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ALFALFA PRODUCTION ON ACID SOILS AFFECTED BY PHOSPHORUS AVAILABILITY AND SOLUBLE ALUMINUM LEVELS IN THE SUBSOIL

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Background. Research to determine the soil conditions that support or hinder production of alfalfa on acid, humid-region soils was initiated in 1990 with successful establishment of alfalfa on a Darco soil. To determine the soil series on which alfalfa could be grown, we sampled the profiles of eight soil series to a depth of six feet. These profile samples were analyzed for acid soil factors that could be harmful to alfalfa production. The soils were limed to raise the surface 6-in depth to approximately pH 7.0. Phosphorus (P) at rates of 0, 50, 100, and 150 lb P_2O_5 /ac was applied to evaluate response of alfalfa to this nutrient. Alfalfa was seeded on these soils in fall 1992.

Research Findings. Alfalfa yield in 1995 was highest on the Thenas, a bottomland soil that contains more available water, than on the upland Bowie, Lilbert, and Darco soils (Table 1). The Darco, Bowie, and Lilbert soils differ in depth of surface sand above the B horizon. The Cuthbert is a red soil similar to the Redsprings and Kirvin series. The Keithville-Sawtown soil is an Alfisol. It and the Lilbert and Darco soils (Ultisols) were lowest in residual soil P. Alfalfa yields were significantly increased by P treatments on each of these soils. Residual soil P was sufficient to prevent alfalfa yield increases due to applied phosphorus in the Cuthbert, Kirvin, Redsprings, Bowie, and Thenas soils. The Redsprings soil has a high clay content and sufficient slope to prevent rapid infiltration of precipitation. There was no yield increase due to P fertilization if the soil P level was 9 ppm or higher.

Results of analysis of these eight soils for 0.01 M $CaCl_2$ soluble aluminum (Al) in the profile determined that the Bowie, Darco, and Lilbert soils contain soluble aluminum levels lower than 1.0 ppm through the 4 ft depth (Table 1). Each of these soils is a Paleudult. The Keithville-Sawtown soil is a Paleudalf that is low in soluble aluminum through the 3 ft depth. The Bowie, Darco, Lilbert, and Keithville-Sawtown are old, humid region soils. As an Alfisol, the Keithville-Sawtown soil has a higher percentage base saturation than the other three. The Thenas is a younger, high-base-saturation soil that is also low in soluble aluminum through the 3 ft depth. The Cuthbert, and Kirvin are red, minimum horizon, humid region soils that have soluble aluminum levels above the critical 1.0 ppm in the 2-3 ft depth. The Kirvin has a toxic level of aluminum in the 1-2 ft depth. The Redsprings soil is also a minimum horizon, humid region soil, but it has a higher percentage base saturation than the Cuthbert, and Kirvin. The Redsprings soil has soluble aluminum above the critical level in the 2-3 ft depth.

Application. From these test results for soluble Al and yield levels on these soils, it appears that the 0.01 M CaCl₂ soluble Al level in the soil profile has a significant effect on alfalfa yield. Aluminum inhibition of root extension deeper into the subsoil inhibits alfalfa growth by limiting uptake of water from these depths, thereby hastening drought stress in high Al content subsoils.

Table 1. Effect of applied phosphorus on yield of Alfagraze alfalfa and levels of phosphorus and aluminum in eight Coastal Plain soils.

Alfalfa dry matter yield								
P ₂ O ₅ rate	Bowie ¹ fsl	Cuthbert fsl	Darco lfs	Keithville- Sawtown fsl	Kirvin ² fsl	Lilbert lfs	Red- springs grav. l	Thenas fsl
lb/ac	-----lb/ac-----							
0	6006 a ³	5192 a	2771 b	559 b	4629 a	4208 b	3096 a	6995 a
50	6514 a	5156 a	4596 ab	3759 a	3813 a	5485 a	3147 a	7040 a
100	7246 a	5138 a	4636 ab	5356 a	5129 a	6408 a	3139 a	8146 a
150	7018 a	5083 a	6301 a	5126 a	4957 a	6003 a	2652 a	6283 a
Soil P levels								
-----ppm-----								
0	9.1	18.1	6.7	5.9	40.3	8.4	9.9	52.0
50	12.8	25.8	17.5	12.1	58.0	17.5	19.2	83.4
100	34.7	30.0	26.5	21.2	66.3	32.4	29.7	77.5
150	32.5	82.2	38.9	34.7	7.9	39.5	30.0	106.8
Soil depth	0.01 M CaCl ₂ soluble aluminum							
ft	-----ppm-----							
0-1	0.13	0.09	0.27	0.22	0.04	0.06	0.37	1.16
1-2	0.03	0.05	0.11	0.01	6.51	0.06	1.01	0.10
2-3	0.20	1.20	0.06	0.29	29.82	0.02	7.49	0.54
3-4	0.21	10.05	0.12	1.34	34.50	0.05	17.60	6.14
4-5	0.11	25.44	1.01	4.27		0.23	32.42	4.06
5-6	0.24	28.42	1.10	4.91		1.85	75.07	4.43

¹CEC's by soil series follow: Bowie - 3.5 (Plinthic Paleudult), Cuthbert - 13.0 (Typic Hapludult), Darco - 3.3 (Grossarenic Paleudult), Keithville-Sawtown - 3.8 (Glossic Paleudalf), Kirvin - 7.6 (Typic Hapludult), Lilbert - 3.0 (Arenic Plinthic Paleudult), Redsprings - 12.1 (Ultic Hapludalf), Thenas - 6.5 (Fluvaquentic Eutrochrept).

²Alfalfa yields are lower because the second growth was unintentionally grazed.

³Values followed by a similar letter are not different statistically at the 95% confidence level.