Evaluation of Phosphorus Availability on Growth and Leaf Nutrient Concentrations in Wheat, Oats, and Rye

Jerri Lynn Dodson, Will McClain, and Melissa Remley

William H. Darr School of Agriculture, Missouri State University, Springfield, MO

Abstract

Adequate phosphorus (P) availability is critical for the growth and sufficient nutrient content of forages for grazing animals. On low fertility soils, it has been found that tall fescue, a cool-season perennial grass, responded to P fertilization with increased yields and improved leaf nutrient concentrations of P, magnesium (Mg), calcium (Ca), and potassium (K) in winter months. Adequate leaf concentrations of these nutrients are important to avoid nutritional disorders in grazing cattle, such as grass tetany. Our objective is to examine the effect of P availability on growth and leaf nutrients in annual cereal grains commonly grown for winter forage. Soft red winter wheat (*Triticum aestivum*), oats (*Avena sativa*), and cereal rye (*Secale cereale*) were grown hydroponically in greenhouse conditions in complete nutrient solutions with varying P concentrations of 0, 200, 400, and 800 µM P. Seedlings were suspended in 400 ml containers with aeration with three containers of each treatment solution in three replicate blocks. After 30 days of growth, plants were separated into roots and shoots, dried, weighed, and stored for nutrient analysis. Shoot growth of wheat, oat, and cereal rye responded to P treatments. Wheat increased 3-fold, oats1.5-fold, and cereal rye 4.5-fold from 0 to 200 µM P. Wheat shoots also increased an additional 17% from 200 to 400 µM P. Root growth responded to P treatments mainly in wheat, with a 73% increase from 0 to 200 µM P and 42% increase from 200 to 800 µM P. Photosynthetic rates increased incrementally with P treatments in wheat, however oats and cereal rye exhibited similar rates at all P treatments except 0 µM P. Both leaf and root P content increased with P treatments. Future analyses of leaf Mg, Ca, and K content will decipher if nutrient concentrations are improved with P availability in these forage species.

Background Information

- Cattle become susceptible to grass tetany when the ratio of K to (Mg+Ca) concentration in forage is higher than 2.2.
- We have found that tall fescue responded to P fertilization on low fertility soils with increased yields and improved leaf nutrient concentrations of P, Mg, Ca, and K.
- Our objective is to examine the effect of P availability on the grass tetany ratio in annual cereal grains commonly grown for winter forage.

Materials and Methods

- Soft red winter wheat (*Triticum astivum*), oats (*Avena sativa*), and cereal rye (*Secale cereale*) were hydroponically grown in greenhouse conditions for 30 days (Figs. 4 and 5).
- Complete nutrient solutions were aerated and contained treatments of 0 µM, 200 µM, 400 µM, and 800 µM P.
- Photosynthetic rates were measured with a Li-Cor 6400 (400 ppm CO_2, irradiance = 1500 $\mu molm^{-2}s^{-1}$).
- At harvest, roots and shoots were separated, oven dried, weighed, then ground to a 5mm screen using a Cyclone Mill.
- Tissues were digested in nitric acid using a Mars 6 microwave digestion system.
- Tissue P was determined colormetrically.

Biomass

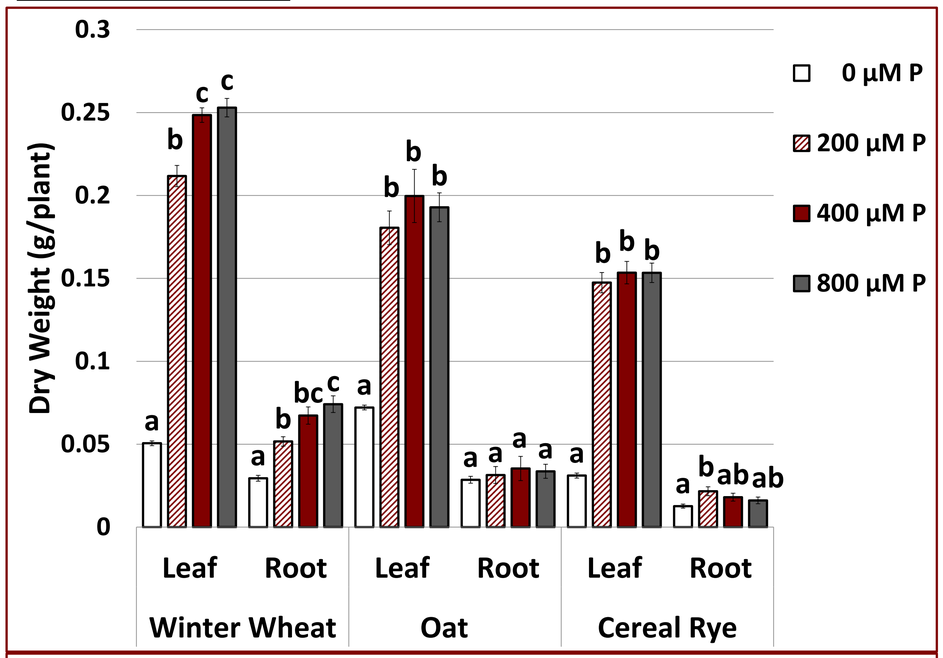

Figure 1. Dry weight of shoots and roots after 30 days of growth. Treatment means ± SE, n=9. Within species and tissue type, values not followed by the same letter are significantly different ($p < 0.05$, Tukey's pairwise comparisons).

Figure 4. Wheat grown for 30 days in hydroponic solutions containing (L to R) 0, 200, 400, and 800 µM P.

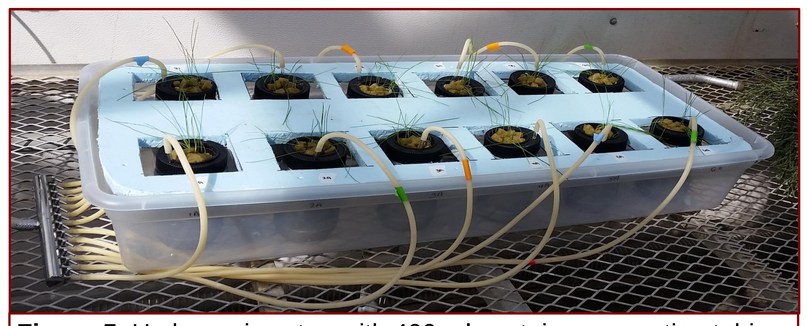

Figure 5. Hydroponic setup with 400 ml containers, aeration tubing, and 15 plants per pot.

Photosynthetic Rate

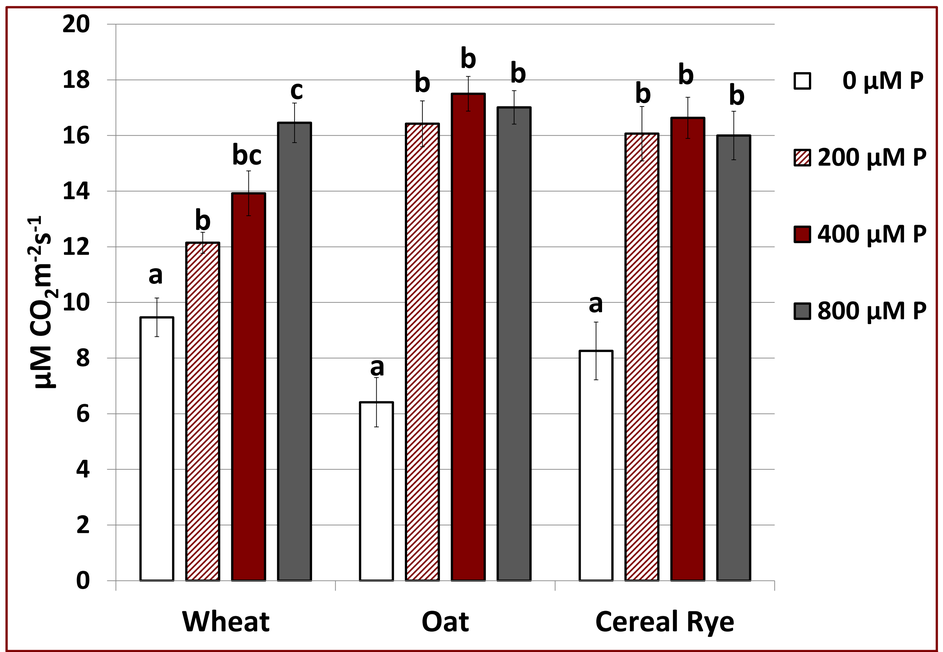

Figure 2. Photosynthetic rates of shoots after 30 days of growth. Treatment means ± SE, n=9. Within species, values not followed by the same letter are significantly different ($p < 0.05$, Tukey's pairwise comparisons).

Phosphorus Content

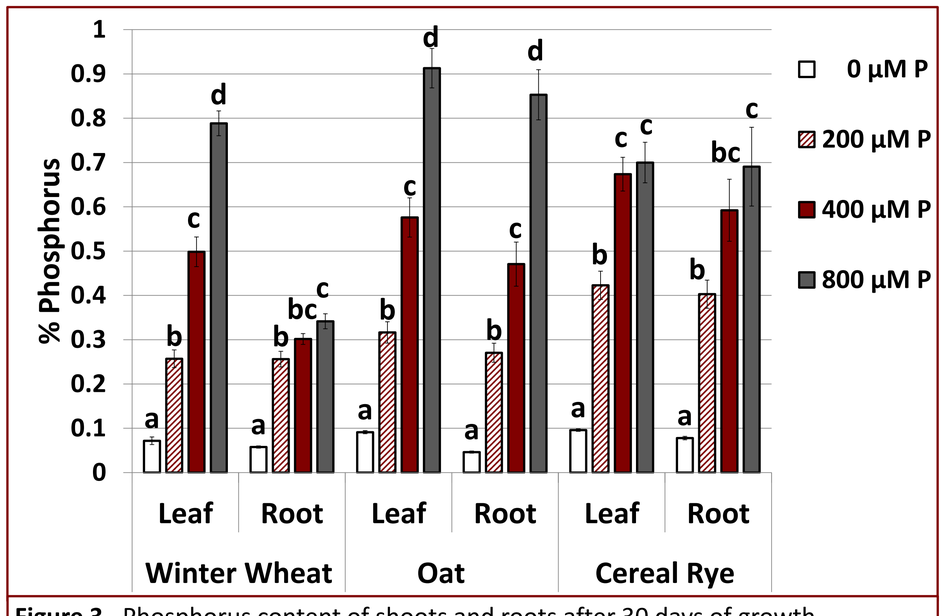

Figure 3. Phosphorus content of shoots and roots after 30 days of growth. Treatment means ± SE, n=9. Within species and tissue type, values not followed by the same letter are significantly different ($p < 0.05$, Tukey's pairwise comparisons).

Results and Discussion

- Growth (Fig. 1) and photosynthetic rates (Fig. 2) were depressed in all 0 µM P treated plants.
- Incremental increases in growth (Fig. 1) and photosynthetic rates (Fig. 2) with P treatment were only found in wheat.
- P tissue content increased with P treatments in all three species (Fig. 3).
- Increases in P tissue content with P treatment suggests that other leaf nutrients, such as Mg, Ca, and K could be incrementally changed with P availability in these species.
- Future analyses of these nutrients will determine if the grass tetany ratio is improved with P availability in these forage species.

Future Research

- Leaf and root tissue will be analyzed for K, Mg, and Ca concentrations using atomic absorption spectroscopy.
- Effects of P availability on the grass tetany ratio will be evaluated.
- Currently, field evaluations of P fertilization on these forage species are being conducted at the MSU Shealy Farm, Fair Grove, MO.

Acknowledgements

- This project was funded by the Missouri State University Graduate College Faculty Research Grant, Thesis Travel Funding, and Thesis Research Funding programs.
- Partial funding was supplied by a USDA-NLGCA Capacity Building Grant.
- Travel was also sponsored by the MSU Darr School of Agriculture.