Enhancing ALMANAC for Simulating Switchgrass Biomass Nitrogen Removal

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Rationale:

The conversion of dedicated energy crops such as switchgrass (*Panicum virgatum* L.) to usable energy is versatile because they can be combusted for heat and electrical power or converted to liquid fuels. Decision–making tools to predict switchgrass yield and N removal would aid switchgrass production and processing. The economics of biomass production are strongly affected by time of harvest and fertilizer needs; therefore, modifying ALMANAC model to predict nutrient removal in response to nutrient supply would aid producers and contractors in economically optimizing harvest date and fertilization.

Objective:

To develop logic for ALMANAC to simulate 'Alamo' switchgrass N removal in harvested biomass of switchgrass by enhancing the existing N uptake logic

Material and Methods

Locations:

Trial number	Trial name	Location	Pertinent objective
1	Growth curve	Fayetteville, AR	Development/Verification
2	Senescence	Fayetteville, AR	Validation
3	N rate trial	Fayetteville, AR	Validation
4	N rate trial	Pinetree, AR	Validation
4	Poultry litter	Fayetteville, AR	Validation
6	Poultry litter	Haskell, OK	Validation

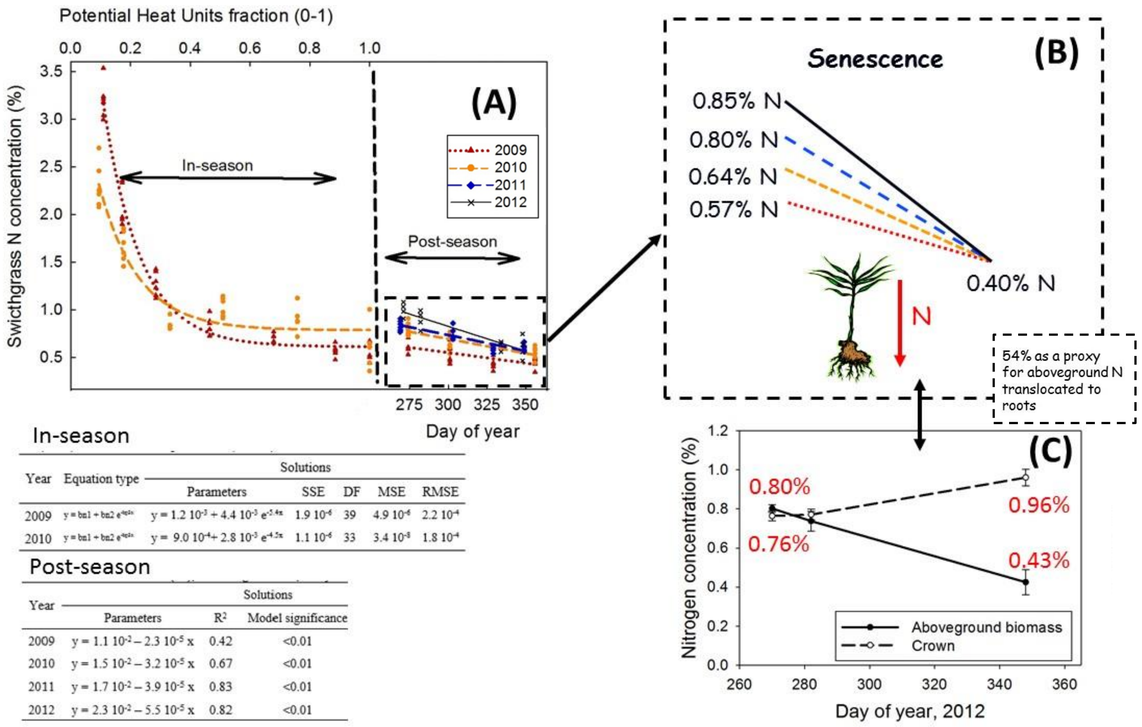
Relevant measurements:

- Aboveground biomass (AGB), N concentration (N%) and removal (Nrem)
- Crown N concentration
- Weather data (air temperature, solar radiation, precipitation, relative humidity, and wind speed)
- Soil horizon description and chemical analysis prior to establishment

Statistical Analysis:

- **Verification:** simulation was considered acceptable if modeled values fit within the 95% confidence interval of the fitted model of observed values.
- **Validation:** model was considered validated if the linear regression of observed and simulated Nrem values had intercept and slope values not significantly different from zero and one, respectively, at α=0.05.

Relevant Findings:



In-season

Year	Equation type	Solutions: Parameters	SSE	DF	MSE	RMSE
2009	$y = b_0 + b_1 e^{-b_2 x}$	$y = 1.2\ 10^{-2} + 4.4\ 10^{-3}\ e^{-5.4x}$	$1.9\ 10^{-4}$	39	$4.9\ 10^{-6}$	$2.2\ 10^{-4}$
2010	$y = b_0 + b_1 e^{-b_2 x}$	$y = 9.0\ 10^{-4} + 2.8\ 10^{-3}\ e^{-4.2x}$	$1.1\ 10^{-4}$	33	$3.4\ 10^{-6}$	$1.8\ 10^{-4}$

Post-season

Year	Solutions: Parameters	R^2	Model significance
2009	$y = 1.1\ 10^{-2} - 2.3\ 10^{-5}\ x$	0.42	<0.01
2010	$y = 1.5\ 10^{-2} - 3.2\ 10^{-5}\ x$	0.67	<0.01
2011	$y = 1.7\ 10^{-2} - 3.9\ 10^{-5}\ x$	0.83	<0.01
2012	$y = 2.3\ 10^{-2} - 5.5\ 10^{-5}\ x$	0.82	<0.01

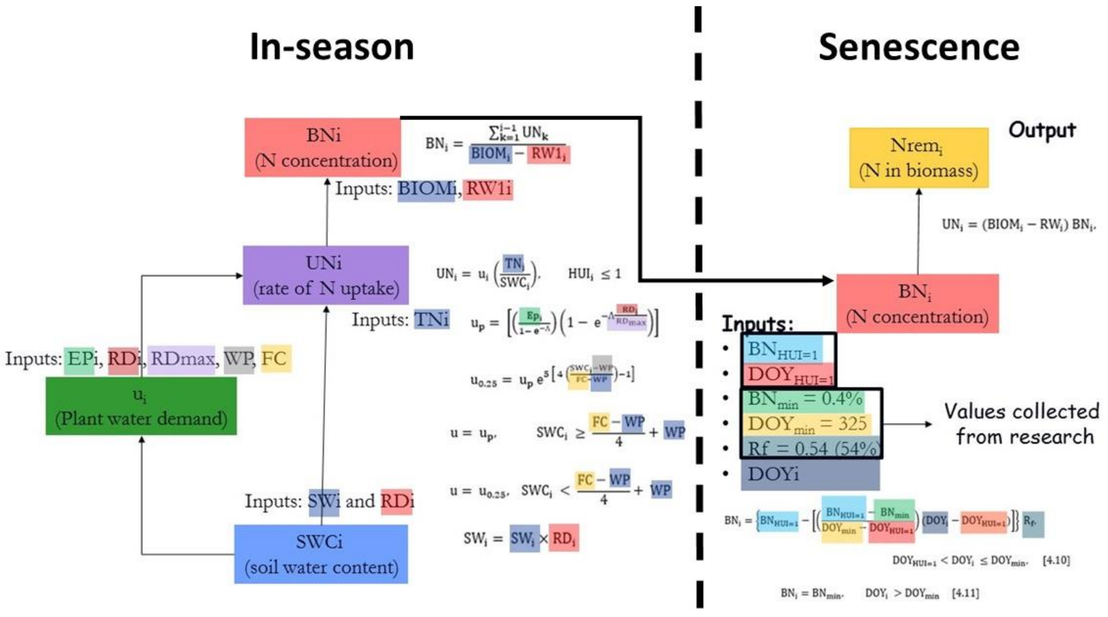
A. The rate of decline of N% during the growing season diminished following an exponential decay-3-parameters equation.

B. During the post-season, the N% decreased linearly from peak yield to the minimum value of 0.40% at DOY 356. AGB in later years had a higher N% at peak yield, which was always reduced to 0.40% at DOY 356.

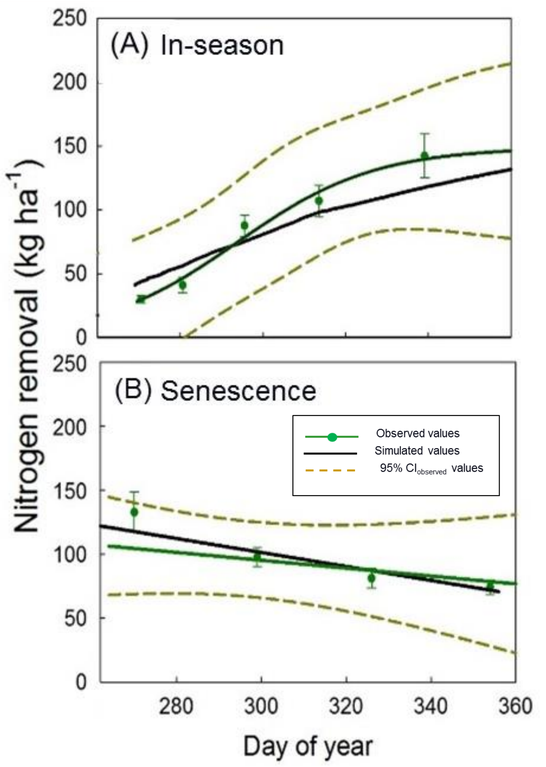
C. Fraction of N% between crown and AGB was 0.54 at DOY 356.

N removal logic development:

Nitrogen removal logic was developed based on an existing N-uptake ALMANAC algorithm, which was previously developed as a N growth stress constraint. This algorithm was modified with new equations based on the research findings presented above.

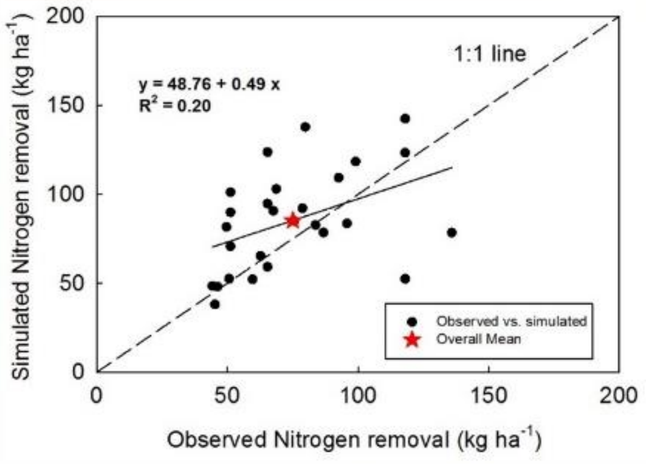


Model Verification:



The new Nrem logic was verified. It correctly simulated Nrem at the same location in which the logic was developed (trials 1 and 2).

Model Validation:



The new logic was not validated. I was unable to simulate Nrem in other locations (trials 3-6).

Conclusions:

The reasons for inaccuracy of the enhanced logic when applied to different locations:

1. Default soil input values were used owing to lack of soil characterization in validation sites

2. Important factors affecting N removal were not considered in the model because they were not elucidated by data analysis. New studies for revealing the factors that affect N removal are essential for improving the proposed equations.