Solubility of Macrominerals from Tall Fescue Fertilized with Different Swine Manure Treatments and Harvested on Four Dates

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Story in Brief

Fertilization with animal manures provides numerous mineral nutrients to the desired crop. Our objective was to determine the impacts of fertilization with manure from different swine dietary or manure treatments on mineral solubility from tall fescue (*Festuca arundinacea* Schreb.) harvested at four growth stages. Manure from pigs fed a normal growing and finishing diet (NORM) or a diet with added phytase (0.03%; PHY) was collected. This manure was applied on March 14, 2003 to supply 113 lb N/acre to three of four experimental tall fescue pastures. The four pastures received either no swine manure (negative control; CONT), NORM, PHY, or PHY with the manure treated with aluminum chloride (0.75%) at application (PHY+AL). Dacron bags containing these forages were either rinsed directly or inserted in the rumen of five ruminally cannulated steers (1,208 lb BW) to determine water solubility and ruminal mineral solubility. Water-soluble phosphorus (P), calcium (Ca), and magnesium (Mg), and ruminally-soluble P, Ca, Mg, and sulfur (S) trends varied across growth stages with respect to the different fertility treatments. In general, water solubility of P and Mg was high (> 70%), while that of S was intermediate (46 to 70%) and that of Ca was low (19 to 36%). Ruminal solubility of P, Mg, and S were high (> 75%) in most instances and that of Ca was greater than 50% in most instances. Therefore, fertilization with different swine manure treatments did not alter forage mineral solubility in a consistent manner, and ruminal solubility is not a limiting factor in forage mineral utilization.

Introduction

With producers using animal manure as an inexpensive source of N fertilizer, phosphorus (P) levels in soil have become a major concern, because excess P may run off into streams and cause water quality problems. Manures are usually high in numerous minerals, thereby influencing those mineral concentrations in forages (McGinley et al., 2004). Pigs lack the enzyme phytase needed to break down phytate, the complex in which plants store P. Therefore, higher P levels are excreted in swine manure. Adding phytase to swine diets improves utilization of P from grain and reduces the amount of supplemental P required (Smith et al., 2004). The combination of phytase and reduced dietary P should lower excreted P, thereby reducing the amount of P applied with swine manure. Aluminum chloride binds chemically to P in manure and prevents it from being leached into the ground water. Our objective was to determine the impact of swine dietary or manure treatments on the solubility of minerals from tall fescue fertilized with swine manure and harvested on four dates.

Experimental Procedures

Growing swine were fed a normal growing diet or a diet with added phytase (0.03%). Manure was collected separately from pigs on each diet, analyzed for N and P content, and then applied on March 14, 2003 to supply 113 lb N/acre to three of four experimental 1-acre pastures of tall fescue with the Max Q™ endophyte. One pasture received no swine manure (CONT). Other pastures received: 1) normal swine manure (NORM); 2) manure from the pigs fed phytase (PHY); or 3) manure from the pigs fed phytase and treated with aluminum chloride (0.75%) at the time of application (PHY+AL). Fertilization to achieve the desired 113 lb N/acre resulted in 17.8, 9.8, and 9.0 lb P/acre being applied to NORM, PHY, and PHY+AL, respectively. Representative sites were selected randomly and protected from grazing with cattle panels formed into circles. Forage samples were clipped to a 1-in stubble height with hand shears on April 3, April 28, May 15, and June 23, 2003 to correspond to vegetative, boot, full bloom, and soft dough stages of maturity. On April 3, samples were gathered at multiple locations prior to initiation of grazing. Thereafter, samples were collected from one randomly-selected enclosure per pasture. Samples were dried in a forced-air oven (122°F) and ground to pass through a 2-mm screen.

Dacron bags containing forage from each combination of manure treatment and harvest date were either: 1) not inserted in the rumen (0-h); or 2) inserted into the rumen of five ruminally-cannulated steers (1,208 lb BW) maintained on a diet of alfalfa hay and concentrate. After a 96-h ruminal incubation, those and the 0-h bags were rinsed, dried, weighed, and the forage was then digested in concentrated nitric acid, and mineral concentrations were determined as described by Galdámez-Cabrera et al. (2004). Mineral disappearance data were analyzed by using PROC GLM of SAS (SAS Inst., Inc., Cary, N.C.). Effects of manure treatment, linear and quadratic effects of harvest date, and their interactions were included in the model. Linear and quadratic coefficients were estimated using the solutions option. Orthogonal contrasts were used to compare effects of: 1) CONT with the mean of NORM, PHY, and PHY+AL; 2) NORM with PHY; and 3) PHY with PHY+AL.

Results and Discussion

Minerals in the water-soluble forage fraction (0-h) represent those that are rapidly soluble and readily available to rumen microorganisms. The influence of fertility treatment on the water-soluble fractions of the macrominerals varied across harvest dates. Water-soluble P changed ($P < 0.05$) quadratically across harvest

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dates for PHY and PHY+AL, but not for CONT and NORM (Figure 1). Water-soluble Ca increased linearly ($P < 0.05$) across harvest dates for CONT and NORM, but not for PHY and PHY+AL (Figure 2). Water-soluble magnesium (Mg) increased quadratically ($P < 0.05$) across harvest dates for NORM, PHY, and PHY+AL, but not for CONT (Figure 3). Water-soluble potassium (K; data not shown) and sulfur (S; Figure 4) increased ($P < 0.05$) in a similar quadratic manner across harvest dates for all fertility treatments. Average water-soluble S across harvest dates was greater ($P < 0.05$) from CONT than the other treatments; from NORM compared with PHY, and from PHY compared with PHY+AL. Although, water-soluble K was lower ($P < 0.05$) for CONT than the other treatments, solubility of K was greater than 99% on all dates regardless of fertility.

The portion of minerals liberated from the forage after 96-h of ruminal incubation represents those minerals that are potentially available to the ruminant animal. The potentially available K fraction was greater than 99% across treatments and harvest dates (data not shown). The ruminally-soluble P fraction from PHY and PHY+AL decreased linearly ($P < 0.05$) across harvest dates, but that from CONT or NORM did not vary over harvest dates (Figure 5). This suggests that forages fertilized with manure from swine fed phytase or fed phytase treated with aluminum chloride may have reduced available P over time. The ruminally-soluble Ca fraction (Figure 6) decreased linearly ($P < 0.01$), whereas the ruminally-soluble Mg fraction (Figure 7) decreased quadratically ($P = 0.02$) across harvest dates from PHY+AL, but not from the other treatments. The ruminally-soluble S fraction declined quadratically ($P < 0.05$) across harvest dates from PHY and PHY+AL but only tended ($P < 0.10$) to decline quadratically from CONT and NORM (Figure 8).

These results are in agreement with those reported from bermudagrass in that the potentially available Ca fraction was lower than that of P, K, Mg, and S (Galdámez-Cabrera et al., 2004). However, the potentially available Mg fraction was slightly higher in this study than was reported for bermudagrass (Galdámez-Cabrera et al., 2004). On a practical basis, the addition of phytase to the diet had minimal effect on ruminal forage mineral solubility.

Implications

The impact of manure treatment on mineral solubility was not consistent across harvest dates. Therefore, relative changes in forage mineral solubility will depend upon the maturity at which the forage is harvested. In most instances, ruminal solubility of K, Mg, P and S was high (75 to 99%) and that of Ca was moderate (52 to 76%) indicating that ruminal solubility is not a limiting factor, generally, in mineral utilization by ruminants consuming tall fescue.

Literature Cited

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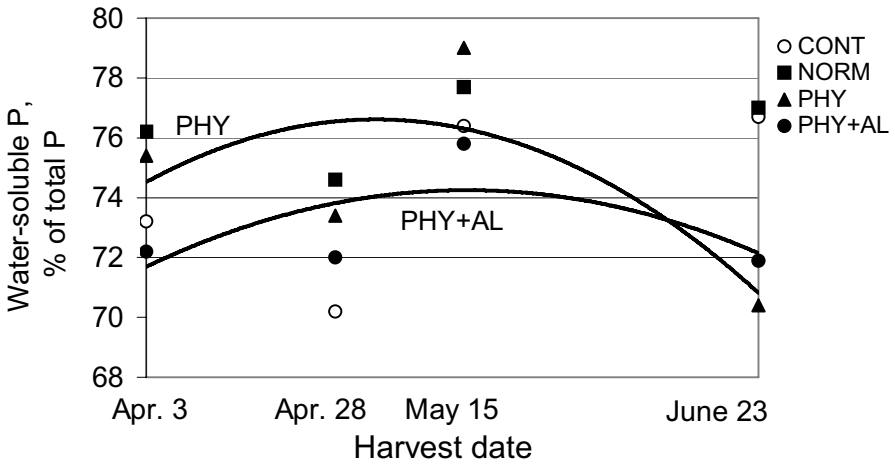

Fig. 1. Forage water-soluble phosphorus concentration (% of total phosphorus) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL).

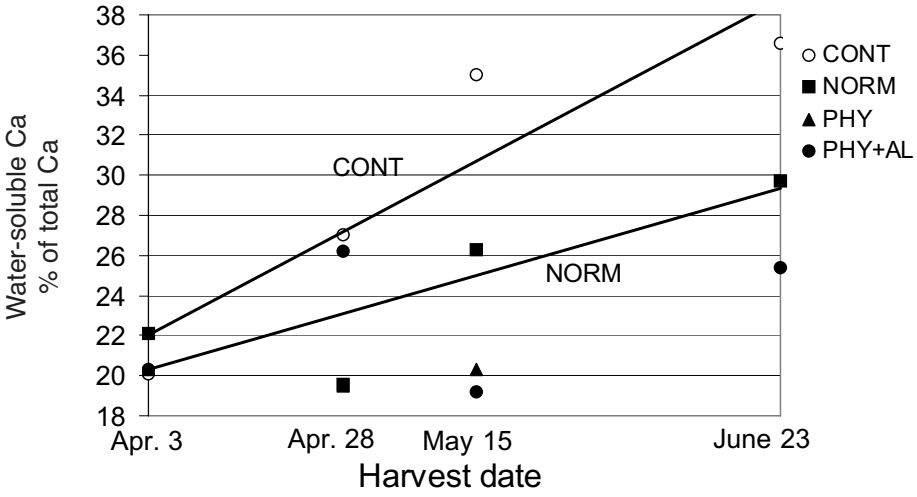

Fig. 2. Forage water-soluble calcium concentration (% of total calcium) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL).

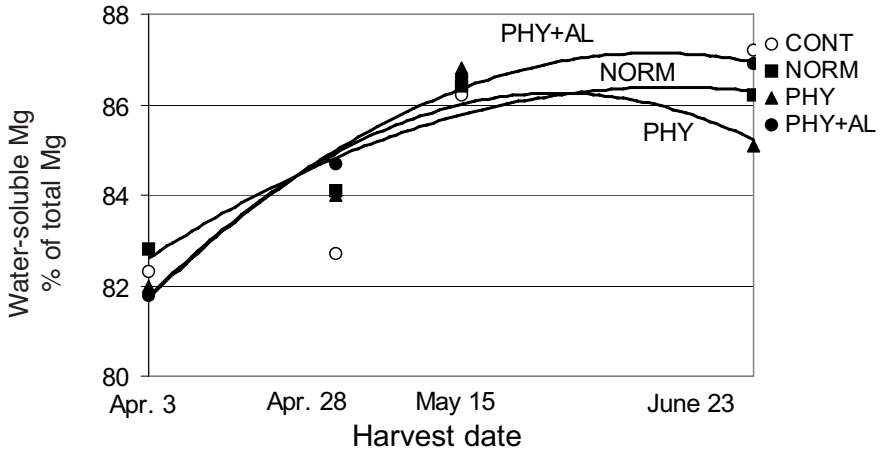

Fig. 3. Forage water-soluble magnesium concentration (% of total magnesium) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL).

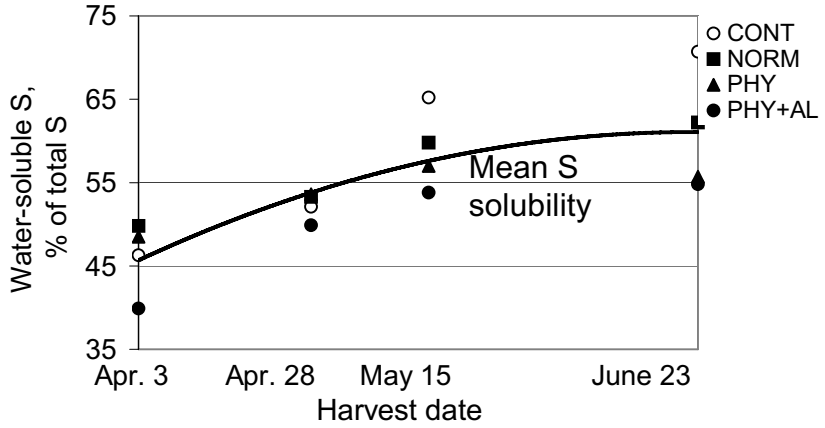

Fig. 4. Forage water-soluble sulfur concentration (% of total sulfur) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL). CONT differed from fertilized fescue, and NORM differed from PHY, and PHY differed from PHY+AL ($P < 0.05$).

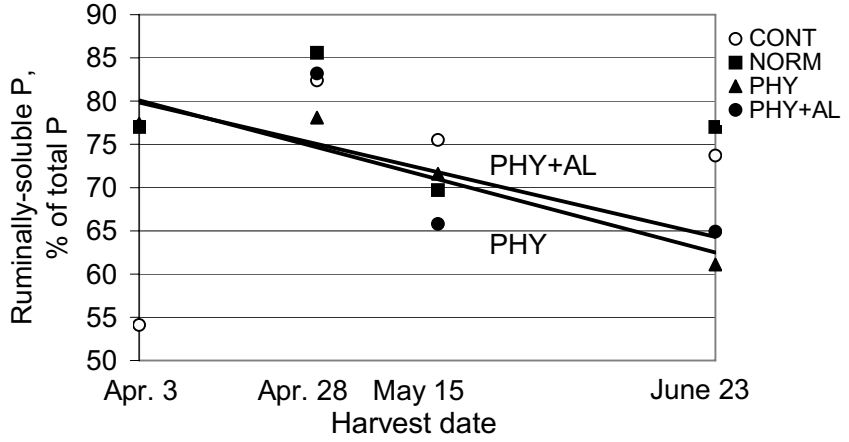

Fig. 5. Forage ruminally-soluble phosphorus concentration (% of total phosphorus) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL).

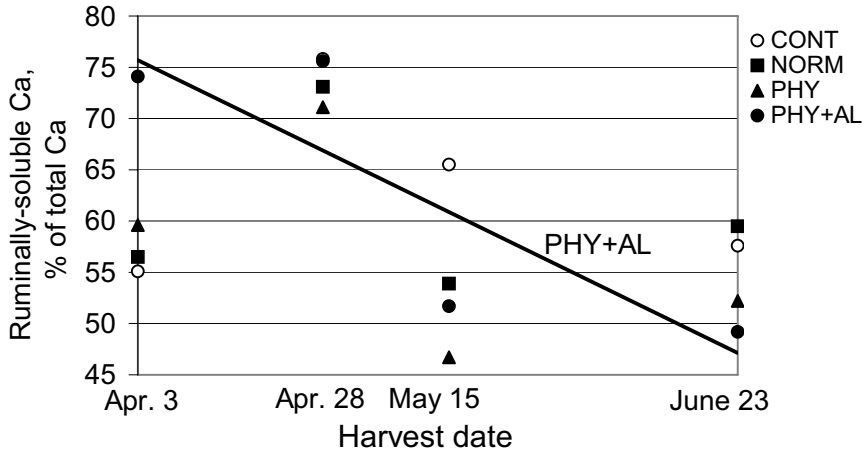

Fig. 6. Forage ruminally-soluble calcium concentration (% of total calcium) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL).

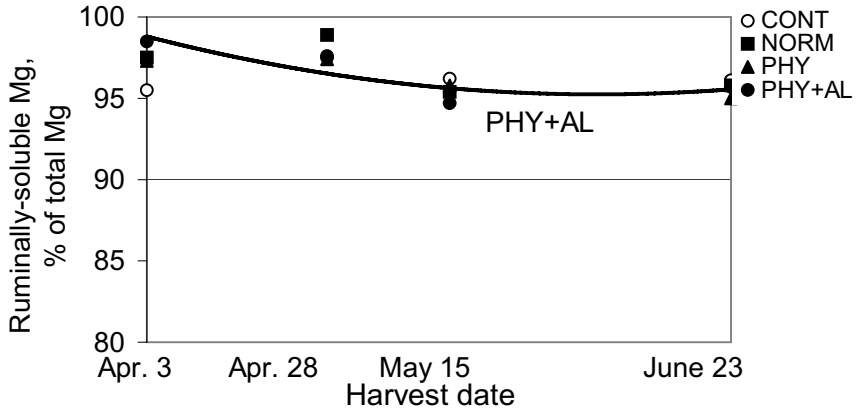

Fig. 7. Forage ruminally-soluble magnesium concentration (% of total magnesium) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL). CONT differed from fertilized fescue ($P < 0.05$).

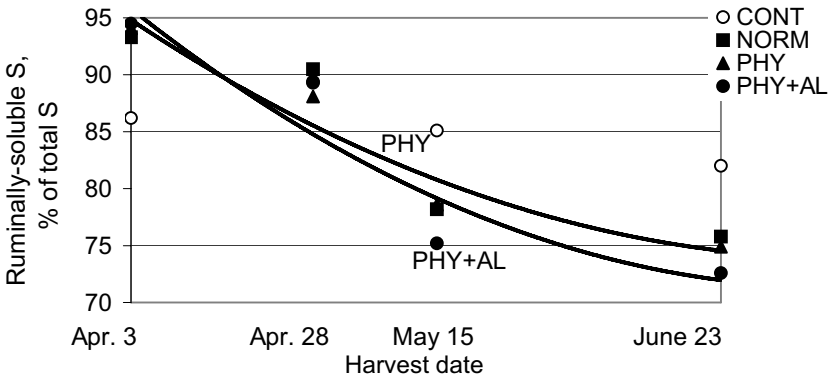

Fig. 8. Forage ruminally-soluble sulfur concentration (% of total sulfur) from unfertilized tall fescue (CONT) or tall fescue fertilized with swine manure from a normal finishing diet (NORM), a diet with phytase (PHY), or PHY with the manure treated with aluminum chloride (PHY+AL). CONT differed from fertilized fescue ($P < 0.05$).