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EFFECT OF SOIL BORON LEVELS AND pH ON YIELD OF ALFALFA

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Background. Boron concentrations and pH are two soil chemical properties that are critically important for alfalfa growth. Alfalfa grows better at soil pH levels of 7.0 and above. Acidic soils require addition of limestone to raise pH to 7.0. As soil pH increases from strongly acidic to 7.0, or neutral, soluble aluminum converts to aluminum hydroxide compounds. Soil boron is made unavailable to plants by the increasing concentrations of aluminum hydroxide. To study the effect of increasing soil pH on the availability of soil boron to alfalfa, we treated a series of plots with increasing rates of boron and of limestone having two effective calcium carbonate equivalent (ECCE) percentages. Limestone rates totaled 0, 3, and 6 tons/acre over a six-year period. Limestone ECCE percentages were 62 and 100. Boron rates initially were zero, one, and two lbs/acre applied annually for clover and for the first year of the alfalfa study. Boron rates were increased to two and four lbs/acre in 1993, the second year of the three-year experiment with alfalfa. We seeded 'Alfagraze' alfalfa at a row spacing of 27 inches into a sod of 'Coastal' bermudagrass. Five to six cuttings of alfalfa were made each season. We sampled the surface soil at depths of 0- to 2- and 2- to 6-inches and analyzed these soils for pH and boron. Other elements analyzed included soil levels of aluminum and manganese. The effects of pH and element concentrations and their interactions at each soil depth were compared with yield of alfalfa using analysis of variance and multiple regression.

Research Findings. Statistical analysis indicated that there was a positive effect of increasing soil pH and boron concentrations and the interaction of these soil chemical properties on yield of alfalfa. Analyses of data by use of multiple regression techniques showed that yield of alfalfa was related to applied boron, soil pH, soil B, and soil manganese. The relationship of these soil chemical properties to yield of alfalfa was stronger in the 2- to 6-inch soil depth than in the surface two inches. Regression analysis generated a predictive equation that estimated alfalfa yield. The R^2 for this predictive equation showed that these soil chemical factors described 76% of the variation in alfalfa yield. The regression equation follows:

$$\text{Yield} = -24.25 + 0.923 \times 2.0 - 0.12 \times 2.0^2 - 16.53 \times B + 26.45 \times B^2 + 6.55 \times pH - 0.37 \times pH^2 + 0.138 \times 7.5$$

Where: B = 2- to 6-inch-depth soil boron soluble in boiling water

pH = soil pH (1:2 soil:water) in the 2- to 6-inch soil depth

Applied B held constant at 2 lb of B/acre and soil manganese at 7.5 parts per million.

Alfalfa yield estimated by this predictive equation is shown in Table 1.

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Data in Table 1 show that alfalfa yields increased as soil pH increased from 5.7 to 7.7. Alfalfa yield increased most rapidly as strongly acid soil was neutralized from 5.7 to 6.2 compared to changing soil pH from 7.2 to 7.7. The 0.70-ton/acre increase in alfalfa dry matter yield as pH was raised from 6.7 to 7.2 would easily pay for the additional limestone required to effect this change in soil pH. This effect of increasing soil pH was similar at all soil boron concentrations. At a constant soil pH, increasing the level of soil boron increased alfalfa production. The yield increase was low (0.2 tons/acre) as soil boron was raised from 0.3 to 0.4 ppm, but began to increase exponentially at higher soil boron levels. Elevating soil boron levels from 0.6 to 0.7 ppm produced approximately 1.8 tons of alfalfa/acre. The low response of alfalfa to hot water-soluble soil boron at levels below 0.4 ppm indicates that soil test boron levels below 0.4 ppm should be considered in the critical range for alfalfa. However, data in Table 1 show that alfalfa yields continue to increase at an increasing rate as the level of soil boron is raised to 0.7 ppm.

Application. Results of this study point out the importance of maintaining adequate levels of boron in soils for alfalfa production. The higher the boron level in the 2- to 6-inch depth of soil, the greater is the alfalfa yield within the range of boron levels tested in this study. Additional research is needed on more soils to confirm this.

Table 1. Estimated response of alfalfa to soil pH_w and to hot-water soluble boron in the 2- to 6-inch depth of a Darco loamy fine sand using data from 1994.

Soil pH	----------Soil boron, ppm----------				
	0.3	0.4	0.5	0.6	0.7
	----------DM, tons/acre----------				
5.7	0.87	1.07	1.80	3.05	4.84
6.2	1.94	2.14	2.87	4.13	5.91
6.7	2.83	3.03	3.76	5.01	6.80
7.2	3.53	3.73	4.46	5.71	7.50
7.7	4.05	4.25	4.97	6.23	8.01