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**FINAL STUDY REPORT**
**Kansas Plant Materials Center**
**Manhattan, Kansas**

# Early Spring Carbon to Nitrogen Ratios of Cereal Rye Varieties

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## ABSTRACT

Cool season grass cover crops are a popular option for cover crop systems. Cover crops provide a wide range of conservation benefits including reducing soil erosion, uptake of excess nitrogen and weed suppression. The ratio of carbon to nitrogen in the above ground biomass of a cover crop determines durability of the cover crop. Durable cover crop residue can be desirable or undesirable depending on the specific resource concern, the cash crop planted following the cover crop, and the planned goals of the cover crop. In this study conducted at Leonardville, KS the carbon to nitrogen ratios of cereal rye (*Secale cereale* L.) varieties were sampled weekly in early spring to better understand the development of those ratios over the growing season. All rye varieties were similar in carbon to nitrogen ratios through the spring. This information provides conservation planners and producers with recommendations on cereal rye varieties based on carbon to nitrogen ratios.


## INTRODUCTION

Use of cool season cover crops is increasing rapidly in the Midwest. Cool season grasses have been a favorite of Kansas producers due to the well adapted growing conditions, availability of seed as well as an infrastructure for management of the crop. Cool season grasses have many benefits such as increasing soil organic matter (Patrick et al., 1957), weed suppression (Mohler and Teasdale, 1993), uptake of excess soil nitrogen (Huntington et al., 1985), and livestock forage production (Sanderson et al, 2018). Carbon to nitrogen ratios (C:N) can be used as a planning tool when prescribing cover crops for conservation purposes. Lower carbon to nitrogen can indicate increased nitrogen mineralization (Sainju et al., 2005). High C:N ratios can indicate reduced nitrogen leaching but also reduce available nitrogen for corn production (Finney et al., 2016). Little is known about C:N changes during early spring growth of cereal rye in Kansas. Current cover crop standards and other cover crop planning tools do not separate cereal rye varieties by growth habits. Therefore, objective of this study was to investigate C:N ratios of cereal rye varieties through the early and late spring to assist conservation planners and producers with prescribing cover crop mixes where C:N ratios are an important consideration.

## MATERIALS AND METHODS

The study was conducted at Leonardville, KS in 2020-2021 on a Wymore silty clay loam with 1 to 3 % slope (Soil Survey Staff 2017). Cereal rye varieties of 'Elbon', 'FL 401', 'Dylan' and Variety Not Stated (VNS) were planted at 100 pounds per acre (USDA-NRCS Kansas FOTG 340A) at a depth of 1 inch into no-till corn stubble on September 18, 2020.

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Soil tests were taken, and nutrients were amended as needed and considered non-limiting. Weeds were chemically killed with glyphosate [N-(phosphonomethyl) glycine] prior to planting. Plots were arranged in a Randomized Complete Block Design with 4 replications. Each plot measured 5 ft x 20 ft and sown with a modified Great Plains Cone Drill (Kincaid Manufacturing, Haven, KS). Plots were not irrigated. Plants were clipped at ground level weekly, March-April, and taken to the Soil Laboratory for chemical analysis at Kansas State University, Manhattan, KS. Weather data from Manhattan, KS (15 miles south east of Leonardville) was used for calculating growing degree days according to procedures of McMaster and Wilhelm (1997). Data analysis was done using SAS (Statistics Analysis Software, Cary, NC). Means were then plotted on a regression curve using Sigmaplot (Sigmaplot Version 11).

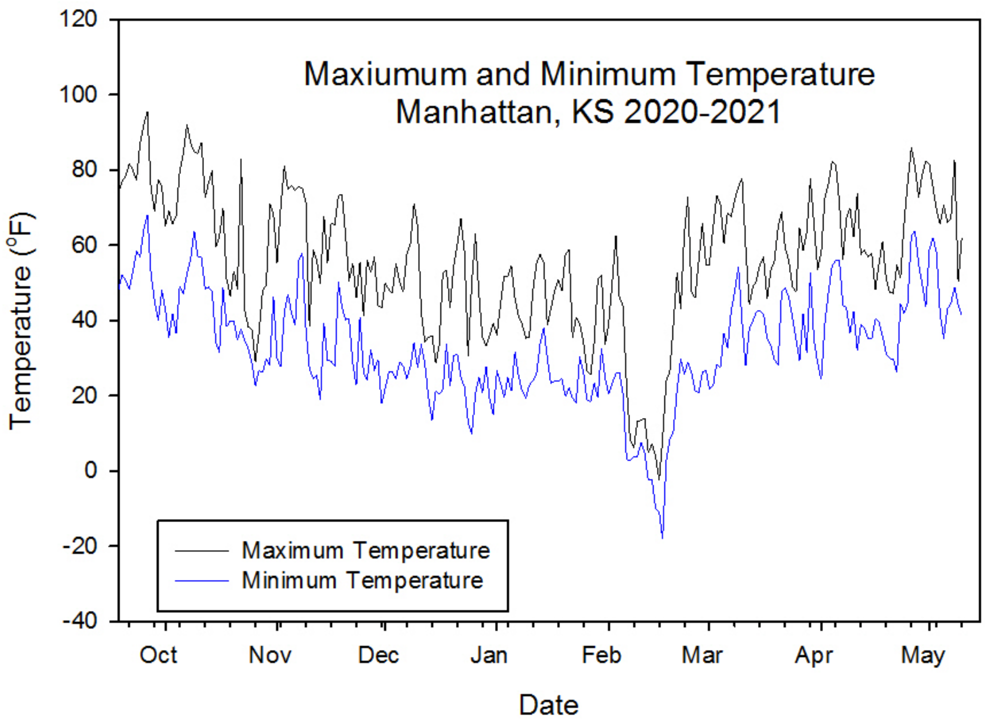

**Figure 1**. Maximum and minimum temperature for Manhattan, KS 2020-2021.

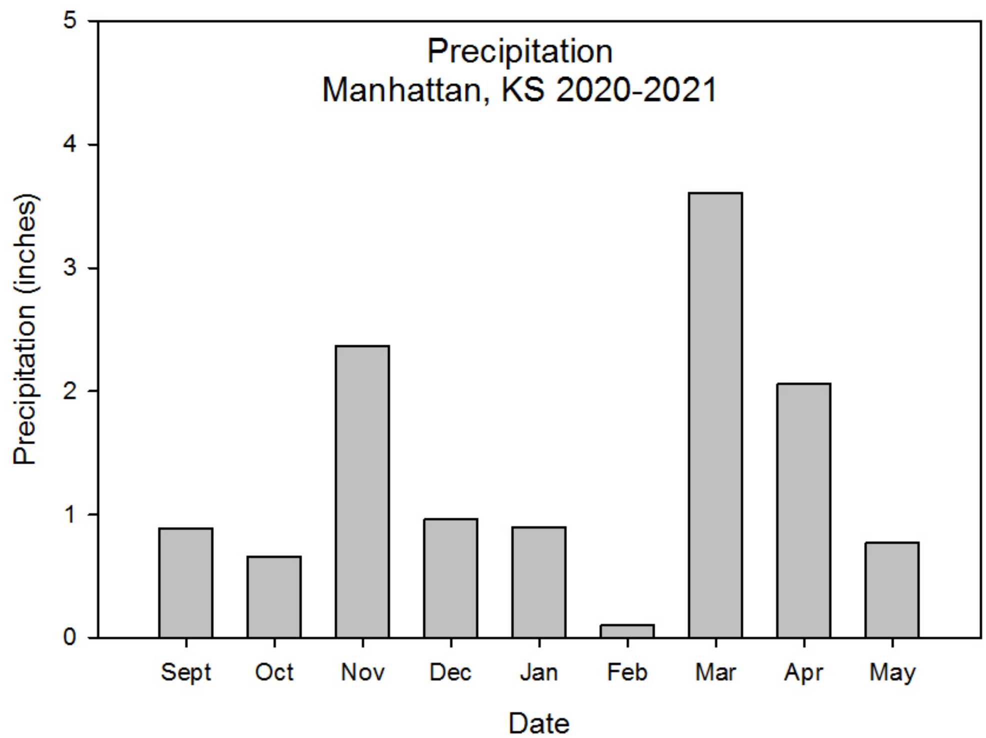


**Figure 2**. Precipitation for Manhattan, KS 2020-2021.

**Table 1**. 30-year averages (1991-2020) for maximum temperature, minimum temperature, average temperature and precipitation for Manhattan, Kansas.

| Month | Temperature | | | Precipitation |
|---|---|---|---|---|
| | Maximum (°F) | Minimum (°F) | Average (°F) | (inches) |
| January | 39.6 | 18.7 | 29.1 | 0.64 |
| February | 45.1 | 22.1 | 33.6 | 1.14 |
| March | 56.3 | 31.5 | 43.9 | 2.17 |
| April | 66.4 | 42.2 | 54.3 | 3.38 |
| May | 75.9 | 54.1 | 65.0 | 5.23 |
| June | 85.8 | 64.3 | 75.1 | 5.47 |
| July | 90.8 | 69.3 | 80.0 | 4.62 |
| August | 89.0 | 66.4 | 77.7 | 4.40 |
| September | 81.3 | 57.1 | 69.2 | 3.41 |
| October | 69.1 | 44.1 | 56.6 | 2.50 |
| November | 54.6 | 31.8 | 43.2 | 1.62 |
| December | 43.0 | 22.5 | 32.7 | 1.19 |

Source: NOAA https://www.ncei.noaa.gov/access/us-climate-normals/

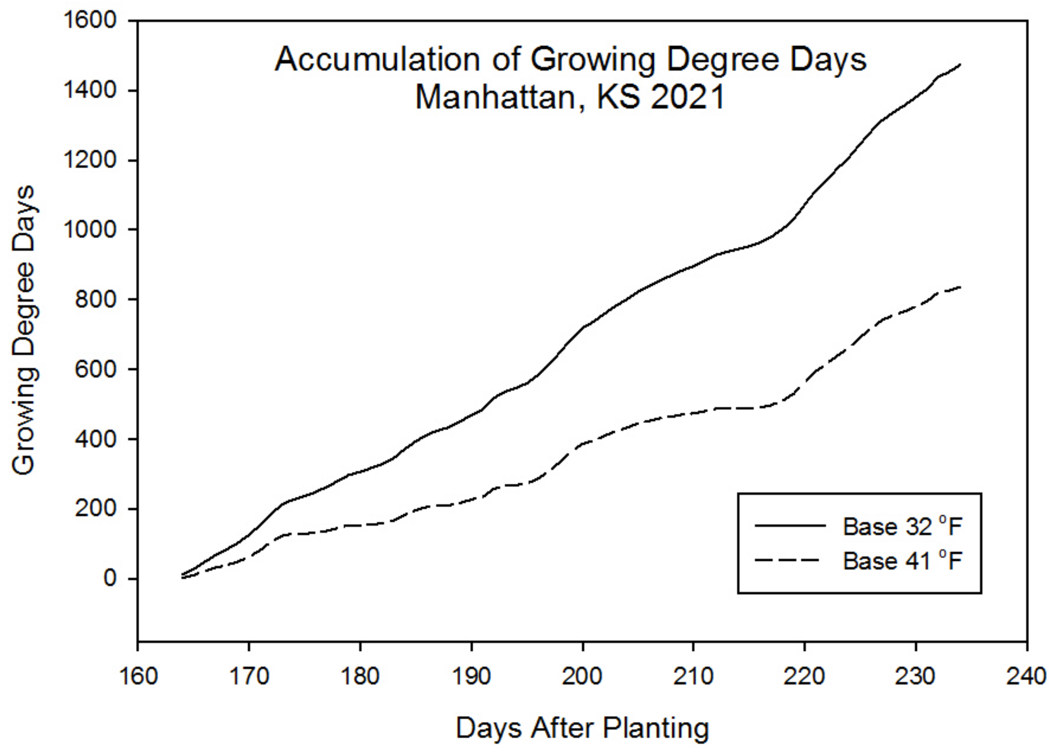


**Figure 3**. Accumulation of growing degree days for Manhattan, KS 2021.

## RESULTS AND DISCUSSION

Cereal rye varieties responded similar to one another on each sampling date. This sampling period was earlier in the growing season while the plants were in the vegetative stage and not at full maturity when carbon to nitrogen ratio is generally determined in cereal rye. Lowry and Brainard (2016) found cereal rye C:N ratios in a range from 20:1-43:1 when harvested at maturity. The upward C:N accumulation trends would suggest C:N ratios increase as the plant reaches maturity, which would agree with other researchers (Clark et. al. 1994). C:N ratios of these varieties were below 20:1 beyond 200 days after planting (Figure 4-7). Decrease in C:N values for FL 401 at 220 days after planting is attributed to an increase in new tillers, resulting in a lower C:N ratio (Figure 6). All varieties showed an increase in total carbon and a decrease in nitrogen as the plants matured through the sampling period (Table 2-5). Overall, cereal rye varieties followed a similar upward trend of C:N ratios.

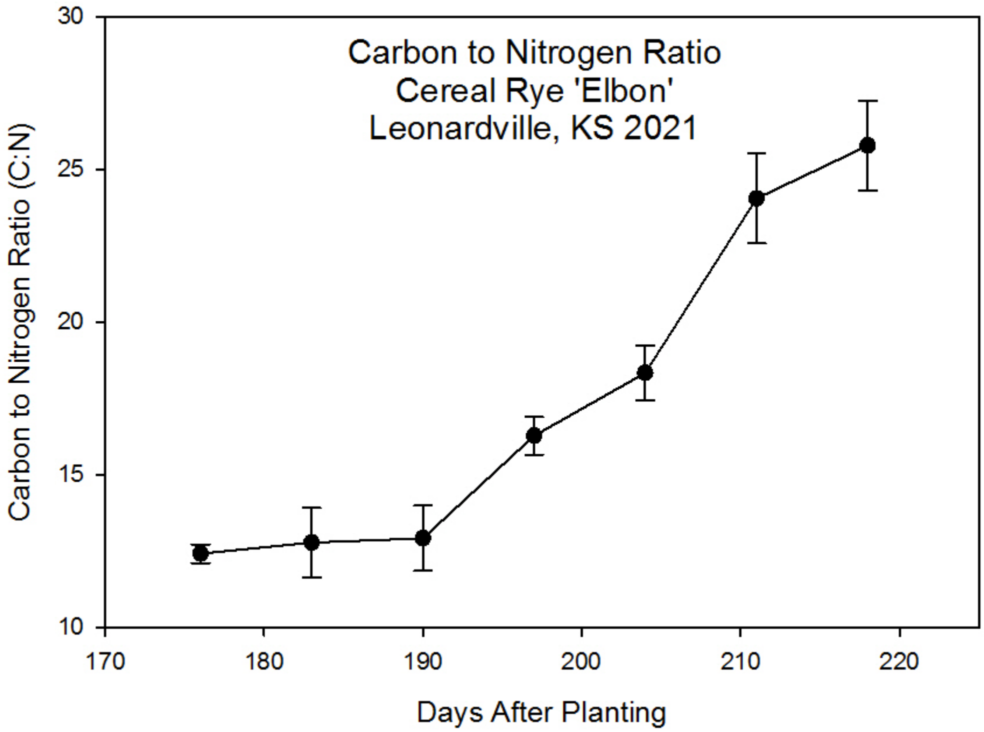


**Figure 4**. Carbon to nitrogen ratio measurements for Cereal Rye ‘Dylan’ for Leonardville, KS 2021. Error bars in figure represent one standard error.

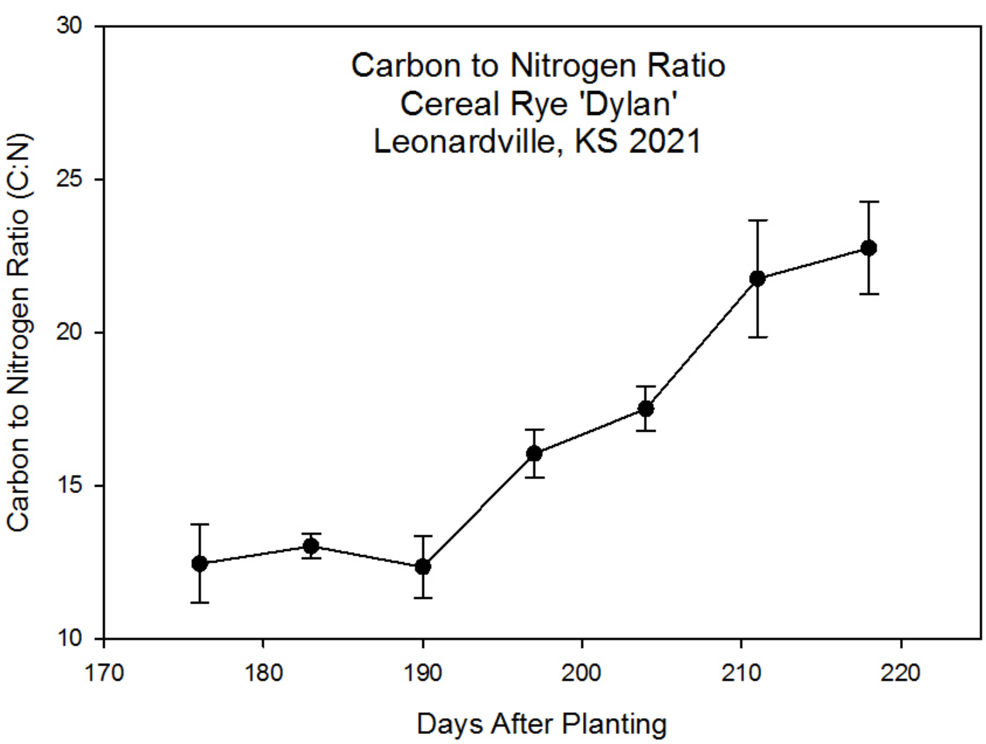


**Figure 5**. Carbon to nitrogen ratio measurements for Cereal Rye ‘Elbon’ for Leonardville, KS 2021. Error bars in figure represent one standard error.

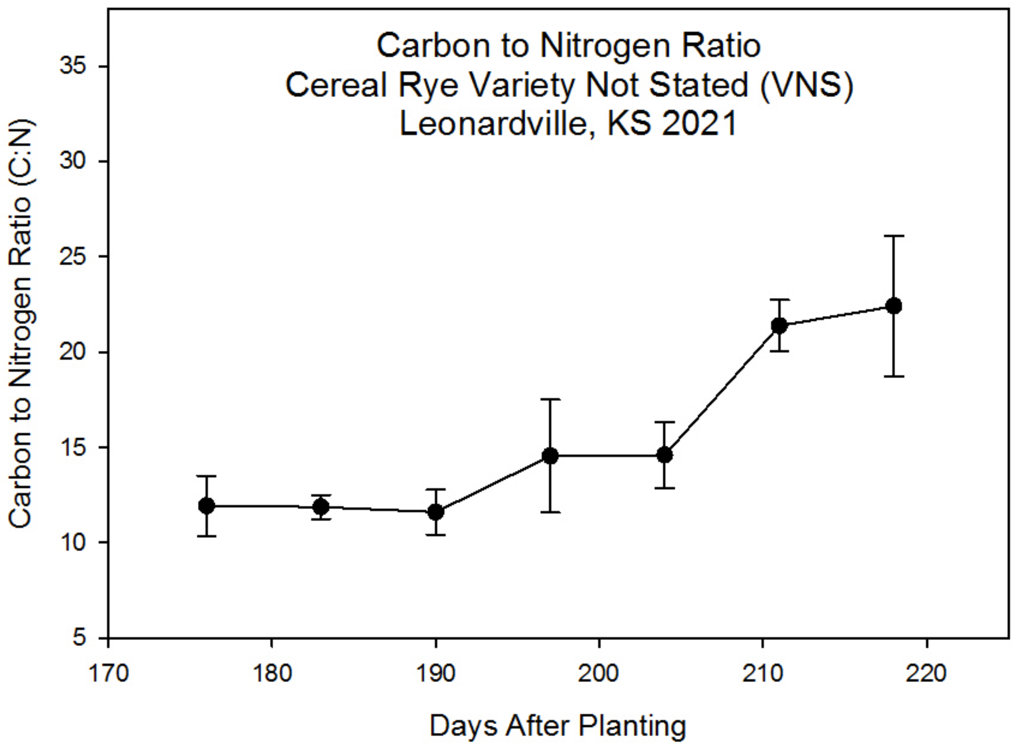


**Figure 6**. Carbon to nitrogen ratio measurements for Cereal Rye 'FL 401' for Leonardville, KS 2021. Error bars in figure represent one standard error.

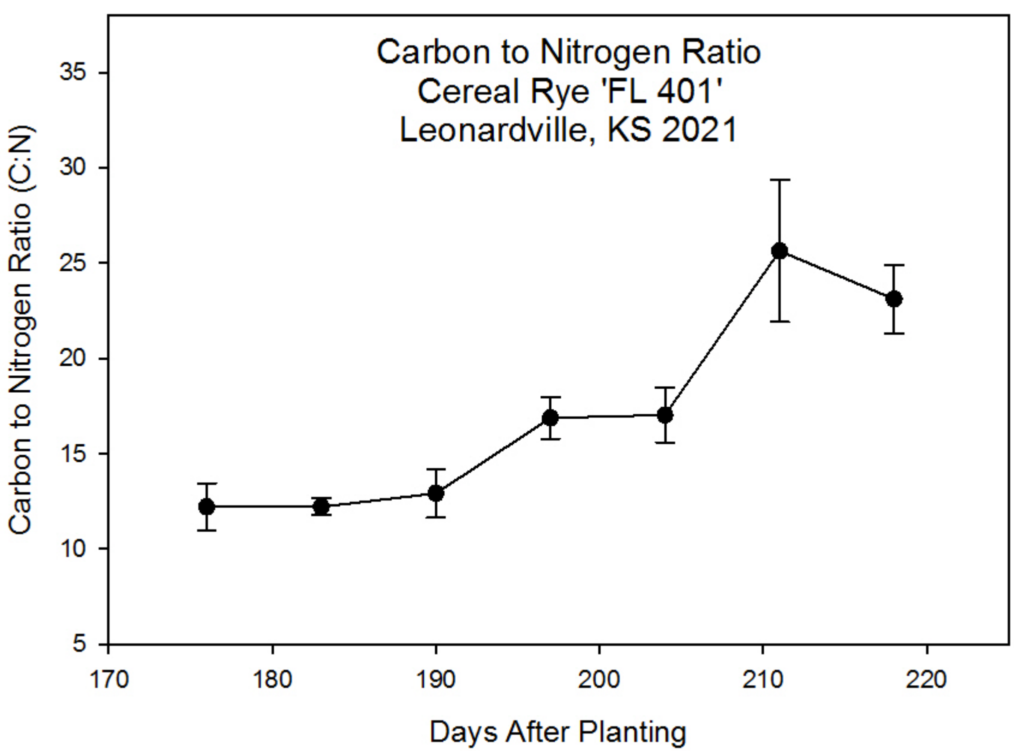


**Figure 7**. Carbon to nitrogen ratio measurements for Cereal Rye variety not stated (VNS) for Leonardville, KS 2021. Error bars in figure represent one standard error.

**Table 2**. Carbon, nitrogen and C:N values for 'Dylan' cereal rye. USDA-NRCS Manhattan, KS.

| Date | Carbon | | Nitrogen | | C:N | |
|---|---|---|---|---|---|---|
| | % | Standard Error | % | Standard Error | C:N | Standard Error |
| 3/12/2021 | 40.03 | 1.56 | 3.24 | 0.39 | 12.44 | 1.28 |
| 3/19/2021 | 40.19 | 2.66 | 3.08 | 0.15 | 13.02 | 0.39 |
| 3/26/2021 | 41.42 | 1.10 | 3.37 | 0.27 | 12.34 | 1.01 |
| 4/2/2021 | 42.40 | 0.38 | 2.64 | 0.12 | 16.04 | 0.78 |
| 4/9/2021 | 42.40 | 0.75 | 2.42 | 0.10 | 17.50 | 0.73 |
| 4/16/2021 | 42.21 | 0.41 | 1.95 | 0.18 | 21.75 | 1.91 |
| 4/23/2021 | 42.01 | 0.22 | 1.85 | 0.12 | 22.75 | 1.51 |

**Table 3**. Carbon, nitrogen and C:N values for 'Elbon' cereal rye. USDA-NRCS Manhattan, KS.

| Date | Carbon | | Nitrogen | | C:N | |
|---|---|---|---|---|---|---|
| | % | Standard Error | % | Standard Error | C:N | Standard Error |
| 3/12/2021 | 40.72 | 2.52 | 3.28 | 0.27 | 12.41 | 0.30 |
| 3/19/2021 | 39.69 | 2.63 | 3.13 | 0.44 | 12.78 | 1.31 |
| 3/26/2021 | 41.00 | 2.17 | 3.19 | 0.32 | 12.91 | 1.06 |
| 4/2/2021 | 42.93 | 0.55 | 2.64 | 0.08 | 16.27 | 0.61 |
| 4/9/2021 | 43.50 | 0.26 | 2.37 | 0.12 | 18.33 | 0.88 |
| 4/16/2021 | 43.16 | 0.17 | 1.80 | 0.11 | 24.05 | 1.47 |
| 4/23/2021 | 42.36 | 0.03 | 1.64 | 0.09 | 25.77 | 1.46 |

**Table 4**. Carbon, nitrogen and C:N values for 'FL 401' cereal rye. USDA-NRCS Manhattan, KS.

| Date | Carbon | | Nitrogen | | C:N | |
|---|---|---|---|---|---|---|
| | % | Standard Error | % | Standard Error | C:N | Standard Error |
| 3/12/2021 | 41.28 | 1.91 | 3.41 | 0.41 | 12.21 | 1.24 |
| 3/19/2021 | 41.80 | 0.63 | 3.42 | 0.16 | 12.22 | 0.42 |
| 3/26/2021 | 41.12 | 0.79 | 3.20 | 0.27 | 12.92 | 1.27 |
| 4/2/2021 | 42.17 | 0.99 | 2.50 | 0.13 | 16.87 | 1.09 |
| 4/9/2021 | 43.33 | 0.13 | 1.70 | 0.24 | 17.03 | 1.44 |
| 4/16/2021 | 43.08 | 0.13 | 1.70 | 0.24 | 25.63 | 3.73 |
| 4/23/2021 | 42.09 | 0.26 | 1.83 | 0.14 | 23.10 | 1.79 |

**Table 5**. Carbon, nitrogen and C:N values for cereal rye variety not stated (VNS). USDA-NRCS Manhattan, KS.

| Date | Carbon | | Nitrogen | | C:N | |
|---|---|---|---|---|---|---|
| | % | Standard Error | % | Standard Error | C:N | Standard Error |
| 3/12/2021 | 39.04 | 4.46 | 3.34 | 0.77 | 11.93 | 1.58 |
| 3/19/2021 | 39.44 | 3.13 | 3.32 | 0.32 | 11.88 | 0.62 |
| 3/26/2021 | 41.54 | 2.45 | 3.62 | 0.58 | 11.61 | 1.18 |
| 4/2/2021 | 42.21 | 1.57 | 3.00 | 0.68 | 14.54 | 2.96 |
| 4/9/2021 | 43.36 | 0.46 | 3.00 | 0.37 | 14.58 | 1.72 |
| 4/16/2021 | 42.86 | 0.29 | 2.01 | 0.11 | 21.38 | 1.34 |
| 4/23/2021 | 42.41 | 0.22 | 1.93 | 0.33 | 22.39 | 3.70 |

## CONCLUSION

There is limited data reporting cereal rye varieties and early growth C:N assimilation in the early spring. This data set provides an accurate local estimate of C:N ratios at early vegetative growth stages of cereal rye in the spring. This data is important for conservation planners who are trying to meet conservation goals with C:N as the driver of the decision. A practical application for using this data is as follows: if durable cereal rye residue is not a specific goal but the potential tie up of soil nitrogen is a concern, terminate the cereal rye 200 days after planting, if a more durable residue is desired, delay termination of the cereal rye until 210 days after planting. This study and data collection effort will continue in the future to include a larger range of days after planting in an effort to fully understand the C:N assimilation of cereal rye throughout the growing season.

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