Analysis of Root Carbohydrates in Alfalfa Treated with Four Harvest intervals and Five Potassium Rates in the Southeast

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Introduction: (Rationale and Objectives)

In recent years, interest in alfalfa has increased in the southeastern United States following the release of newer varieties that are more adaptable to the harsh environment in the region. Potassium application and harvest regime are known to impact alfalfa stand life, seasonal yield, and forage quality. Current recommendations for appropriate harvest timing and fertilization are generated from research in northern climates with different varieties. A need was identified to examine the effects of harvest regime and potassium application in the Southeast. A study was conducted at the University of Georgia, Tifton Campus to evaluate these variables, as well as a follow up evaluation of root material to determine carbohydrate response to the treatment combinations on pure alfalfa stands in the South.

Root carbohydrates are a snapshot of plant reserves headed into winter and provide for a successful stand in the following spring (Brown et al. 1990). Much of the literature today focuses on northern climates, with an importance on maintaining root reserves for the colder winters. However, there is evidence that warm and humid climate of the southeast hastens maturity and increases cutting frequency, further depleting root carbohydrates (Brown et al. 1990). Potassium fertility and harvest frequency can affect alfalfa stand persistence. Root carbohydrates are therefore likely affected by the changes in fertilization and maturity at cutting. Mays and Evans (1973) found that their total available carbohydrate results in the South were markedly different from northern publications, increasing the need for additional data about root carbohydrate behavior in the region.

This project sought to define the differences in root carbohydrate amount between potassium fertilization and harvest interval treatments and show the effect that these treatments might have on long term stand vitality. This project was in conjunction with a 2-year study that evaluated pure stand alfalfa forage yield, quality and stand persistence in the Southeast

The overall objective of this project was to provide a more complete analysis of above and below ground alfalfa plant material under varied management in the Southeast. The project focused primarily on below ground plant responses.

Materials and Methods: (Study Description)

The base study for this project was funded by USDA-NIFA-AFRP Grant **#2016-70005-25653** and occurred from 2017-2018 at the UGA Tifton Campus, Beef Cattle Unit, in Tifton, GA. Data collection began on the two-year old stand of alfalfa with 14-inch row spacing in 2017. The experimental design was a split plot design with four replications. The main plot comprised of 16 150 sq. foot plots that were randomly assigned to 4 harvest treatments: bud stage, 10% bloom stage, 30% bloom stage and 50% bloom stage. Within each maturity stage, sub plots were assigned to evaluate the influence of five different potassium rates (0, 60, 90, 120 and 150 pounds per acre) split applied at 3 times throughout the season. All remaining nutrients were applied as necessary per UGA recommendations and annual soil test analysis.

After the final harvest in Year 2 of the original study, a destructive harvest was performed on all plots to collect roots for carbohydrate analysis. A 0.5 by 1-m steel rectangular frame was manufactured to attach to a three-point hitch on a tractor. The bottom edge of the frame was sharpened to create a blade to cut through the soil. Approximately 227 kg was added as tractor weights to the back of the frame to maintain depth within the soil. Starter trenches were dug 1-m deep at the beginning of each row. The cutter bar was placed in the trench and dragged to the end of the row to cut the roots. Roots were excavated from three, 0.1-m2 quadrats after associated crowns and stems were counted. Roots were immediately washed in water and transported on ice to be hammer-milled (No. 10 Hammer Mill, CS Bell Company), vacuum sealed in a FoodSaver bag (Sunbeam Products), and frozen at –18◦C. Samples were later freezedried and ground to pass a 1-mm screen in a Wiley Mill and then subsequently ground through a 1-mm screen in a Cyclone Sample Mill (Model 3010-030; UD Corporation). Ground root samples were shipped to Cumberland Valley Analytical Lab (Waynesboro, PA) for nonstructural carbohydrates (NSC), ethanol-soluble carbohydrate (ESC) and starch concentrations using the procedures outlined in Hall (2009) and Dubois et al. (1956).

Project Objectives and Corresponding Results:

(1) To quantify root carbohydrates in alfalfa harvested at bud, 10%, 30% and 50% bloom and fertilized at 0, 60, 90, 120, and 150 pounds per acre for two years
(2) To provide a better understanding of root vitality in alfalfa grown in the deep south, and better define harvest and fertilization recommendations to producers considering pure alfalfa stand establishment in the Southeast.

(1) Root carbohydrate analyses determined that regardless of K fertilization rate, harvest timing affected starch and NSC content of roots (P <0.01; Table 1)
(2) To optimize both alfalfa yield and persistence, current recommendations for alfalfa harvest timing and K fertilization should be maintained in the southern Coastal Plains.

Conclusions and Implications:

Potassium fertilization did not elicit responses in any root carbohydrate analyses (including starch, NSC, ESC; data not shown; $P > .25$).

Root carbohydrate analyses determined that harvest timing affected starch and NSC content of roots ($P < .01$; Table 1). Both starch and NSC declined with increasing maturity stage at harvest with bud stage being the highest and 50% bloom treatment being the lowest for both analyses ($P < .01$). This was likely a consequence of carbohydrate remobilization within the plant. As alfalfa maturity reaches the 50% bloom stage, shoot growth from new crown buds begins, this is supported by carbohydrates that are remobilized from taproot storage, thus causing a dip in root carbohydrate reserves (Brown et al. 1972; Heichel et al. 1988).

Table 1. Effect of harvest timing (based on growth stage) on root starch and non-soluble carbohydrates of a three-year old alfalfa stand grown in Tifton, Georgia; data pooled over block.

Growth Stage[†]	**Starch**[‡]	**NSC**[‡]
	(g kg^{-1})	
Bud	193[a§]	316[a]
10% Bloom	164[ab]	303[a]
30% Bloom	150[bc]	292[a]
50% Bloom	113[c]	242[b]
SE	14.0	16.2
P-Value	<0.01	<0.01

† As defined by Mueller and Fick (1989).
‡ As described in Hall (2009) and Dubois et al. (1956).
§ Means within a column followed by the same letter are not significantly different at ($P \leq 0.05$)

Source: Thinguldstad et. al. 2020

Current management recommendations for alfalfa in the south include harvesting on a 28- to 35-day interval once alfalfa plants have reached the 10% bloom stage, fertilizing with at least the minimum amount of potash recommended by annual soil tests, and dividing the fertilizer into at least three applications during the season (Hancock et al., 2009). To optimize both alfalfa yield and persistence, current recommendations for alfalfa harvest timing and K fertilization should be maintained in the southern Coastal Plains.

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The complete project is available open access:

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