The Silent Decline in Soil Potassium Levels and Its Effect on Alfalfa Productivity in the Central and Western U.S.

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Introduction

- Alfalfa (*Medicago sativa* L.) is an important perennial forage crop:
  - Grows in the U.S. and many parts of the world;
  - Exported from hay farms to domestic livestock operations;
  - Exported to many countries around the world;
  - Value of the crop is in excess of $10 billion (USDA-NASS, 2014);
  - Fills an important rotational niche in the agricultural systems;
  - Fixes nitrogen (N) and supplies N to the following crops.
- Alfalfa production is heavily reliant on soil nutrients:
  - Continuous production results in depletion of soil nutrients (Lissbrant et al., 2009);
  - Potassium (K) is a key element and removed in high quantities with hay harvesting (Tarkalson and Shapiro, 2005);
  - Our knowledge on the effects of K application to soils with adequate residual amounts and soils with declining K is still rudimentary.
- Recent report suggests that median K levels have started to decline in many states of USA (IPNI, 2016):
  - K deficiency symptoms are commonly observed in alfalfa grown on Wyoming soils (Figure 1).

Objective

- Determine the effects of K, cultivar, and harvest time on growth, yield, nutritive value, and stand persistence of alfalfa.

Figure 1. Sims' Ranch, Wyoming, USA: Top - alfalfa the year after seeding; white splotching on occasional leaflets (K deficiency symptom). Middle - closeup shows white spots ringing the leaflets, compared to normal leaflets. Bottom - shows progression of K deficiency symptoms.

Materials and Methods

- Study location:
  - University of Wyoming Sustainable Agriculture Research and Extension Center, near Lingle, Wyoming, USA (42°14'N, 104°30'W; 1272 m elevation).
- Study design:
  - Randomized complete block design with four replicates.
- Three factors:
  - Two alfalfa cultivars (HI-GEST 360, low lignin alfalfa; AFX 457, conventional alfalfa).
  - Four K rates (0 [control], 56, 112, and 168 kg K_2O ha^{-1}).
  - Two harvest times (optimum growth stage [late bud to 10% bloom] and 7 days after the first harvest).
- Alfalfa seeding rate:
  - 22 kg pure live seeds ha^{-1}.
- Planting date:
  - September 8, 2016.
- Initial data collection:
  - Emergence, seedling count, and visual estimate of nutrient deficiency symptoms.
- Harvesting in 2017:
  - 4 harvests were made in 30 days interval (June to October) at each harvest time.
- Data analysis:
  - ANOVA using Proc MIXED.

Results and Discussion

- The study is well-established and ongoing.
- Observation is being made and data is being collected continually.
- Treatments had no significant effect on early crop establishment in 2016.
  - The average number of seedlings (254 m^{-2}) seemed to be enough for a successful alfalfa stand establishment (Islam, 2013).
- No visible nutrient deficiency symptoms were observed.
- In 2017, K affected (P<0.05) forage accumulation in alfalfa cultivars. For example, Hi-Gest 360 (8372 kg ha^{-1}) and AFX 457 (8283 kg ha^{-1}) had the highest total forage accumulation at 168 and 112 kg K_2O ha^{-1}, respectively (Table 1).
  - Moderate level of K was needed for high yield of AFX 457, while a high level of K was needed for similar yield of Hi-Gest 360.
- On average, late harvest time had higher forage accumulation (2260 kg ha^{-1}) than early harvest time (2055 kg ha^{-1}) (Figure 2A).
- K uptake followed same trend (87 vs. 81 kg ha^{-1}) (Figure 2B).
- Nutritive value was not affected (P>0.05) by application of K.

Conclusion

- Alfalfa stand was well-established with the influence of irrigation water and precipitations in the establishment year;
- K application affected forage yield at different harvests;
- Forage nutritive value was not affected by K application;
- K uptake by alfalfa was high which translated into high yield;
- No nutrient deficiency symptoms were noticed in alfalfa warranting continuous and long-term monitoring of the study.

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Table 1. K effect on alfalfa cultivar at different harvest (‡) at the University of Wyoming Sustainable Agriculture Research and Extension Center, near Lingle, Wyoming in 2017.

Treatment	Hi-Gest 360					AFX 457				
K_2O	‡ 1	2	3	4	Total	1	2	3	4	Total
	kg ha^{-1}									
0	1603b†	1158b	2227c	2048c	6947c	1781a	1069b	2316c	2227c	7393c
56	1603b	1158b	2583b	2138b	7393b	1781a	1158a	2316c	2316b	7571b
112	2049a	1247a	1870d	2138b	7304b	1692b	1069b	2850a	2672a	8283a
168	1870ab	1069c	3028a	2405a	8272a	1514c	1158a	2494b	2361b	7482b
Mean	1781	1158	2427	2182	7491	1692	1114	2494	2383	7682

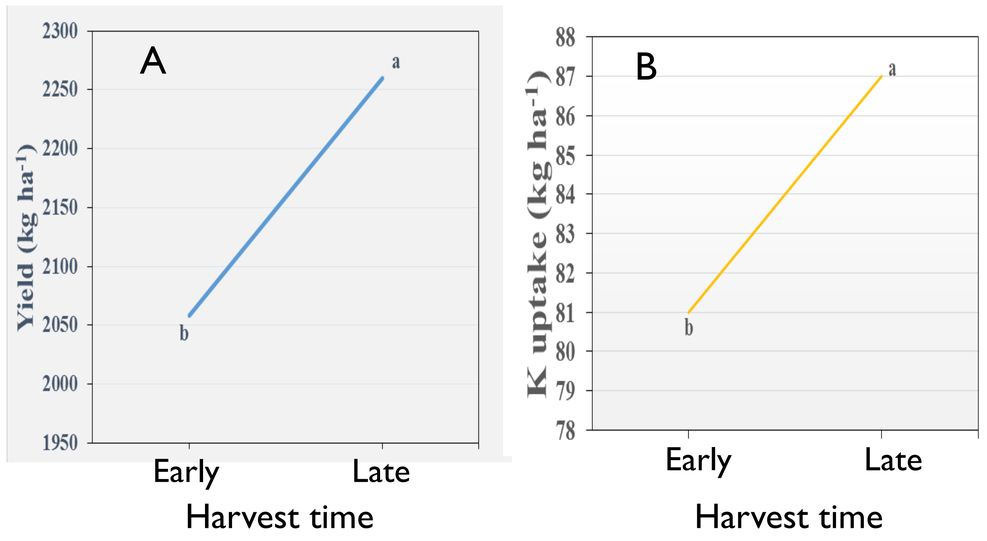

Figure 2. Average forage yield (A) and K uptake (B) of alfalfa at the University of Wyoming Sustainable Agriculture Research and Extension Center, near Lingle, Wyoming in 2017.

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