Do Robotic Mowers Influence the NDVI of Tall Fescue Under Reduced Irrigation?

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Introduction

Reference crop evapotranspiration or reference evapotranspiration (ET_{ref}), is the estimation of the evapotranspiration from the "reference surface." We can calculate ET_{ref} based on the location weather data and the Penman–Monteith Equation [1].

The ET_{ref} in our study was determined by historical site data of turf center at University of Kentucky and irrigation treatments were applied every three days based on ET_{ref} and the total rainfall since the last irrigation event. The normalized difference vegetation index (NDVI) is used to determine the density of greenness of turfgrasses. The closer the NDVI number to 1 the greener the grass. NDVI is strongly associated to turf quality [2].

Robotic mowers are marketed to maintain turfgrasses in a high quality with less labor input. Customers also claim that compared with the past, even if they use less fertilizer and water, their lawns will look healthier when they use robotic mowers [3]. However, few researches are looking at what robotic mowers improve on turfgrasses.

In this study, different evapotranspiration treatments were applied on robotic and rotary mower plots. Our hypothesis was that robotic mowers maintain higher NDVI compared to the rotary mower values on tall fescue turf under reduced irrigation.

Methods and Materials

- **Plot**
  - Location: turf center at University of Kentucky ;
  - Grass type: mix of Pedigree tall fescue, Rebel V tall fescue, Pennington ATF 1258 tall fescue, Ridgeline KY bluegrass, Monte Carlo KY bluegrass, and Wildhorse KY bluegrass
  - Size: 10 meters x 10 meters;
  - Irrigation: 4.5 inches K2 Pro Gear Drive Sprinkler;
- **Mower**:
  - Robotic mower: Husgvarna 430XH automowers;
  - Rotary mower: John Deere ZTrak Z925a mower;
  - Robotic mowers mowed Tuesday and Friday for 1 hour each day. Rotary mower used on Friday. All mowers are set to 3.5 inches. Robot blades were replaced and rotary blades sharpened approximately every 90 days.
- **Treatments:**
  - Robotic mower with 60% ET_{ref} replacement (ROB60)
  - Robotic mower with 70% ET_{ref} replacement (ROB70)
  - Rotary mowers with 80% ET_{ref} replacement (ROT80)
- **Data**
  - Data were collected weekly during October to December 2019, and April to September 2020 using a GreenSeeker handheld NDVI .
  - All data were analyzed using anova(lm.) and ggplot() of Rstudio

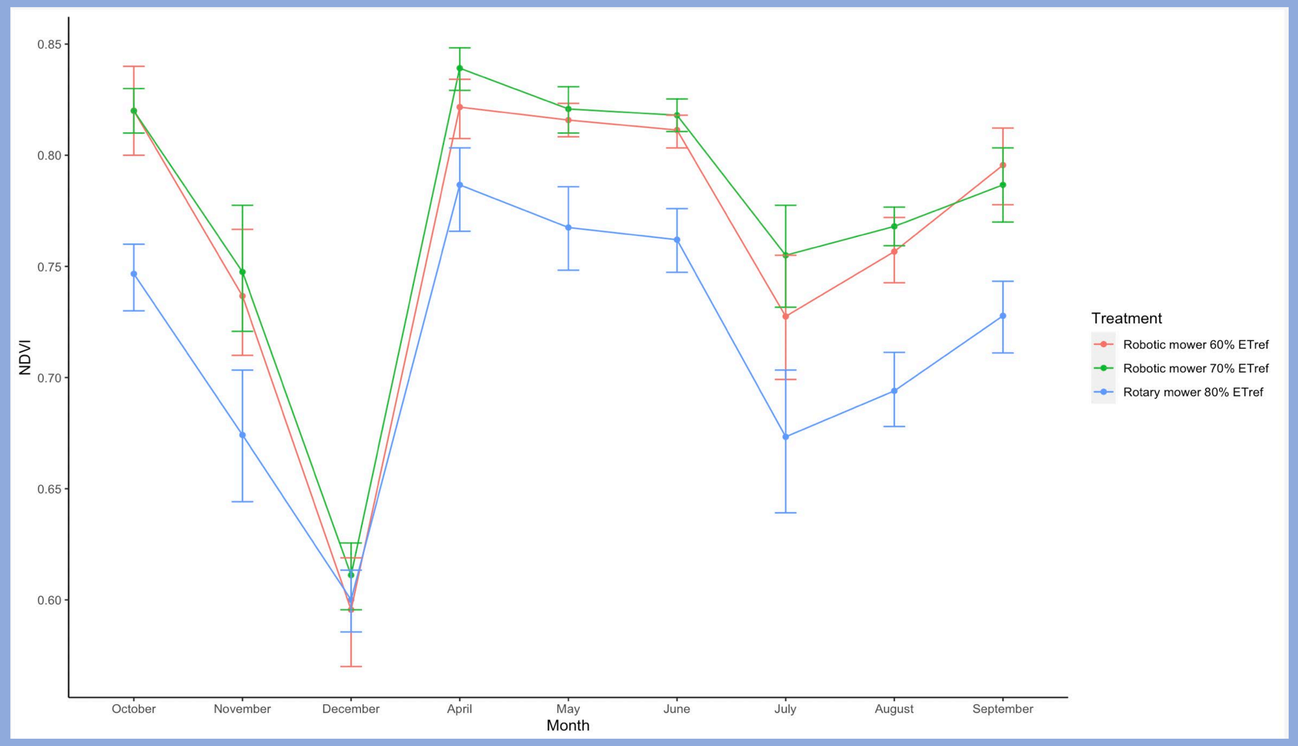

Fig. 1 Means of NDVI (the normalized difference vegetation index) values of tall fescue (*Festuca Arundinacea*) maintained at 60%, 70%, or 80% reference ET (ETref) mowed by robotic or rotary mowers in Lexington, KY in growing season (from October to December 2019 and April to Septmber 2020).

Fig. 2 Overlook of plots at turf center at University of Kentucky .

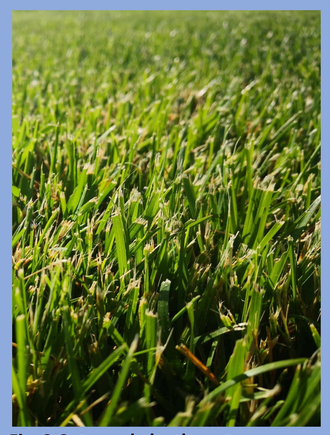

Fig. 3 Cuts made by the rotary mower.

Fig.4 Cuts made by a robotic mower.

➢ Robotic mower resulted in an 8.5% greater NDVI than rotary mower throughout growing season with less water.

Results

- During December 2019, when tall fescue went dormancy, mower type resulted in equivalent NDVI (p=0.467);
- During the whole growing season, robotic mower plots (ROB60 and ROB70) shows no differences (except in April 2020) on NDVI;
- During growing season, robotic mower plots (ROB60 and ROB70) resulted in an average of 8.5% greater NDVI than rotary plots (ROT80).
- Data recorded in April 2020 had the lowest percentage of increasing NDVI (5.6%) between robotic and rotary mower treatments.
- Data of November 2019 and July 2020 showed the highest percentage of increasing NDVI (10.1%).

Table 1. Monthly average NDVI of tall fescue maintained at 60%, 70%, or 80% reference ET (ETref) mowed by robotic or rotary mowers in Lexington, KY in growing season (from October to December 2019 and April to Septmber 2020). Letters a, b and c represent significantly different (p<0.05).

Treatment	NDVI								
	2019			2020					
	Oct	Nov	Dec	Apr	May	Jun	Jul	Aug	Sep
Robotic mower 60% ETref	0.820^{a}	0.737^{a}	0.596^{a}	0.822^{b}	0.816^{a}	0.811^{a}	0.728^{a}	0.757^{a}	0.796^{a}
Robotic mower 70% ETref	0.820^{a}	0.748^{a}	0.611^{a}	0.839^{a}	0.821^{a}	0.818^{a}	0.755^{a}	0.768^{a}	0.787^{a}
Rotary mower 80% ETref	0.747^{b}	0.674^{b}	0.600^{a}	0.787^{c}	0.768^{b}	0.762^{b}	0.673^{b}	0.694^{b}	0.728^{b}
P-value	<0.001	<0.001	0.46642	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

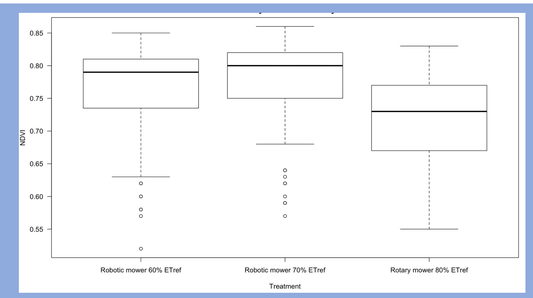

Fig. 5 Average NDVI of tall fescue maintained at 60%, 70%, or 80% reference ET (ETref) mowed by robotic or rotary mowers in Lexington, KY from Oct. 2019 to Sept. 2020 by treatments.

Discussion

We observe from the pictures that the appearance of the robotic mower plots are better than those of the rotary plots. However, this might be caused not only by irrigation treatment. As we can see from the pictures , the cuts made by robotic (Pic.2) and rotary (Pic.3) mowers are also different. With the same frequency of changing (robotic mowers)/ sharping (rotary mower) blades, robotic mowers tended to leave cleaner cuts on tall fescue turf compared to the rotary mower.

Conclusion

Overall, the robotic mower plots resulted in greater NDVI values than rotary mower plots even with lower evapotranspiration replacement. This was likely caused by a sharper leaf cut from the robotic mowers.

Limitations and work in the future

Because of the number of robotic mowers and the space we had, we could not include more treatments, such as rotary mowers with 60% or 70% ETref replacement or robotic mower with 80% ETref replacement.

Future work can also include measurements to determine the differences in soil compaction and moisture between treatments. The reasons why robotic mowers leave cleaner cuts than rotary mowers is also worth determining.

Reference

[1] Colmer, T.D. and Barton, L., 2017. A review of warm-season turfgrass evapotranspiration, responses to deficit irrigation, and drought resistance. Crop Science, 57(S1), pp.S-98.

[2] Leinauer, B., VanLeeuwen, D.M., Serena, M., Schiavon, M. and Sevostianova, E., 2014. Digital image analysis and spectral reflectance to determine turfgrass quality. Agronomy Journal, 106(5), pp.1787-1794.

[3] https://myrobotmower.com/what-are-the-benefits-of-a-robot-lawn-mower/