan T. Grabau, graduate student

Alyssa K. Kuhn, graduate student

Mary E. Drewnoski, associate professor, Animal Science, Lincoln, NE

Daren D. Redfearn, professor, Agronomy and Horticulture, Lincoln, NE