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Case Study 6.3-3 Phosphorus fertilizer protects roots from aluminum toxicity in acid Oklahoma soils.

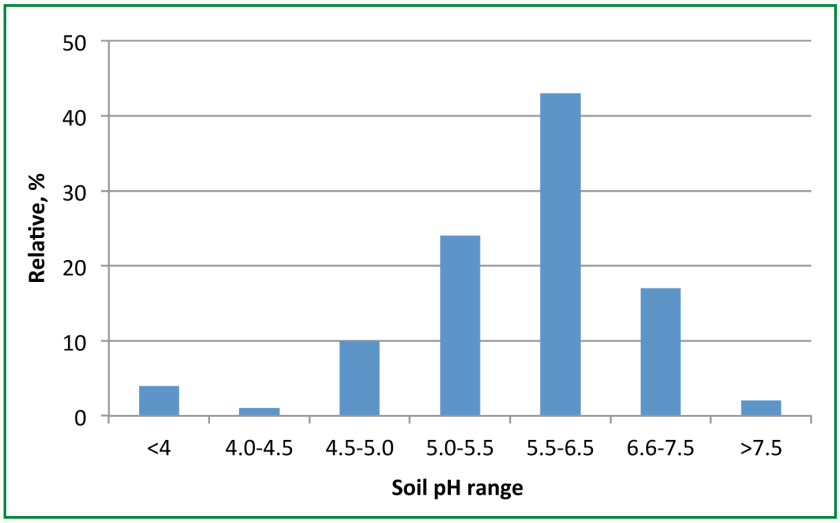

Figure 1. Summary of the soil pH values for the 614 samples submitted to the Oklahoma State University Soil, Water, Forage, Analytical Laboratory under wheat crop code during 2011.

Grain producers throughout the United States commonly farm a large percentage of rented land. Lease agreements can widely vary both in length of term and the amount of inputs that the land owner will pay. The wheat belt of Oklahoma is known for having large areas with low soil pH levels. A recent survey showed 38% of soil samples having a soil pH level below 5.5 (**Figure 1**). For farmers in Oklahoma short term leases with limited shared expenses have limited the practicality of agricultural lime for remediation of acidic soils. In the dry environment it may take up to one year before the lime applied has completely corrected the soil acidity problem. In a situation where the lease agreement is only 1-2 years there may be no economic benefit for the producer to apply lime, especially in regions where winter wheat average yields range from 20 to 40 bushel per acre.

Aluminum (Al) and manganese (Mn) toxicities are the greatest issue associated with soil acidity. Available Al, a predominant element in the regions soils, is pH dependent. A change of 1.0 pH level changes available Al by 1000 fold. For example a soil with a pH of 5.0 will have an approximate Al concentration of 27 ppm (critical level toxic to winter wheat is 27 ppm) while a soil with a pH of 4.0 will have an Al concentration of approximately 27,000 ppm. Aluminum and Mn toxicities not only impact grain yield but have an even greater impact on biomass production. Kariuki et al (2007) recorded the impact of soil acidity on eight current winter wheat lines. Correcting soil acidity increased wheat grain yield by 82% and increased forage production by 150%. In Oklahoma wheat forage production is as important as grain. Oklahoma is unique in that approximately 50% of the four million acres of winter wheat are grazed annually, much of this under the dual –purpose "Graze-N-Grain" management.

To maintain productivity in the short term producers have been in-furrow band applying phosphorus (P) fertilizer to alleviate the impact of Al toxicity, since the long term investment in ag lime is impractical. In the mid to late 1970's the first Oklahoma research was performed which documented that the addition of P fertilizer with the seed at planting could significantly reduce the impacts of Al and Mn toxicities in winter winter wheat. Soon after Oklahoma State University recommended the "Banding of Phosphate in Wheat: A Temporary Alternative to Liming" (**Figure 2**).

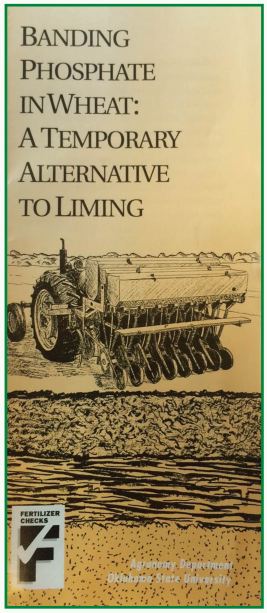

Figure 2. The cover of an extension brochure distributed in Oklahoma during the 1980s.

Banding P fertilizers aid in low-pH soil conditions as phosphate reacts with metals like Al and Mn creating very insoluble solid compounds. Phosphorus in high concentration in the seed zone reduces the harmful effects of the metals on the emerging seedling.

Since the initial work in the 70's Oklahoma State University researchers have often revisited to topic to refine recommendations and evaluate responses and economics. The current recommendation for winter wheat producers working on low-pH short term lease ground is to apply 30 lb P_2O_5/A with the seed as 18-46-0 (diammonium phosphate) for grain only wheat, and 60 lb P_2O_5/A for dual-purpose grain plus forage wheat production. This recommendation however is for soils with adequate soil test P, but low soil pH. When soil test P is below optimum the 30 or 60 units is applied in addition to the amount normally recommended.

In 1992 Boman et al reported the impact of banding P fertilizer with seed on winter wheat forage production (**Figure 3**). Across the four locations (Carrier and Hennessey with two

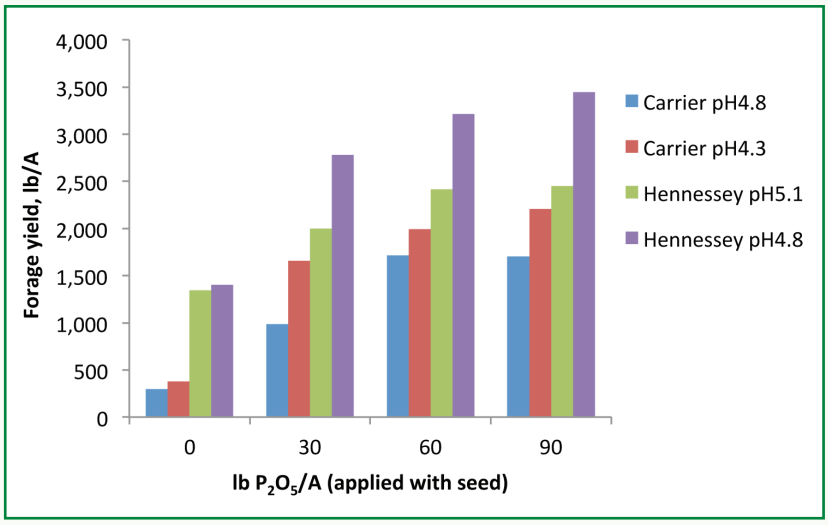

Figure 3. The impact of banding P fertilizer with seed at planting in four acidic soils on winter wheat forage production in Oklahoma. Chart adapted from Boman et al. 1992.

pH levels each) the addition of P increased forage yield from 2 to 4 fold. The work by Kaitibie et al (2002) documented an additional aspect of banding P. In the variable and often arid climate of Oklahoma the activation of lime can take a significant amount of time, upwards of one year. In comparison, banding P has an immediate impact on the alleviation of metal toxicities. **Figure 4** shows the incorporation of lime improved forage yield but not to the degree of banding P. For continuous winter wheat producers the time between application of lime and planting can be quite short. Typically the previous crop will be harvest in mid-June and in the best case scenario lime would be applied and incorporated by mid-July. At this point there is only 60 days until the next wheat crop is planted in early to mid-September. Figure 4 also documents the impact on grain yield, demonstrating that soil acidity has the greatest impact on winter wheat forage production and therefore the dual-purpose wheat producer.

For the short term tenant of a low-pH winter wheat field the one time investment of $60-$120 per acre in slow reacting lime is not an economically viable option. For a cost of approximately $25 per acre winter wheat producers of the southern Great Plains have been using the in furrow P fertilizer "Band-Aid" for the past 40 years. This is not the ideal management practice; however until lease agreements are changed it is likely to remain common.

The practice of banding P fertilizer for this purpose is also being used in the production of winter canola. Winter canola is more sensitive to soil acidity than winter wheat; it is also more sensitive to nitrogen fertilizer placed with the seed. Other studies have shown that the addition of P broadcast or banded with seed had a significant impact on stand, winter survival and final grain yield.

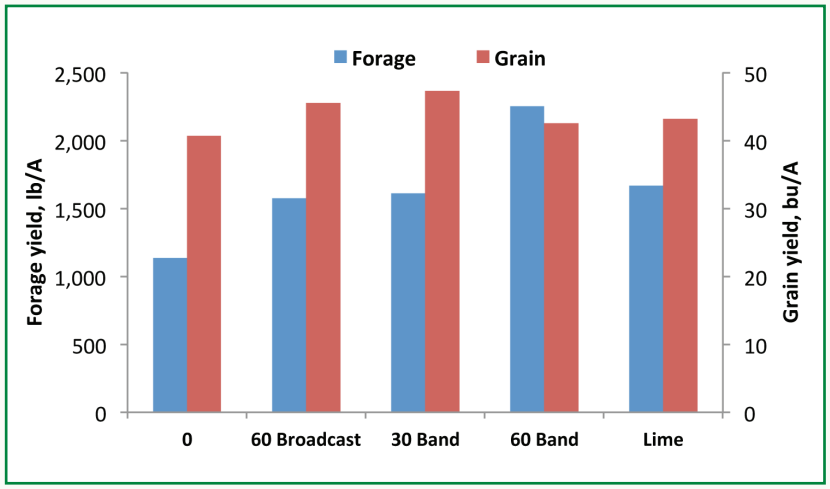

Figure 4. The impact of applying P fertilizer and lime on the forage and grain production of winter wheat in Oklahoma. Chart adapted from Kaitibie et al. 2002.

Reference

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