Pasture pH and Liming Issues Affecting Forage Yield

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Soil Acidity

In theory, acidity refers to the concentration of active hydrogen ions (H^+) in a system. It is measured by an index called pH. The lower the pH the more the active hydrogen ions present and the more acidic the system. A pH of 7 (as is the case for distilled water) is neutral ($H^+ = OH^-$), and for soil, a pH of 7 is too high for most forages grown in Florida. A pH of 5 to 6 is slightly acidic and satisfactory for most Florida forages to grow. A pH of 4 is too low or very acidic and will result in poor root growth or function of most Florida forages. There are a few native Florida soils with pH greater than 7 and these are usually underlain by marl and in some places, hard limestone. The range of soil pH relative to its acidity or alkalinity is depicted in Figure 1.

Soil acidity tends to increase with repeated use of nitrogen (N) fertilizer because the commonly used N fertilizers contain an ammonium radical. Soil micro-organisms cause biological oxidation of ammonium to nitrate (nitrification). This is a two-step process that generates hydrogen ions.

1) $2NH_4^- + 3O_2 = 2NO_2^- + 2H_2O + 4H^+$ (Nitrosomonas)

2) $2NO_2^- + O_2 = 2NO_3^-$ (Nitrobacter)

Increase in soil acidity is countered by liming with calcium or calcium/magnesium compounds which have the ability to increase soil pH. For example, it requires 60 pounds (lb) of lime to neutralize the acidity from 100 lb of ammonium nitrate and 110 lb of lime to neutralize the acidity from 100 lb of ammonium sulfate. Increasing soil acidity to pH less than 5 can reduce the availability of boron, molybdenum, and sulfur in the soil, reduce nutrient uptake and forage production by more than a third, regardless of N fertilization. Additionally, increasing soil acidity to pH less than 5 can predispose grass to yellowing and damage by soil-born insects. Increasing soil alkalinity to pH greater than 7 (such as from repeated use of lime-stabilized sludge) will reduce the availability of soil iron, manganese, zinc, copper, and cobalt, and create forage production problems similar to increased soil acidity.

Bahiagrass Performance

Bahiagrass decline, a major problem with our premier pasture grass, usually begins with yellowing of the pasture in small or big patches. Later, affected pasture areas turn brown and die which is normally associated with the burrowing and tunneling activity of mole crickets. On damaged areas with high mole cricket infestation, the 6 to 10 inches of soil surface layer is honeycombed with numerous mole cricket galleries and the ground feels spongy when stepped on. A severely damaged pasture has virtually no root system and the plants are easily pulled from the soil by cattle or foot traffic in a pasture. Research and surveys conducted throughout south central Florida implicate pasture and grazing management factors in mole cricket-induced bahiagrass decline.

Field Study

In one of our multi-county trials, the Range Cattle Research and Education Center (Range Cattle REC) evaluated the long-term combined effect of liming and N-fertilization on bahiagrass pasture performance. We applied three types of fertilizer and a control (no fertilizer) annually to portions of bahiagrass pasture that were either limed to maintain a pH of 5.0 or not limed and had an initial pH of about 4.3. The four fertilizer treatments applied every spring from 1998 to present were: 1) 60 lb/acre of N from ammonium sulfate (N), 2) 60-25-60 lb/acre of N-P_2O_5-K_2O from ammonium sulfate, triple super phosphate, and muriate of potash (NPK), 3) 60-25-60 lb/acre of N-P_2O_5-K_2O plus 20 lb/acre of a Frit Industries, Inc. micro-nutrients mix which contained B, Cu, Mo, Fe, Mn, Mo and Zn (NPKM), 4) no fertilizer control (Cont.). Approximately a ton of lime was applied every two to three years to maintain a pH of 5 on limed areas. Bahiagrass performance was measured by dry matter yield, crude protein content, forage digestibility, and condition of bahiagrass ground cover in spring.

Dry Matter Yield

Effect of lime

On pastures at Hardee (pasture 71A), Pasco, and Manatee sites, forage yield was not affected by liming to a pH of 5 throughout the three to five years (Figure 2). The no-lime plots at these sites retained a pH of about 4.5 for the entire period. However, lime treatment increased bahiagrass forage yield by 24% across all fertilizer treatments on Hardee (pasture 87; Figure 2B) where the no-lime, fertilized plots showed a pH decline to about 4.3 (Figure 2).

Effect of fertilizer

Yield increase from fertilizer application compared with non-fertilized control ranged from 18% on the Manatee site to 31% on the Pasco site with the Hardee sites intermediate. However, we hardly noticed any clear differences in forage yield among the N, NPK, and NPKM fertilizer treatments on the two Hardee pastures and on the Manatee pasture (Figure 2A, B). On the other hand, forage dry matter yield increased by 10% when the NPK and NPKM treatments were applied compared with the N only treatment on the deep sandy soil at the Pasco site. We did not observe any improvement in yield by applying micronutrients per se.

Nutritive Value

Lime application had little to no effect on seasonal average crude protein content or digestibility (IVOMD) of bahiagrass forage. However, seasonal crude protein content increased by about 2% units (12% versus 10%) with the application of any fertilizer containing N. This protein enhancement attribute of N was greater immediately after N application in the spring and diminished with time through the season. Forage IVOMD for the no-fertilizer control was always among the lowest (47%) although improvement with N application varied from site to site.

Spring Vegetative Ground Cover

Effect of lime and fertilizer

At the beginning of grazing in the spring of 1998, all the newly established bahiagrass plots at the Hardee sites had an excellent stand of nearly 100% green ground cover (Figure 3A, B). Two years later (2000), the color of bahiagrass ground cover on plots started to sort out into lime versus no-lime sections, where all limed plots were completely green in the spring but the color of no-lime plots depended on fertilizer treatment. This interaction between lime and fertilizer treatment became even more pronounced with passage of time. In 2002, five years into the experiment, minimum spring color change or damage to the bahiagrass sward (1- 4% ground cover consisted of yellow, brown, or weedy cover) was noticed for plots limed to pH 5 whether or not they received fertilizer or for no-lime plots that were not fertilized on both Hardee sites (Figure 3A, B). Damage was most severe (20 - 69% of ground cover) when bahiagrass was not limed but received yearly application of any N-containing fertilizer. The combination of acidic soil conditions (pH less than 4.5) and repeated N fertilization seemed to weaken the bahiagrass root-stolon system, cause severe yellowing in the early spring growth, and made it easier for mole cricket damage to occur.

Effect of sludge

Some livestock producers apply lime-stabilized sludge to pastures to reduce the cost of fertilizer and lime. Lime is added in the processing of sludge primarily to control pathogens, insect vectors, and odor; which makes limed-sludge an excellent source of slow-release plant nutrients (especially N and P), organic matter, and lime. During application, the pH of limed-sludge could range between 7 and 11, N content between 3% and 5% of dry sludge, and P content between 2% and 4% of dry sludge. Four years of repeated application of limed-sludge at the Range Cattle REC – Ona, has shown that when used at recommended agronomic rate (200 lb N/acre), bahiagrass forage production responds well to sludge organic fertilizer and there is no damage to the sward. In those studies, we applied limed-sludge up to 160 lb of N yearly and improved annual dry matter yield from 2 T/acre where no sludge was applied to 5 T/acre. There was no excessive build up of plant nutrients or trace metals in the soil from sludge application and soil pH only increased from 5.0 to 5.3 in four years. However, bahiagrass roots cannot function properly to absorb sufficient iron, manganese, and other micronutrients when the soil pH approaches 7. Several bahiagrass pastures in Polk, Pasco, and Hardee counties where excessive amounts of limed-sludge were applied repeatedly attained a soil pH of about 7 and lost substantial portions of the grass stand to weeds in a manner similar to symptoms of bahiagrass decline. It was easy to identify the strips in those pastures where sludge was heavily applied.

Conclusions

Under grazing conditions in south-central Florida, bahiagrass forage dry matter yield and crude protein content on typical flatwoods soils can improve substantially with N but not with P or K fertilizer application. The situation may be different on the deep sandy soils where the addition of some P and K to N fertilizer could make a difference. Repeated N fertilization without adequate lime application to bahiagrass pastures induces widespread early spring yellowing and eventual stand loss to weeds. In acid soil situations, a producer is better off first liming to raise the soil pH to 5 or greater before applying N fertilizer. Precautions for using limed-sludge are: 1) apply material uniformly over pasture at recommended agronomic rate; 2) monitor the soil pH every 2-3 years; and 3) alternate limed-sludge use with inorganic N-fertilizer such as ammonium sulfate or nitrate in order to stay within the optimum pH range of 5.0 to 6.0.

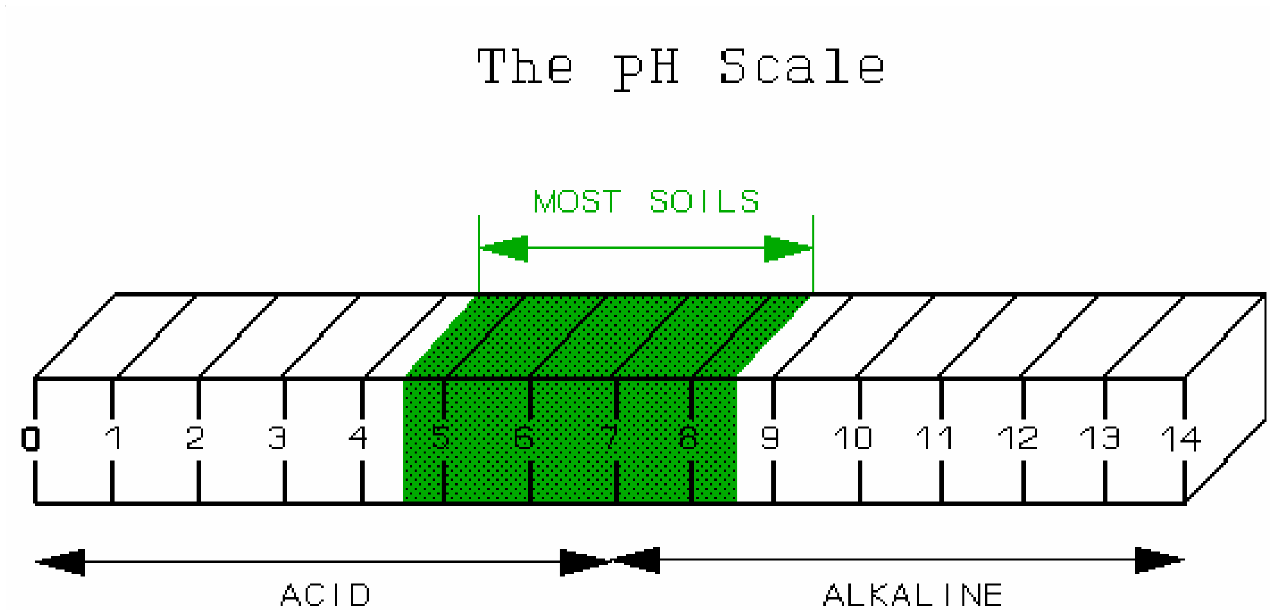


Figure 1. The normal range of soil pHs on an acidity-alkalinity scale.

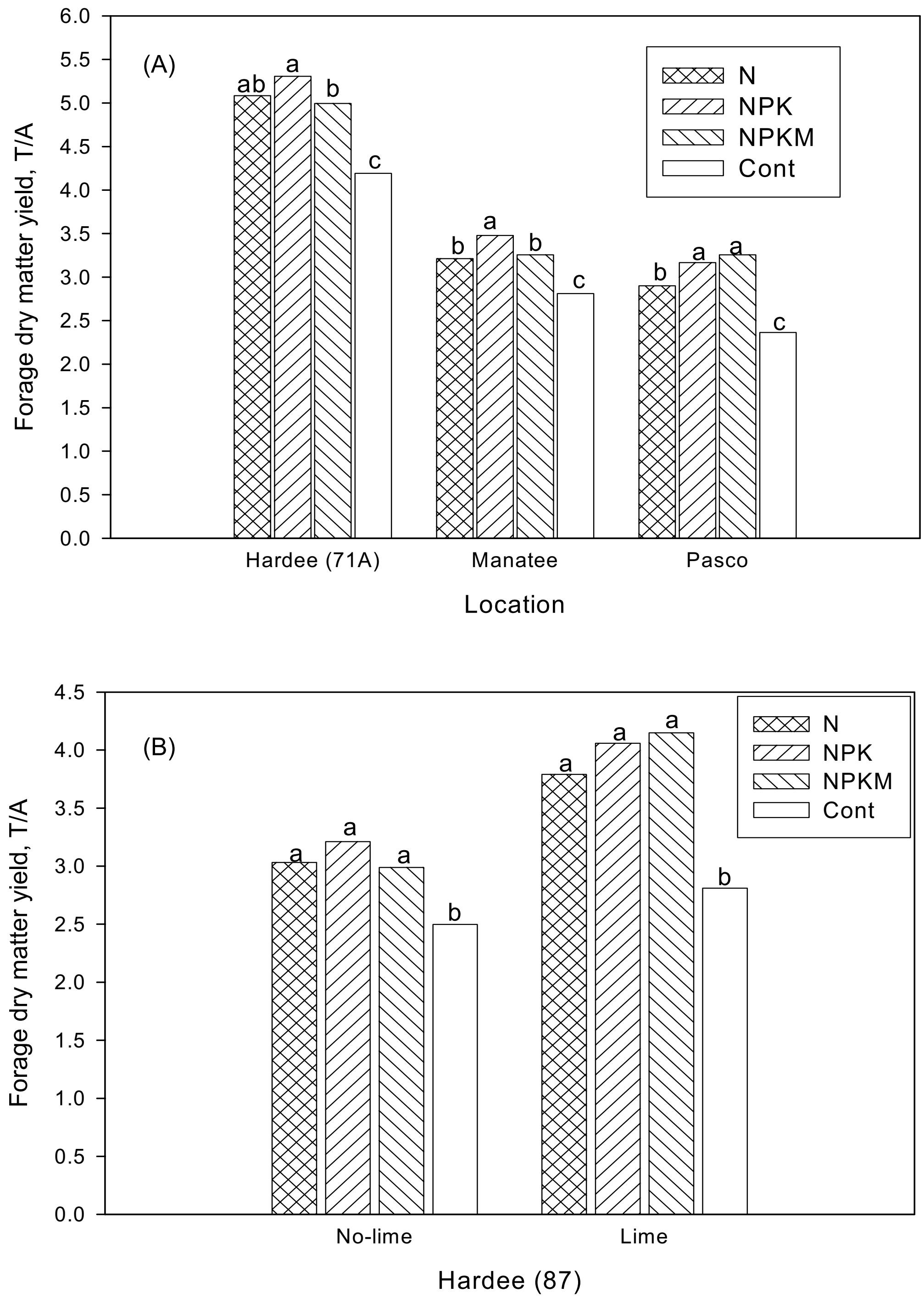
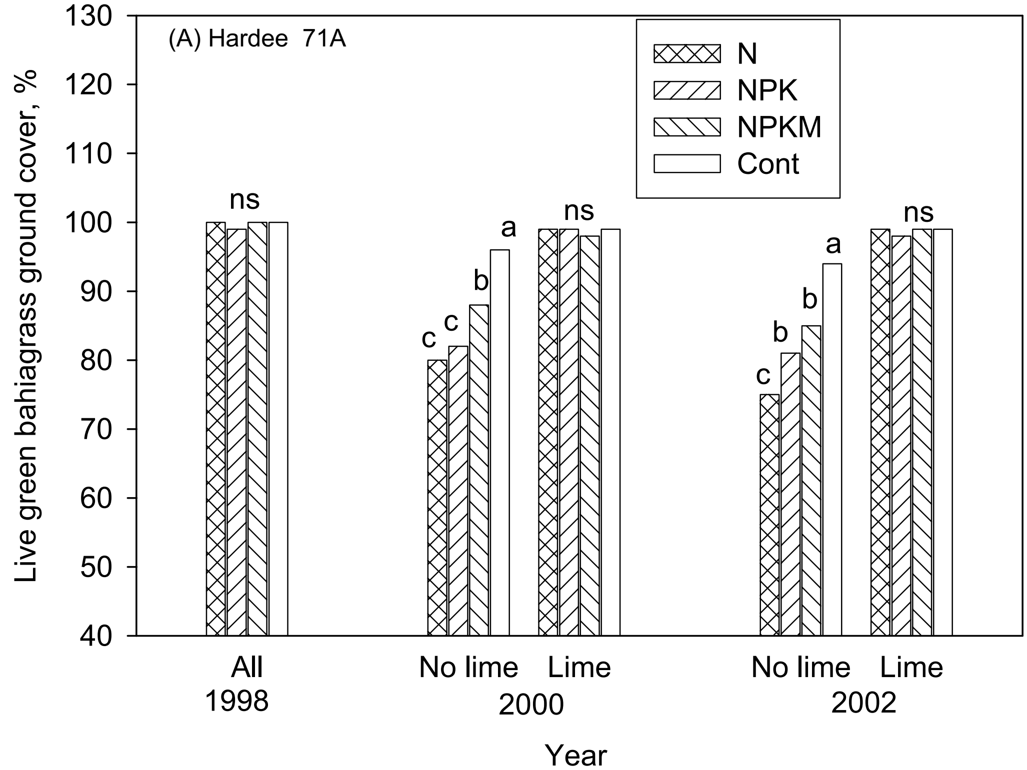


Figure 2. The effect of fertilizer and lime application on bahiagrass forage production in south central Florida. Bars represent three-year means for Manatee and Pasco sites and five-year means for Hardee sites. Bars with different superscripts differ P<0.05.



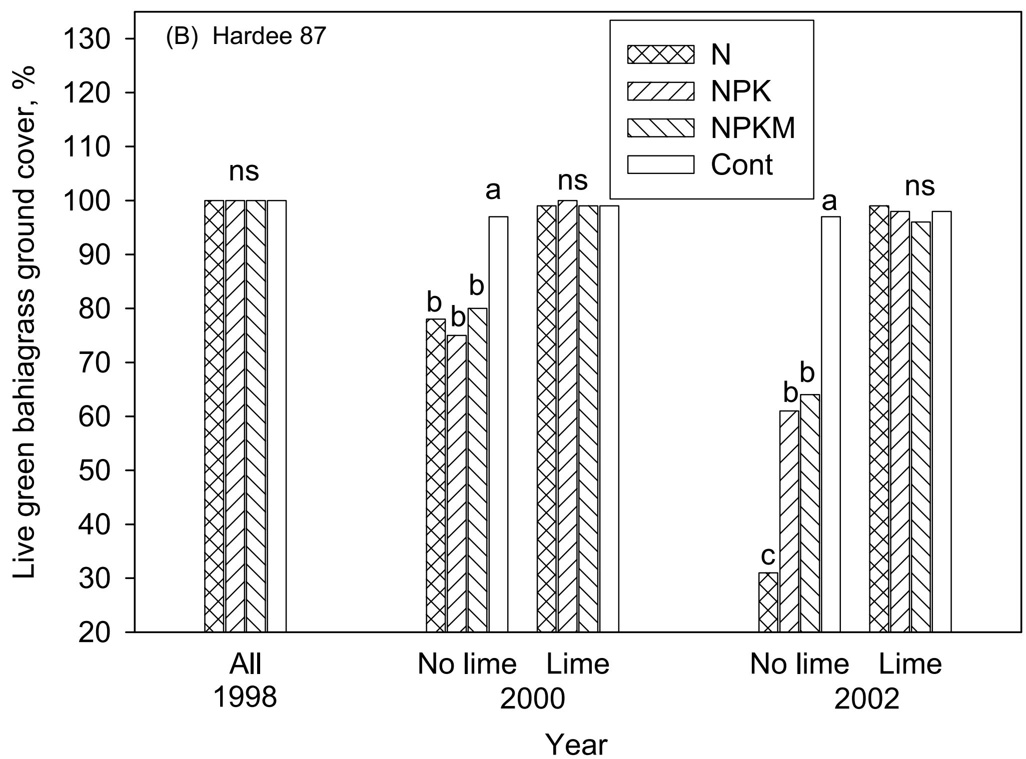


Figure 3. The interaction between fertilizer, lime, and year on percentage spring live, green bahiagrass ground cover (damage consisted of yellow, brown, or weedy cover). Bars with different superscripts differ P<0.05.

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