To determine the effects of long-term P and K fertilization on stratification of soil P and K by sampling depth.

To determine how P and K distribution influences fine root density and vertical distribution of alfalfa roots.

To determine the impact of P and K on taproot volume and physiology.

The application of P and K fertilizer will substantially influence soil P and K concentrations by sampling depth, the overall fine root distribution of alfalfa as a function of depth in soil profile, and alfalfa taproot volume and composition.

**Objectives**

1. Averaged across fertility treatments, soil P concentrations were greatest where plants were fertilized with 0 K/75 P at 0 to 5 cm, 5 to 10 cm, 10 to 15 cm, 15 to 20 cm, and 40 to 60 cm. Soil K concentrations were greatest where plants were fertilized with 400 K/0 P at 0 to 5 cm, 5 to 10 cm, and 10 to 15 cm (Figs. 1 and 2).

2. Averaged across fertility treatments, the greatest density of fine roots were observed in the uppermost 5 cm of the soil profile. Significant differences between fertility treatments in root length density were observed at the 15 to 20 cm soil depth with root length densities being greatest for plants fertilized with 400 K/0 P (Fig. 3).

3. Application of 400 K/75 P fertilizer increased alfalfa taproot volume over those of plants provided 400 K/0 P, 0 K/75 P or 0 K/0 P (Fig. 4).

4. The P and K fertilizer treatments impacted organic reserves in taproots.

   - There was no effect of fertility on taproot sugar concentrations at any sampling date (Fig. 8).

   - In June 2004, the addition of 400 K/75 P reduced taproot sugar concentrations. In September 2004, fertilizing with 400 K/75 P reduced taproot sugar concentrations. There was no effect of fertility on taproot sugar concentrations in May 2005 (Fig. 6).

   - In June and May 2005, fertilizing with 400 K/75 P increased taproot amino-N concentrations. There was no effect of fertility on taproot amino-N concentrations in September 2004 (Fig. 7).

**Conclusions**

**Hypothesis**

- To determine the effects of long-term P and K fertilization on stratification of soil P and K by sampling depth.

- To determine how P and K distribution influences fine root density and vertical distribution of alfalfa roots.

- To determine the impact of P and K on taproot volume and physiology.

**Objectives**

1. Averaged across fertility treatments, soil P concentrations were greatest where plants were fertilized with 0 K/75 P at 0 to 5 cm, 5 to 10 cm, 10 to 15 cm, 15 to 20 cm, and 40 to 60 cm. Soil K concentrations were greatest where plants were fertilized with 400 K/0 P at 0 to 5 cm, 5 to 10 cm, and 10 to 15 cm (Figs. 1 and 2).

2. Averaged across fertility treatments, the greatest density of fine roots were observed in the uppermost 5 cm of the soil profile. Significant differences between fertility treatments in root length density were observed at the 15 to 20 cm soil depth with root length densities being greatest for plants fertilized with 400 K/0 P (Fig. 3).

3. Application of 400 K/75 P fertilizer increased alfalfa taproot volume over those of plants provided 400 K/0 P, 0 K/75 P or 0 K/0 P (Fig. 4).

4. The P and K fertilizer treatments impacted organic reserves in taproots.

   - There was no effect of fertility on taproot starch concentrations in June and September 2004. In May 2005, the addition of 400 K/75 lowered taproot starch concentrations (Fig. 5).

   - In June 2004, the addition of 400 K/0 P reduced taproot sugar concentrations. In September 2004, fertilizing with 400 K/75 P reduced taproot sugar concentrations. There was no effect of fertility on taproot sugar concentrations in May 2005 (Fig. 6).

   - In June and May 2005, fertilizing with 400 K/75 P or 400 K/75 P increased taproot amino-N concentrations. There was no effect of fertility on taproot amino-N concentrations in September 2004 (Fig. 7).

**Conclusions**

**Figure 1.** Soil P concentrations were greatest in the top 5 cm of the soil profile. Soils provided 400 K/75 P or 0 K/75 P at 0 to 5 cm, 5 to 10 cm, 10 to 15 cm, 15 to 20 cm, and 40 to 60 cm. Soils that received 0 K/75 P had the greatest P concentrations. (Data averaged over treatments and sampling dates.)

**Figure 2.** Soil K concentrations were greatest in the top 5 cm of the soil profile. Soils provided 400 K/75 P or 400 K/0 P at 0 to 5 cm, 5 to 10 cm, 10 to 15 cm, and 15 to 20 cm. Soils that received 400 K/0 P had the greatest K concentrations. (Data averaged over treatments and sampling dates.)

**Figure 3.** Alfalfa fine roots were most abundant in the top 5 cm of the soil profile. In all treatments, at least 61% of the fine roots are found in the uppermost 15 cm, while densities drop at 40 cm and below to values as low as 1 cm/cm². Fertilizer influenced root length densities at 15 to 20 cm, where plants fertilized with 400 K/0 P had the greatest root densities. (Data averaged over treatments and sampling dates.)

**Figure 4.** The addition of 400 K/75 P fertilizer increased alfalfa taproot volume. (Data averaged over taproot volumes obtained at all sampling dates.)
Figure 5. There was no effect of fertility on taproot starch in June and September 2004. In May 2005, 0 K/0 P plants had the highest starch concentration, while plants fertilized with 400 K/75 P had the lowest. The addition of 400 K/75 P lowered the starch concentrations in May 2005.

Figure 6. In June 2004, 0 K/0 P plants had the highest taproot sugar concentrations, whereas plants fertilized with 400 K/0 P had greatly reduced taproot sugar levels. In September 2004, plants fertilized with 0 K/75 P had the highest sugar concentrations, while plants receiving 400 K/75 P had the lowest sugar concentrations. There was no effect of fertility on taproot sugar concentrations in May 2005.

Figure 7. In June 2004, addition of 400 K/0 P increased amino-N concentrations in alfalfa taproots. In September 2004, there was not a significant effect of fertility on taproot amino-N concentrations. Plants that received 400 K/75 P or 0 K/75 P fertilizer had the greatest concentration of amino-N. Plots given 400 K/0 P fertilizer had the lowest amino-N concentrations. In May 2005, fertilizing with 400 K/0 P or 400 K/75 P increased taproot amino-N concentration.

Figure 8. There was no effect of fertility on taproot protein concentrations at any sampling date.

Materials and Methods
In September 2001, a complete randomized block design of two K (0 and 400 kg K/ha/yr) and two P (0 and 75 kg P/ha/yr) treatments was created in a stand of ‘5454’ alfalfa that had been established in 1997. Fertilizer was applied in November 2001 and following the first and last forage harvests of the 2002 and 2003 growing seasons with half the specified amount in each application. Forage was harvested 4 times annually at about 30-d intervals during each growing season. Taproots were dug to a depth of 20 cm in September 2003, June 2004, September 2004, and May 2005. Taproots were washed free of soil and cut to a length of 15 cm. Upper and lower diameters of these taproot segments were measured with a calipers, and the volume of the taproot calculated. One inch diameter cores were taken to a depth of 1 m in June 2004, September 2004, and May 2005. Eighteen cores were taken from each 10 x 13 m plot. The cores were divided into eight depths: 0 to 5 cm; 5 to 10 cm; 10 to 15 cm; 15 to 20 cm; 20 to 30 cm; 30 to 40 cm; 40 to 60 cm; and >60 cm. Fine roots from nine cores were gently washed free of soil, and roots removed, cleaned, and stored in a 10% (v/v) ethanol solution. The fine roots were scanned and root features quantified using WinRHIZO to determine root length density. Soil from the other nine cores was air-dried and ground to pass a 2-mm screen. Soil P and K extractions were performed using Mehlich 3 buffer. Soil P concentrations were interpolated to Bray P1 and soil K concentrations were determined directly by flame spectrometry. Taproots sampled in June 2004, September 2004, and May 2005 were frozen on dry ice. Root tissues were lyophilized, ground to pass a 1-mm screen, and stored at -20°C until analyzed. Carbohydrates were analyzed using procedures described by Li et al. (1998). Amino nitrogen (amino-N) concentration was determined using a ninhydrin assay as described by Hendershot (1993). Soluble protein was estimated using protein dye-binding (Bradford, 1976). Statistical analysis was performed by ANOVA, and the least significant difference (LSD) at the 5% level of probability is provided where significant (NS = not significant).

References

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