Update Report:

Autonomous and Conventional Mowing Strategies and Nitrogen Fertility Impacts on Mowing Quality, Turfgrass Quality and Disease Incidence in Four Turfgrass Species

Tessa Hospod[1]
Victoria Wallace[2]
John C. Inguagiato[1]
Jason J. Henderson[1]
1 Department of Plant Science and Landscape Architecture
2 Department of Extension
University of Connecticut
1376 Storrs Rd., Unit 4067
Storrs, CT 06269-4027
*Corresponding author (tessa.hospod@uconn.edu)

2025

Summary

Labor is typically the largest item in the operating budget of most businesses. This would include commercial lawn care companies, athletic grounds crews and golf course maintenance crews. Mowing demands across all facets of the turfgrass industry remains a huge draw on available labor resources. Autonomous mowers have become a growing advantage to help alleviate labor shortage concerns and expand mowing schedule options such as mowing at night. The aim of this research is to investigate potential maintenance benefits of utilizing autonomous mowers in comparison to conventional gasoline-powered mowers and their effects on increased mowing quality, turfgrass quality, and reduced disease pressure. A 3x3 factorial nested design with five replications is being utilized to evaluate the impact of mowing regime (mower type and timing) on mowing quality, turfgrass quality and disease incidence in tall fescue. A second study, initiated in the fall of 2023, is being utilized to further investigate the impact of mowing regime as well as height of cut and species on mowing quality, turfgrass quality, and stress tolerance. This study reveals that mowing autonomously can increase long term nitrogen fertility response and improve turfgrass quality during periods of increased stress during the summer months. Dark green color index and turfgrass quality ratings proved significantly higher in autonomously mowed areas than conventional areas throughout all years of the study thus far. Furthermore, disease incidence in certain pathogens decreases significantly by mowing autonomously. Quantitative methods to more accurately measure turfgrass response are being explored to better understand the extent of potential physiological changes that are occurring in response to mowing regime, fertility, and time of day mowed.

Introduction

In turfgrass management, mowing is the most basic yet time consuming cultural practice to exist on any type of mowed turf that influences all other facets of cultural practices (Turgeon, 2005). In recent years, limiting factors of labor resources have struggled to meet the demand in the turfgrass industry. According to the National Association of Landscape Professionals, 51% of landscaping company owners agree that staffing is their top business challenge (Odom, 2023). To help alleviate this strain, timely solutions have been made in automated mowing technology, drone sprayers, robotic painters, and more to increase the reliability and safety of these common human-operated management tasks. In an industry that is labor-intensive, and time constrained for windows of operations, automated mowing technology has risen among distributors and has been integrated into management programs on golf courses, landscaping companies, and athletic fields (Saidani et al., 2021). Autonomous mowing has proven advantages of flexibility in maintenance schedule, decreasing human exposure to dust, pollen, allergens, and injury from mowing conventionally (Hicks & Hall, 2000). Furthermore, autonomous mowing systems can save up to $20-30/hr on fuel, labor, and maintenance costs (Rathmell, 2020).

The limited research surrounding the improved mowing quality and turfgrass quality associated with autonomous mowing has potentially restricted the adoption of this technology into practice. Research has documented that autonomous mowing can increase turf density, turf quality, and decrease disease incidence in combination with fertility treatment on a tall fescue lawn (Pichio et al., 2018, Grossi et al., 2016). Mowing autonomously can also improve the quality of cut and overall mowing quality (Hartstock, 2021). Autonomous mowers operating at night could create mechanical disruption of developing mycelium and/or reduce leaf wetness periods and reduce diseases like brown patch, red thread, or dollar spot (Ellram et al., 2007).

The objectives of this research are to evaluate how mowing regime and nitrogen fertility affect 1) turfgrass quality, 2) mowing quality and 3) disease incidence. An additional study has been added to evaluate how mowing regime, height of cut, and species affect 1) turfgrass quality and 2) stress tolerance.

Materials and Methods

Study Design

A field experiment was initiated at the University of Connecticut Plant Science Research and Education Facility (41.8° N, -72.23° W), CT, USA on fine sandy loam soil in June 2022 and is currently ongoing. The experimental area consisted of a mature stand of tall fescue (*Festuca arundinacea*). The design was a 3x3 factorial arranged in a nested design. The first factor, mowing regime has three levels: 1) Autonomous daytime mowing, 2) Autonomous nighttime mowing, and 3) Conventional rotary mowing. Each mowing regime treatment encompassed 420 m^2. The second factor, nitrogen fertility, had three levels: 1) None, 2) Low (98 kg N ha^{-1} yr^{-1}, and 3) High (196 kg N ha^{-1} yr^{-1}. The nitrogen fertility treatments were nested within each mowing regime and each experimental unit was 1.83 m x 1.83 m plots (3.34 m^2 each) and had five replications. The timing of the nitrogen fertility applications were May and September. The total nitrogen rates applied on an annual basis were split where 50% was applied in the spring (May) and 50% was applied in the fall (September). The products used were urea (45-0-0) (Andersons Golf Products, Maumee, OH) and poly-coated urea, controlled release fertilizer (43-0-0) (Harrell's Auburn, MA). Each fertilizer treatment applied was half urea and half poly-coated urea to achieve the specified nitrogen rate. Mowing height for the entire study is constant at 57 cm. Both autonomous regimes are mowed using a Husqvarna 550 EPOS Automower (Husqvarna, 2025). Two automowers are being used; one for daytime and one for nighttime. A zero-turn Scag Tiger Cat II 48' Velocity Plus mower is used to mow the conventional rotary treatment (Scag Power Equipment, 2025). Conventional mowing was completed once weekly, considering the demand for less frequency of mowing maintenance that many homeowners employ (Yue et al., 2017). Conventional mowing was completed at 12:00pm 1x/week. Autonomous day mowing was completed at 12:00pm daily and autonomous night mowing was completed at 3:00am nightly during periods of high clipping yield (spring-early summer). Frequency is adjusted to 3x/week during all other times to decrease unnecessary stress, trafficking and trampling effects on the turf.

During the first two years of the study (2022-2023), autonomous mowing was completed with a randomized mowing trajectory which operates by making repeated passes, overlapping the selected area in no particular order until the work area is completed. Randomized mowing patterns were adjusted to systematic patterns as technology was updated. Unlike randomized patterns, systematic patterns have a pre-selected path in which the mower will complete the work area in one selected direction like conventional mowing patterns. Systemic patterns increase working efficiency and turf quality (Sportelli et al., 2021).

In fall of 2023, a second study was initiated in a separate research area with the objectives of evaluating the impact of mower type and mowing height on turfgrass quality and stress tolerance in four turfgrass species. The study is arranged in a split-split, nested design with five replications and has three factors. The first factor, mower type has two levels: 1) conventional rotary mowing, and 2) autonomous mowing. The second factor, mowing height (HOC) has three levels: 1) 32mm, 2) 57mm, and 3) 83mm. The third factor, turfgrass species, has four levels: 1) Kentucky bluegrass (*Poa pratensis*), 2) perennial ryegrass (*Lolium perenne*), 3) creeping red fescue (*Festuca rubra*), and 4) tall fescue (*Festuca arundinacea*). The research field was split by HOC. Each HOC was split by mower type. Turfgrass species are nested within each mower type with five replications. Experimental units are 1.83 m x 1.83 m plots. The research area was established in September of 2022. In the first year of this study, plots were solely mowed conventionally to enable the turfgrass to establish. Autonomous mowers were installed at the end of the first year of the study (fall 2023) and data collection was initiated in spring of 2024. Three Husqvarna 550EPOS Automowers are being used to mow autonomous plots (550H for 83mm HOC, a 550 for 57mm HOC, and a 550 for 32mm for HOC) (Husqvarna, 2025). A Toro SR4 21" Super Recycler Personal Pace mower is used to mow the conventional plots (The Toro Company, 2025). Conventionally mown plots are mown once a week while autonomously mown plots are mown every day during peak growing season and three times a week during all other periods. This entire study area receives a total of 147 kg N ha^{-1} yr^{-1} fertility applications, which consisted of methylene urea (40-0-0) (Harrell's Auburn, MA), and are applied twice per year (May and September at a rate of 74 kg N ha^{-1}).

In both studies, autonomous mower blades are changed monthly, and conventional blades are sharpened each spring and fall. In 2025, plans have been implemented to sharpen conventional mower blades once a month for added consistency. During both trials, irrigation was applied as needed. Pesticides were applied minimally as pre-emergent herbicides for annual grassy weeks, post emergent herbicides for perennial broadleaf weeds and fungicides for occasional disease outbreaks.

Data Collection

The data collected on the original study consists of qualitative as well as quantitative methods to measure mowing quality, turfgrass quality, and disease incidence. Turfgrass quality ratings are collected on a 1-9 scale (1=poor, 9=excellent) every four weeks during the growing season (Morris & Shearman, 1998). Quantitative measurements to analyze Dark Green Color Index (DGCI) were taken on an iPad using the FieldScout GreenIndex+ Turf app biweekly (FieldScout, 2025). Disc measurements were taken every six weeks to measure the height of the canopy (mm) and measure the consistency in HOC between mowing regimes (Santillan et al., 1979). Disease ratings were collected as outbreaks occurred. Rating scales for disease consisted of percent (%) blight (0%=no disease, 100%=full disease). A 1-9 scale rating (1=no resistance, 9=full resistance) was also utilized (Morris & Shearman, 1998).

Soil samples were collected prior to treatment applications at 0-5 cm and 5-10 cm depths. Subsequent soil samples are routinely taken at the same depths each fall to track potential changes in soil quality. These include % N, %C, %OM, C:N ratio, pH, K, Ca, P, Mg, Al, B, Cu, Fe, Mn, Zn, S, Pb, and CEC. As changes in turfgrass quality and mowing quality were observed, soil mineralization potential was measured using CO2 sensors in the winter of 2024 (Gan et al., 2023). Tissue samples were taken in September of 2024 before the second fertility treatment and analyzed for factors including percent moisture, starch, and water-soluble carbohydrates (%WSC) in turfgrass leaf tissue (Goering and Van Soest, 1970; Hall et al., 2015; Hall et al., 1999). Percent starch and %WSC were used to calculate percent total nonstructural carbohydrates (%TNC).

Additionally, in the second study during the 2024 season, tall fescue was assessed for quality of cut by determining leaf cut index (LCI) and leaf tip chlorosis index (LTC). Twenty leaf samples were randomly collected from each tall fescue plot in the 2.25” conventional and autonomous mowing regimes three days after a mowing event. Samples were adhered to black paper and scanned digitally using an Epson Perfection V19 II flatbed scanner. Images were then analyzed for LCI and LTC using ImageJ software (National Institute of Health, 1997 and Shaddox, 2020).

Results

DGCI

Significant differences in DGCI attributed to mowing regime and nitrogen fertility treatments were primarily observed as interactions in 2023 and 2024. The majority of data collection dates show a similar trend where the autonomous mowed plots have a longer nitrogen fertility response compared to conventional mowing. Both autonomous mowing regimes (day and night) had significantly higher DGCI than conventional mowing regime at low and high fertility levels. In most cases, there is no significant difference between mowing regimes at no fertility indicating that this response is not a result of quality of cut.

2023

There was significant interaction between mowing regime and fertility treatment on DGCI in the majority of data collection dates in 2023. There appears to be a trend represented across dates (Figure 1). At no fertility, there is no significant difference between mowing regimes. At low and high fertility, both autonomous day and autonomous night are significantly higher than conventional. This trend was first observed on August 9 of 2023, the first data collection date of DGCI for this study. This was after the first fertility treatment which was on May 3 (3 months prior). This observation shows a longer-term N fertility response in both autonomous day and nighttime mowing regimes months after treatment. Differences between nitrogen fertility levels were not observed in the conventional mowing regime. Two dates in 2023 had no significant interaction and were a few weeks after the second fertility treatment which was applied on September 22. Immediate response to fertility is slower with autonomous mowing than conventional but proves a long-term N response later in the season during periods of elevated stress and environmental pressures.

2024

Like the previous year, there was significant interaction between mowing regime and fertility treatment on DGCI in the majority of data collection dates in 2024. At no fertility, there is no significant difference between mowing regimes. At low and high fertility, both autonomous day and autonomous night were significantly higher than conventional. This trend, which was evident on the majority of dates in 2023, was observed clearly across more dates in 2024 (Figure 2). The only dates that did not show this trend were after the second fertility treatment, which was September 20 of this year. Long term N fertility response of autonomous mowing was demonstrated again 3 months after the first fertility treatment on May 1. DGCI values of the autonomous mowing regimes at low fertility are higher than the conventional mowing regime at high fertility demonstrating that potentially less nitrogen fertility inputs are needed to maintain turfgrass quality while utilizing autonomous mowing.

Turfgrass Quality

Differences in turfgrass quality ratings were observed as significant interaction between mowing regime and nitrogen fertility for the majority of dates in 2023-2024 (Table 2). Turfgrass quality ratings followed very similar trends to DGCI re-enforcing the longer-term N fertility response to autonomous mowing regimes that was observed in this data set. Across both years of the study, on all dates but one, both autonomous regimes received higher quality ratings at low fertility than the conventional regime at high fertility. This again indicates that less input can potentially be used to maintain turfgrass quality while utilizing autonomous mowing.

2023

There was a significant interaction between mowing regime and fertility treatment on turfgrass quality ratings on all dates in 2023. On all dates but one, at no fertility, there is no significant difference between mowing regimes which demonstrates consistency in the quality of cut between mowing regimes. At low and high fertility, both autonomous day and autonomous night are significantly higher than conventional (Figure 3). A significant difference in quality ratings up to 5 months after the first fertility treatment of this year proves a positive extended long-term response of nitrogen fertility in autonomous mowing regimes.

2024

There was a significant interaction between mowing regime and nitrogen fertility on turfgrass quality ratings on all but two dates in 2024. The data shows a very similar trend to 2023 showing a longer-term response of autonomous mowing to nitrogen fertility (Figure 4). Like 2023, on all dates but one, at no fertility, there is no significant difference between mowing regimes, demonstrating consistency in the quality of cut between mowing regimes. Trends at low and high nitrogen fertility remain the same as 2023.

Disc Measurements

Disc measurement data demonstrated an increase in mowing consistency as trajectories of the autonomous mowers were changed random patterns to systematic patterns (Table 3).

2022

There was a significant interaction between mowing regime and nitrogen fertility on the height of canopy in 2022. Although there is only one data collection date, this data serves as a reference point shortly after the study was initiated. At no fertility, conventional HOC was significantly higher than autonomous day which as significantly higher than autonomous night. At low fertility, autonomous day was significantly higher than autonomous night but not significantly higher than conventional. At high fertility, there was no significant difference between mowing regimes. This demonstrates that initially there was inconsistency in HOC while operation in random mowing trajectories with the autonomous mowing regimes.

2023

There was a significant interaction between mowing regime and nitrogen fertility on the height of canopy on half of the data collection dates in 2023. Throughout this year, there is a clear difference between the consistency of cut in both autonomous mowing regimes from the start of the season when mowing trajectories were set to random patterns versus the end of the season when systematic patterns were implemented. Systematic patterns increased the consistency of cut in both autonomous mowing regimes.

2024

There was a significant interaction between mowing regime and nitrogen fertility on the height of canopy on some dates in 2024. In 2024, autonomous mowers operated under systematic trajectories reinforced that systematic mowing patterns seem to provide more consistent height cut compared to random.

Mowing Quality

2024

There was a main effect of mowing regime on LCI in 2024. LCI was significantly lower in the autonomous mowing regime than the conventional mowing regime. A LCI value of 1.0 would indicate a flawless cut (Shaddox, 2020). Lower values, closer to 1.0, are demonstrated with the autonomous mower regime and not the conventional mowing regime, which is significantly higher. The quality cut in the autonomous mowing regime is greater than in the conventional mowing regime.

There is a main effect of mowing regime on LTC in 2024. LTC was significantly lower in the autonomous mowing regime than the conventional mowing regime. A value of 0.0 would indicate no leaf tip chlorosis (Shaddox, 2020). The area of chlorotic tissue is minimized by utilizing an autonomous mowing regime.

Disease Incidence

Disease data was collected as outbreaks occurred over the course of the study. Data is limited to date and plans for inoculation are in place for the 2025 season to gather more consistent and conclusive data on disease incidence as affected by mowing regime and N fertility. Thus far, data has been collected on dollar spot and brown patch which both indicate that autonomous mowing regimes (day and night) can decrease disease pressure as compared to conventional mowing.

2022

On August 10 of 2022, a dollar spot outbreak was observed, and data was collected to indicate % blight (Figure 5). There was a significant interaction between mowing regime and nitrogen fertility on % blight of dollar spot. At no fertility there was no significant difference between mowing regimes. However, at low fertility there was significantly more disease in the conventional mowing regime than in the autonomous day mowing regime. There was no significant difference between conventional and autonomous night. At high fertility, the conventional mowing regime had significantly more dollar spot incidence than both autonomous mowing regimes. Dollar spot incidence overall increased with fertility level with conventional mowing which has the opposite effect for both autonomous regimes.

2024

On July 19, 2024, a brown patch outbreak was observed, and data was collected on a 1-9 rating scale to indicate disease resistance to this pathogen between mowing regimes and N nitrogen fertility. Differences were observed as main effects. There was a nitrogen fertility main effect and a mowing regime main effect (Table 4). Data was only collected on low and high fertility levels of all mowing regimes. Resistance to brown patch was significantly higher at the high fertility level compared to the low fertility level. Additionally, resistance to this disease was significantly higher in both autonomous mowing regimes compared to mowing conventionally, indicating that mowing autonomously can reduce disease incidence of brown patch.

Soils Data (%N, %C, % organic matter, C:N ratio, and soil mineralization potential)

Few meaningful differences were observed on soils data collected 2022-2024. Soils data for %N, %C, C:N ratio, %OM and soil mineralization potential were inconsistent in the first two years that data was collected.

Total Nonstructural Carbohydrates

Differences in TNC were observed as a significant interaction between mowing regime and nitrogen fertility in 2024 (Figure 6). At no and low nitrogen fertility levels, the autonomous night mowing regime had significantly higher TNC than the conventionally mowed treatments. Additionally, where no nitrogen fertility was applied, the autonomously mowed day treatments also had higher TNC than the conventionally mowed treatments. However, at the high nitrogen rate, autonomous night was not significantly different than the conventionally mowed treatments.

Leaf Moisture

Differences in leaf moisture were observed as mowing regime and nitrogen fertility main effects in 2024. Regardless of nitrogen fertility level, both autonomous mowing regimes had significantly higher leaf moisture than the conventional mowing regime. Treatments receiving high nitrogen fertility, regardless of mowing regime, had significantly higher leaf moisture compared to treatments receiving low or no fertility

Discussion

This study was designed to investigate the influence of autonomous mowing and nitrogen fertility on turfgrass quality, mowing quality, and disease incidence in four turfgrass species. This research is currently ongoing in the form of two separate research studies which have plans to continue through at least 2025. The results from two full years of data collection on the original study reveal that mowing regime and nitrogen fertility have a significant effect on turfgrass quality, mowing quality, and disease incidence. One season of data collected on the second study demonstrates promising results but will need further data collection in the 2025 season.

Generally, among data types collected to assess turfgrass quality, autonomous mowing regimes in combination with nitrogen fertility, have higher turfgrass quality compared to the conventional mowing regime. So far, there is no consistent difference in turfgrass quality between autonomous day and night mowing regimes. Additionally, autonomous mowing can increase mowing quality compared to conventional mowing. Mowing quality data (LCI/LTC) has only been collected on tall fescue to date, however this species is characterized by its thick and coarse leaf blades which can be difficult to cut cleanly with a conventional mower. Throughout this study, autonomous mowing has demonstrated to reduce disease pressure in certain pathogens on tall fescue. There has been no indication thus far as to whether autonomous mowing timing (day or night) has any effect on disease incidence. Plans for 2025 include inoculation of this study to gather more consistent data and draw conclusions.

As differences in turfgrass quality between mowing regimes were observed, soil data was analyzed to determine if these differences in quality were caused by changes in the soil. Although there were slight differences observed in the soil, they were not consistent effect on soil quality to draw conclusions. Tissue analysis in 2024 revealed that there were significant differences in different components of turfgrass leaf tissue between mowing regimes and nitrogen fertility levels. Data to date points to slight changes in plant physiology that seem to be occurring from the autonomous mowing regimes. Additional tissue collection dates are needed to further investigate this observation.

Literature Cited

Beard, J. B. (1973). Turfgrass: science and culture.

Ellram, A., Horgan, B., & Hulke, B. (2007). Mowing strategies and dew removal to minimize dollar spot on creeping bentgrass. *Crop Science*, *47*(5), 2129-2137.

FieldScout. Fieldscout GreenIndex+ Turf. Available online: https://apps.apple.com/us /app/fieldscout-greenindex-turf/id692008137 (access on 24 Jan 2025).

Gan, H., Roper, W. R., Groffman, P. M., Morris, T. F., & Guillard, K. (2023). Automated sensor-based quantification of soil water retention and microbial respiration across drying conditions. *Soil Biology and Biochemistry*, *180*, 108987.

Goering, H.K. and P.J. Van Soest. 1970. Forage Fiber Analyses (apparatus, reagents, procedures, and some applications). ARS/USDA Handbook No. 379, Superintendent of Documents, US Government Printing Office, Washington, D.C. 20402. p15.

Grossi, N., Fontanelli, M., Garramone, E., Peruzzi, A., Raffaelli, M., Pirchio, M., ... & Volterrani, M. (2016). Autonomous mower saves energy and improves quality of tall fescue lawn. *HortTechnology*, *26*(6), 825-830.

Hall, M. B., & Collaborators: Arbaugh J Binkerd K Carlson A Doan T Grant T Heuer C Inerowicz HD Jean-Louis B Johnson R Jordan J Kondratko D Maciel E McCallum K Meyer D Odijk CA Parganlija-Ramic A Potts T Ruiz L Snodgrass S Taysom D Trupia S Steinlicht B Welch D. (2015). Determination of dietary starch in animal feeds and pet food by an enzymatic-colorimetric method: Collaborative study. *Journal of AOAC International*, *98*(2), 397-409.

Hall, M.B., W.H. Hoover, J.P. Jennings and T.K. Miller Webster. 1999. A method for partitioning neutral detergent soluble carbohydrates. J. Sci. Food Agric. 79: p.2081.

Hartstock, A. 2021. Robotic mowers can increase cut quality. *Golf Course Management Magazine*. 89(6):p. 79.

Hicks II, R. W., & Hall, E. L. (2000, October). Survey of robot lawn mowers. In *Intelligent Robots and Computer Vision XIX: Algorithms, Techniques, and Active Vision* (Vol. 4197, pp. 262-269). SPIE.

Husqvarna. Husqvarna 550 EPOS. Available online: https://www.husqvarna.com/us/robotic-lawn-mowers/automower-550epos/ (access on 24 Jan 2025).

Morris, K. N., & Shearman, R. C. (1998, October). NTEP turfgrass evaluation guidelines. In *NTEP turfgrass evaluation workshop, Beltsville, MD* (pp. 1-5).

National Institute of Health. (1997). *ImageJ* (Version 1.54) [Computer software]. https://imagej.net/ij/

Odom, J. (2023, December 20). *Industry insights: See how other industry companies performed in 2023*. The Edge from the National Association of Landscape Professionals. https://blog.landscapeprofessionals.org/industry-insights-landscape-professionals-responses-to-end-of-the-year-pulse-survey/

Pirchio, M., Fontanelli, M., Frasconi, C., Martelloni, L., Raffaelli, M., Peruzzi, A., ... & Grossi, N. (2018). Autonomous mower vs. rotary mower: Effects on turf quality and weed control in tall fescue lawn. *Agronomy*, *8*(2), 15.

Rathmell, L. (2020, June 26). *Ready for Robots*. Lawn&Landscape. https://www.lawnandlandscape.com/article/ready-for-robots/

Saidani, M., Pan, Z., Kim, H., Wattonville, J., Greenlee, A., Shannon, T., ... & Cluzel, F. (2021). Comparative life cycle assessment and costing of an autonomous lawn mowing system with human-operated alternatives: Implication for sustainable design improvements. *International Journal of Sustainable Engineering*, *14*(4), 704-724.

Santillan, R. A., Ocumpaugh, W. R., & Mott, G. O. (1979). Estimating Forage Yield with a Disk Meter 1. *Agronomy Journal*, *71*(1), 71-74.

Scag Power Equipment. Scag Tiger Cat II 48’ Velocity Plus. Available online: https://www.scag.com/product/zero-turn-riding-mowers/tiger-cat-ii/ (access on 24 Jan 2025).

Shaddox, T. W., Munshaw, G. C., & Cropper, K. Cut Quality of Turfgrass Leaves As Influenced By Robotic and Rotary Mowers. In *ASA, CSSA and SSSA International Annual Meetings (2020)| VIRTUAL*. ASA-CSSA-SSSA.

Sportelli, M., Fontanelli, M., Pirchio, M., Frasconi, C., Raffaelli, M., Caturegli, L., ... & Peruzzi, A. (2021). Robotic mowing of tall fescue at 90 mm cutting height: Random trajectories vs. systematic trajectories. *Agronomy*, *11*(12), 2567.

The Toro Company. Toro SR4 Super Recycler. Available online: https://www.toro.com/en/homeowner/walk-behind-mowers/super-recycler mowers?srsltid=AfmBOoprrxEBJDwTadIsNWNmEihHG0bmr9JS024Zn0PpYmDqOvIP4eGE (access on 24 Jan 2025).

Turgeon, A.J. 2005. Turfgrass Management. Prentice Hall, Upper Saddle River, NJ.

Yue, C., Wang, J., Watkins, E., Bonos, S. A., Nelson, K. C., Murphy, J. A., ... & Horgan, B. P. (2017). Heterogeneous consumer preferences for turfgrass attributes in the United States and Canada. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *65*(3), 347-383.

Tables and Figures

Tables

Table 1. Effect of mowing regime and N fertility on Dark Green Color Index (DGCI) in 2023-2024

	2023							
Main effects	9 Aug	24 Aug	14 Sept	3 Oct	22 Sept	11 Oct	18 Oct	25 Oct
N Fertility								
0	0.5531c	0.6035b	0.8424b	0.6988c	0.6141b	0.6326c	0.6072c	0.6112c
2	0.6042b	0.5863b	0.8185b	0.7921b	0.6489b	0.7327b	0.7579b	0.8486b
4	0.7064a	0.6714a	0.9127a	0.8575a	0.7438	0.7834a	0.8450a	0.9382a
Mowing Regime								
Conventional	0.5727b	0.5520b	0.8271b	0.7497b	0.5550c	0.7085a	0.7551a	0.8091ab
Robotic Day	0.6467a	0.6067b	0.8538ab	0.7521b	0.6948b	0.7087a	0.7398a	0.8461a
Robotic Night	0.6443a	0.7025a	0.8927a	0.8466a	0.7571a	0.7315a	0.7152a	0.7427b
Variation source	ANOVA							
N Fertility	***	**	**	***		***	NS	***
Mowing Regime	***	**	***	***		NS	***	*
N Fert x MR	***	***	***	*		NS	NS	*

*, **, *** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Table 1. Effect of mowing regime and N fertility on Dark Green Color Index (DGCI) in 2023-2024

	2024													
Main effects	1 May	13 May	29 May	11 June	26 June	9 July	30 July	13 Aug	27 Aug	9 Sept	25 Sept	8 Oct	22 Oct	6 Nov
N Fertility														
0	0.4669c	0.5040b	0.5421c	0.3921c	0.4557c	0.4669c	0.5737b	0.6090b	0.7351c	0.7229c	0.6125c	0.6657c	0.5249c	0.4995c
2	0.5959b	0.7839a	0.7523b	0.7514b	0.5744b	0.5471b	0.6247a	0.6099b	0.8224b	0.8061b	0.8311b	0.8445b	0.6260b	0.6027b
4	0.6646a	0.8118a	0.7940a	0.8406a	0.6164a	0.5875a	0.6423a	0.6387a	0.8668a	0.8655a	0.9796a	0.9457a	0.7159a	0.7093a
Mowing Regime														
Conventional	0.5448b	0.5485b	0.5941b	0.5119b	0.4991c	0.4564b	0.5799b	0.5806c	0.7439c	0.7671b	0.8243a	0.8501a	0.6161b	0.5851b
Robotic Day	0.5534b	0.7893a	0.7561a	0.7201a	0.5865a	0.5767a	0.6328a	0.6201b	0.8016b	0.8149a	0.8049a	0.7807b	0.6138b	0.5946b
Robotic Night	0.6291a	0.7619a	0.7381a	0.7514a	0.5609b	0.5684a	0.6279a	0.6568a	0.8787a	0.8125a	0/7940a	0.8251ab	0.6369a	0.6317a
Variation source	ANOVA													
N Fertility	***	***	***	***	***	***	***	**	***	***	***	***	***	***
Mowing Regime	***	***	***	***	***	***	***	***	***	NS	NS	*	*	**
N Fert x MR	**	**	***	***	***	***	**	NS	NS	NS	NS	*	*	*

*, **, *** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Table 2. Effect of mowing regime and N fertility on turfgrass quality ratings in 2023-2024

	2023					2024					
Main effects	2 June	7 July	11 Aug	15 Sept	20 Oct	3 June	28 June	30 July	21 Aug	19 Sept	18 Oct
N Fertility											
0	4.4667c	4.8667c	4.8667c	4.8667c	4.8667c	4.3333c	5.0000c	5.1333c	5.6000c	5.6000c	5.1333c
2	7.0667b	7.2667b	7.4000b	7.2000b	7.200b	7.1333b	7.0667b	7.0667b	7.2667b	6.1333b	7.0667b
4	8.0000a	7.9333a	7.9333a	7.8000a	7.8000a	8.1333a	7.8667a	7.8000a	8.2000a	7.6667s	8.3333a
Mowing Regime											
Conventional	5.9333b	6.0667b	5.8667b	5.6667b	5.6667b	6.000c	6.3333a	6.1333b	6.2667b	6.2667a	6.7333a
Robotic Day	6.4667b	6.9333a	7.1333a	7.0667a	7.0667a	6.5333b	6.7333a	6.8667a	7.3333a	6.4667a	6.9333a
Robotic Night	7.1333a	7.0667a	7.2000a	7.1333a	7.1333a	7.0667a	6.8667a	7.0000a	7.4667a	6.6667a	6.8667a
Variation source						ANOVA					
N Fertility	***	***	***	***	***	***	***	***	***	***	***
Mowing Regime	**	**	***	***	***	***	NS	***	***	NS	NS
N Fert x MR	*	***	***	***	***	**	***	**	*	NS	NS

*, **, *** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Table 3. Effect of mowing regime and N fertility on height of canopy (disc height in mm) in 2022-2024

	2022	2023						2024				
Main effects	24 Aug	28 June	19 July	1 Aug	30 Aug	15 Sept	18 Oct	29 May	8 July	19 Aug	30 Sept	6 Nov
N Fertility												
0	54.5333c	55.1333c	51.6000c	51.8667c	52.2000c	58.6000c	59.5333c	54.7333c	56.2000b	54.4667a	57.7333a	56.8667a
2	60.5333b	62.6667b	63.0000b	62.8667b	62.9333b	63.6667b	63.2667b	57.1333b	57.0667ab	57.0000a	57.2000ab	56.2667b
4	64.9333a	67.4667a	65.6667a	67.0000a	67.2667a	65.0667a	65.2000a	58.2667a	57.9333a	57.1333a	56.9333b	56.6667ab
Mowing Regime												
Conventional	62.2667a	59.1333b	58.7333a	58.6000b	58.8000b	61.2667a	61.9333a	52.2667c	52.2000c	53.7333c	56.7333b	56.0000c
Robotic Day	60.3333ab	62.2667ab	59.8000a	61.2667a	61.2000ab	62.5333a	62.6000a	57.3333b	60.5333a	57.6000b	57.9333a	56.6000b
Robotic Night	57.4000	63.8667a	61.7333a	61.8667a	62.4000a	63.5333a	63.4667a	60.5333a	57.4667b	59.2667a	57.2000b	57.2000a
Variation source							ANOVA					
N Fertility	***	***	***	***	***	***	***	***	***	NS	*	NS
Mowing Regime	*	NS	NS	**	*	NS	NS	***	*	***	***	***
N Fert x MR	***	NS	NS	*	*	NS	*	*	*	NS	NS	NS

*, **, *** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Table 4. Effect of mowing regime and N fertility on brown patch severity in 2024

Main effects	July 2024
N Fertility	
0	.
2	5.3333b
4	6.2667a
Mowing Regime	
Conventional	4.6000b
Robotic Day	6.3000a
Robotic Night	6.5000a
Variation source	
N Fertility	***
Mowing Regime	***
N Fert x MR	NS

*, **, *** Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Figures

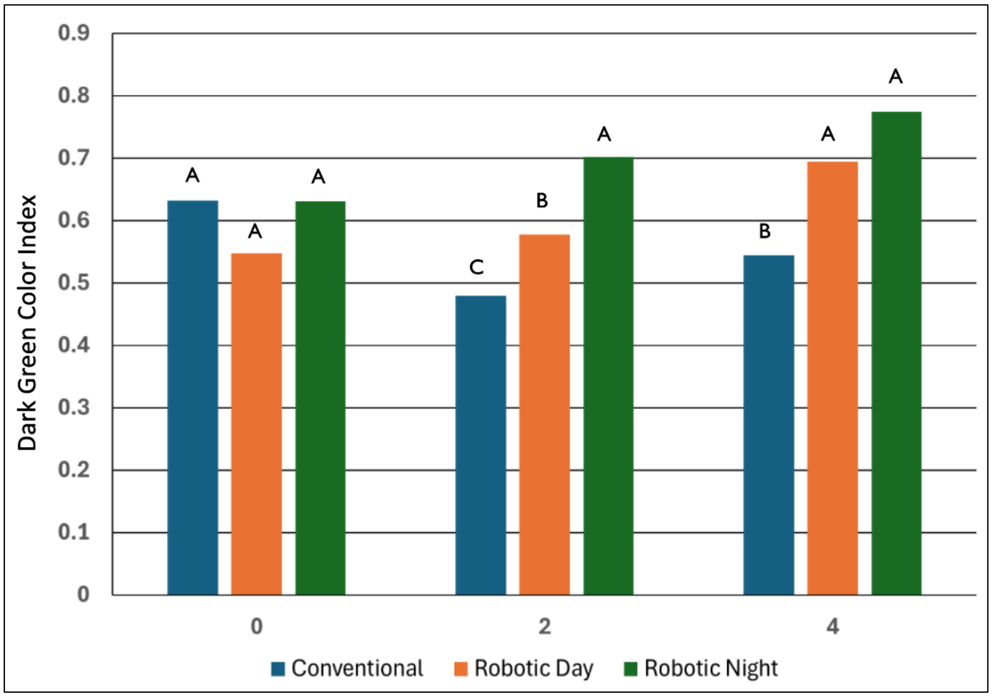

Figure 1. The interaction of mowing strategy and nitrogen rate on DGCI, August 24, 2023

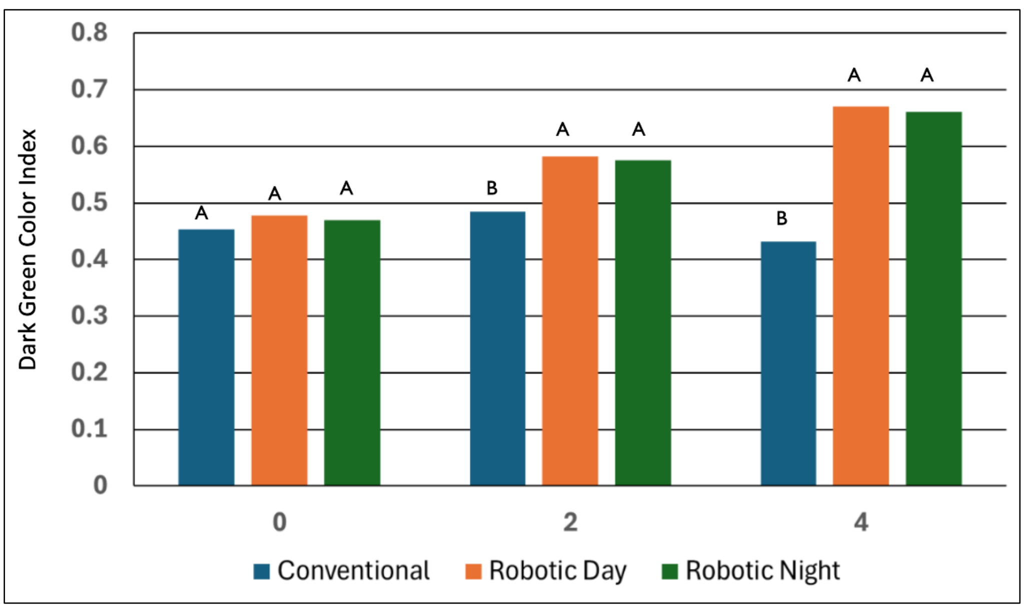

Figure 2. The interaction of mowing strategy and nitrogen rate on DGCI, July 9, 2024

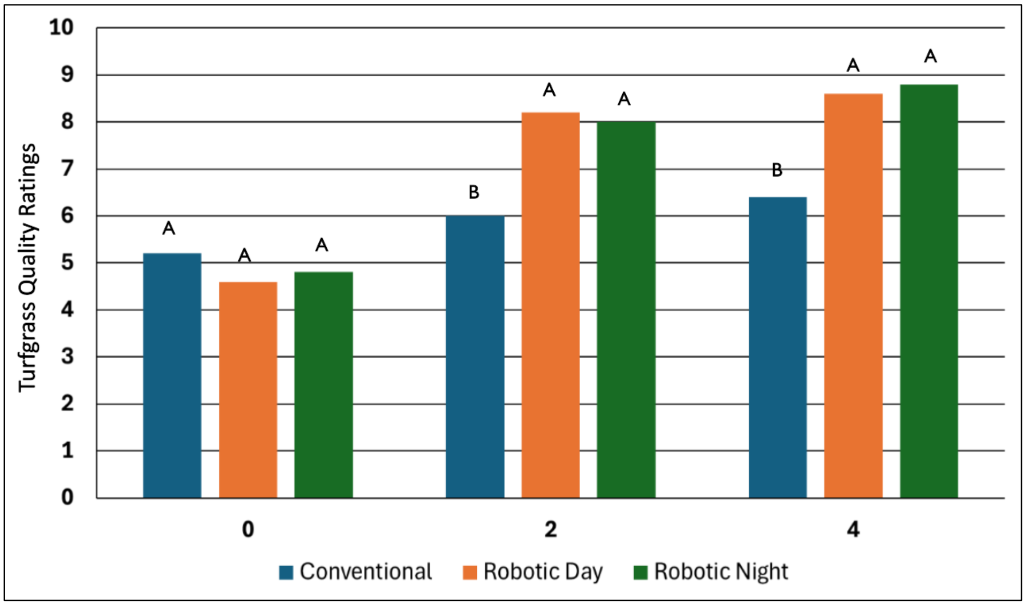

Figure 3. The interaction of mowing strategy and nitrogen rate on turfgrass quality ratings, August 11, 2023

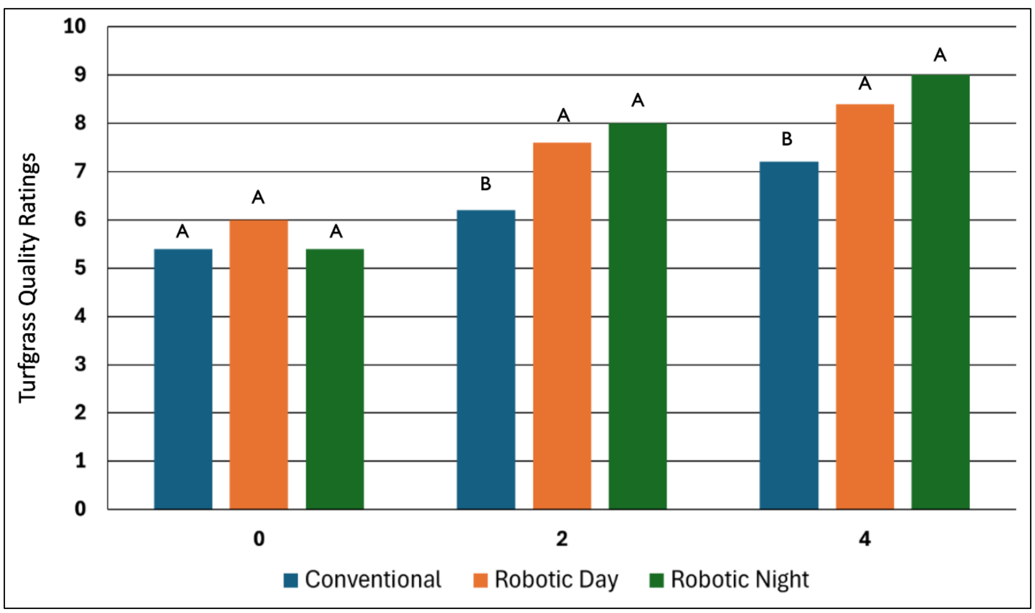

Figure 4. The interaction of mowing strategy and nitrogen rate on turfgrass quality ratings, August 21, 2024

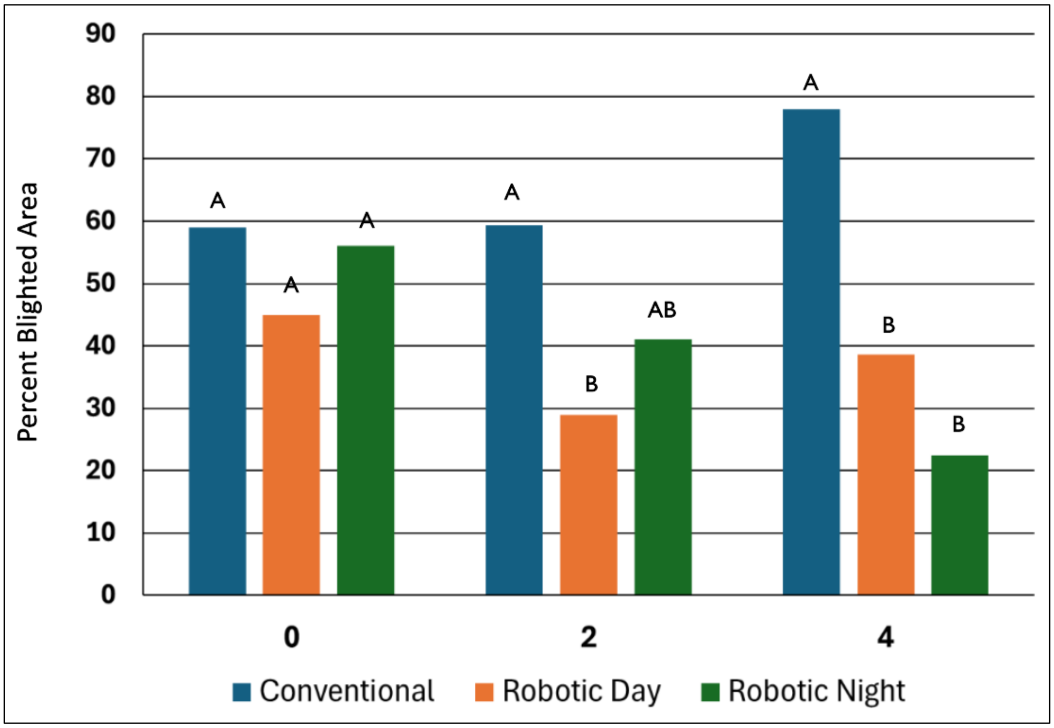

Figure 5. The interaction of mowing strategy and nitrogen rate on dollar spot severity, August 10, 2022

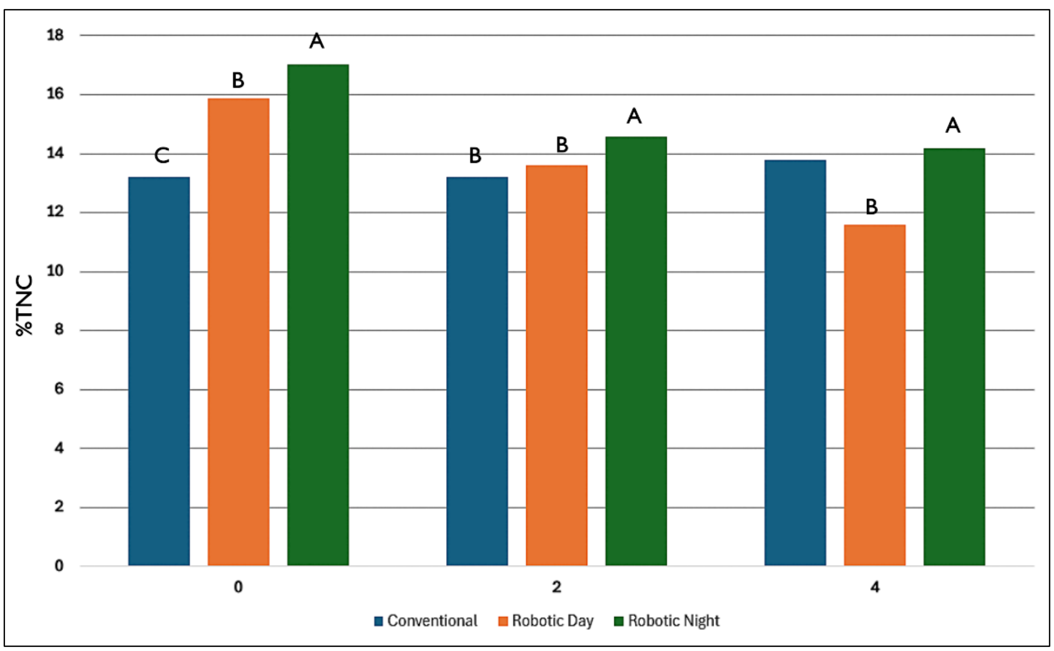

Figure 6. The interaction of mowing strategy and nitrogen rate on percent total nonstructural carbohydrates (%TNC), September 13, 2024

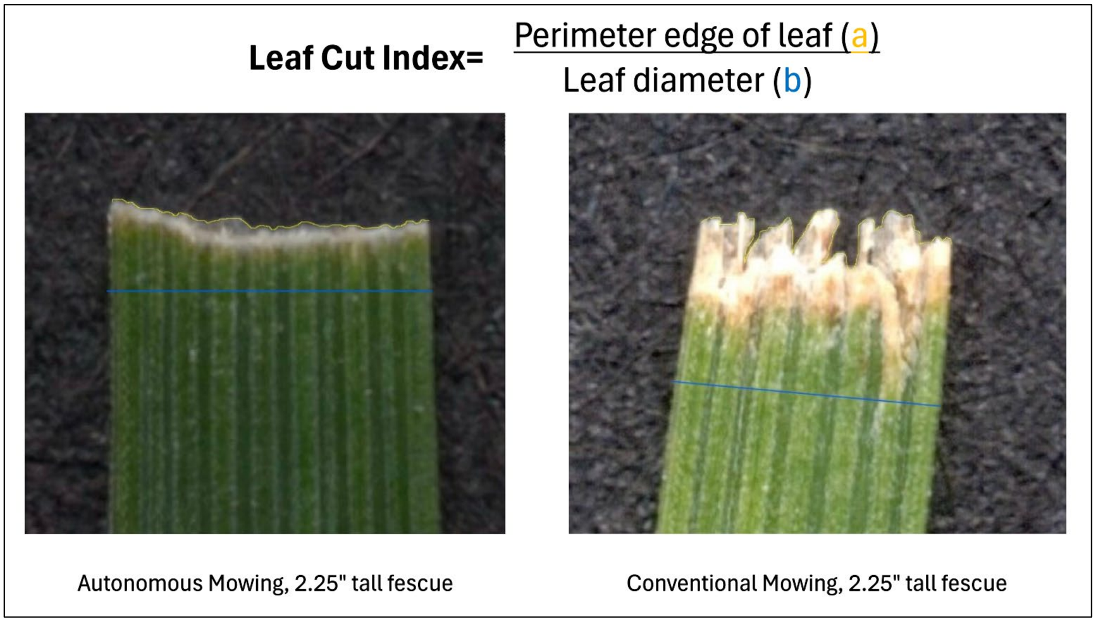

Figure 7. Mowing regime effect on LCI in 2.25” tall fescue, July 10, 2024

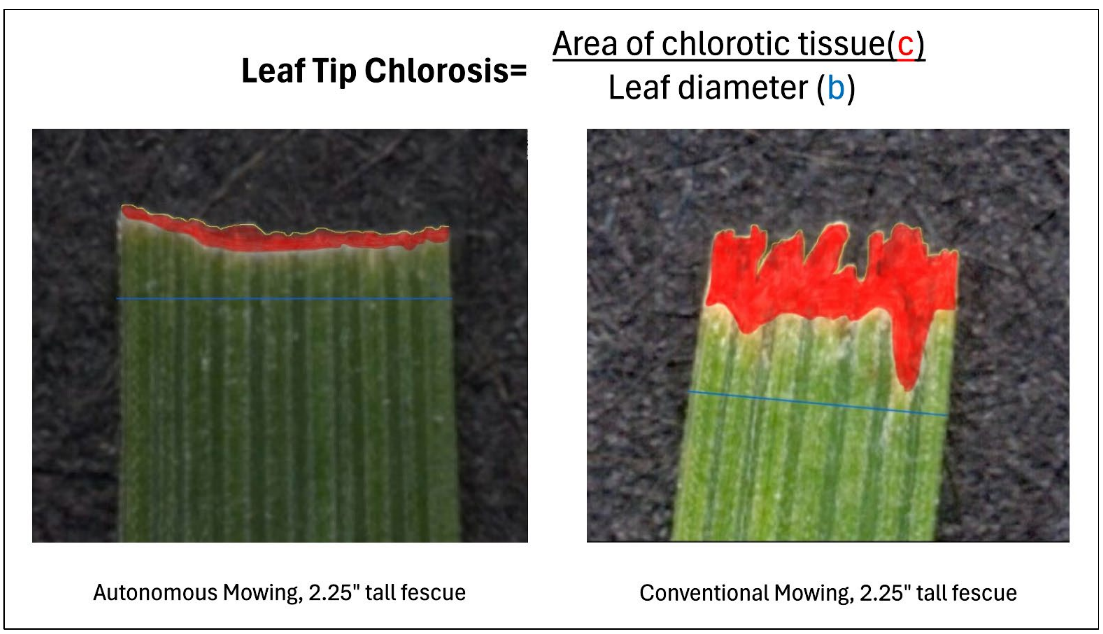

Figure 8. Mowing regime effect on LTC in 2.25” tall fescue, July 10, 2024