A R K A N S A S

Decreasing Phosphorus Runoff from Poultry Litter with Aluminum Sulfate

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Many recent studies conducted at the University of Arkansas and across the nation have focused on identifying best management practices (BMPs) to alleviate the problems associated with excessive P build up in the soil. An effective practice identified in recent research involves the addition of aluminum sulfate (alum) to poultry litter.

> Poultry litter has long been recognized as a valuable nutrient source for crops and pastures. However, poultry litter has a fairly consistent nitrogen (N) to phosphorus (P) ratio of about 2:1. Since the recommended application rate is often based only on the N requirement of the crop, P may be applied in excess of crop demand, increasing the potential for off-site loss through runoff and erosion.

Arkansas Studies-Phosphorus Management

Previous studies conducted at the University of Arkansas have shown that when poultry litter is surface-applied to a pasture, 80 percent or more of the P in the runoff is in the dissolved or soluble form. Therefore, one way to reduce P in runoff would be to add a chemical amendment to the litter, converting the P to a less soluble form. It was shown in laboratory studies that the addition of alum to poultry litter is extremely effective in decreasing the solubility of P in poultry litter. Building on this information, a field study was initiated at the Main Agricultural Experiment Station of the University of Arkansas. Alum treated litter and normal (untreated) litter were applied at a rate of 5 tons/A to tall fescue plots. Two rainfall simulations, each at 2 inches per hour for 45 minutes, were then conducted (2, 6 and 9 days after litter application), and runoff samples from the plots were collected. Soluble reactive P concentrations in the runoff water were 87 percent lower from the alum-treated litter plots compared to the untreated litter plots for the first runoff event, and 63 percent less for the second. Total forage yields showed the greatest response to application of alum-treated litter. The yield response was most likely due to an increase in available N resulting from decreased ammonia (NH_3) volatilization from the alum-treated litter.

Additional research on runoff P from pastures was done on a field scale level at a commercial broiler farm in northwest Arkansas. Six commercial broiler houses are located on the farm; three houses were treated with alum at the end of each growout, and the other three houses were used as controls (received no chemical amendments). All six houses were managed as typical commercial broiler houses, with six growouts per year, each growout lasting approximately 6 weeks. At the farm site, two one-acre watersheds were built and instrumented with automatic water samplers in order to collect runoff that occurs from storm events. In 1995, each watershed received a 2.5 ton/A application of litter. In 1996 and 1997 the application rate was 4 tons/A. One watershed received litter from the poultry houses that had been treated with alum, and the other watershed received litter from the poultry houses used as controls. The poultry litter was applied in the spring of the year (April or May) as is the typical practice in northwest Arkansas. The forage produced on the watersheds was either harvested as hay or mowed and left on the surface. The watersheds were not grazed.

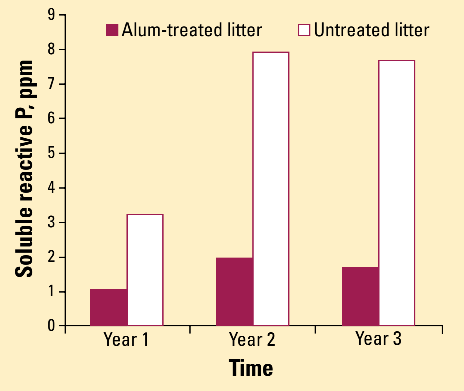

Figure 1. Soluble reactive P concentrations in run-off from each watershed.

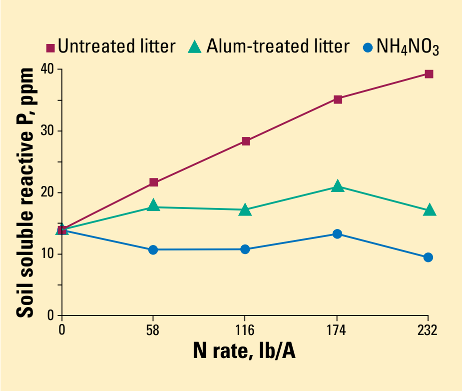

Figure 2. Soil soluble reactive P concentrations, June 1997.

Figure 1 shows the soluble reactive P concentrations in parts per million (ppm) in runoff samples from each watershed. The data in this graph represent all runoff events for the year averaged together to calculate the mean concentration value. Soluble reactive P concentrations in the runoff from the watershed treated with alum-amended litter remained consistently low each year and were much lower than the runoff from the watershed treated with untreated litter. The runoff samples were also analyzed to determine runoff aluminum (Al) concentrations. There were no differences in Al concentrations in runoff between the watershed receiving alum-treated litter and the watershed receiving untreated litter.

Although these studies concluded that alum is extremely effective in reducing the amount of P in runoff, there was still a question about its effects on soil test P levels. To address this question, an additional small plot study was conducted at the Main Agricultural Experiment Station of the University of Arkansas. The study used 52 tall fescue plots where 13 different treatments were applied. There were four replications of each treatment. The 13 treatments were: untreated litter and alum-treated litter (10 percent alum by weight) at application rates of 1, 2, 3, and 4 tons/A; ammonium nitrate (NH_4NO_3) at 58, 116, 174, and 232 lb N/A; and an unfertilized control. The NH_4NO_3 rates were equivalent to the rates of N applied with alum-treated litter. Each treatment was applied in the spring of the year for 3 years. Soil cores (0 to 2 in.) were taken periodically throughout the study and extracted for water soluble P. **Figure 2** shows the results from June 1997, after 3 years of litter and fertilizer treatment applications. Water soluble soil P levels in all plots treated with alum-treated litter, regardless of the application rate, were not significantly different than soil P levels in the unfertilized control plots. Plots that received the untreated poultry litter had the highest soil test P levels, and these levels increased as the application rate of the litter increased. Plots treated with the NH_4NO_3 had the lowest soil test P values.

Additional Benefits

Other studies have shown that P is not the only nutrient reduced in runoff when poultry litter is treated with alum. Runoff studies at the University of Arkansas have demonstated that copper (Cu) and zinc (Zn) concentrations in runoff from plots treated with poultry litter can be high enough to cause potential problems. In a study that compared metal concentrations in runoff between plots receiving untreated litter and alum-treated litter, it was determined that alum can reduce the concentrations of arsenic (As), Cu, iron (Fe), and Zn. This is an additional environmental benefit, since these trace metals can cause problems in aquatic environments.

The practice of treating poultry litter with alum is environmentally beneficial. It can also mean increased profits for poultry producers.

Alum spread on litter in poultry houses offers several benefits.

Ammonia volatilization results in high levels of NH_3 gas in the atmosphere of poultry houses, which can be harmful to the health of birds and farm workers.

In order to test the effects of adding alum to poultry houses to reduce NH_3 volatilization, two broiler farms were chosen...one had six houses, the other four houses. The litter in all of the houses was removed at the beginning of the study and replaced with fresh wood shavings. After each growout, the litter was de-caked using a commercial de-caking machine, and alum was applied in half of the houses on each farm. The other houses were controls. The rate of alum used was 4,000 lb/house after each growout.

Reductions in litter pH decreased NH_3 volatilization from the litter, which resulted in significant reductions in atmospheric NH_3 in the alum-treated houses compared to control houses. Ammonia fluxes were reduced 99 percent by alum for the first four weeks of the growout. These lower NH_3 levels resulted in significantly heavier birds in houses treated with alum than the controls (3.65 lb for control birds and 3.80 lb for birds grown on alum-treated litter). Mortality tended to be lower (3.9 vs. 4.2 percent), and feed conversion (1.98 vs. 2.04) was better for birds grown on alum-treated litter compared to controls. Energy usage was also lower, with propane use approximately 11 percent lower and electricity use 13 percent lower for the houses treated with alum. Tabulating all the savings listed above by using alum, the total benefit to the grower and integrator would be approximately $940.00 per house per growout. The cost of using alum, including the application and incorporation, is approximately $480.00 per house per growout. Therefore, the benefit /cost ratio of this practice is 1.96, indicating that it is very cost-effective.

Summary

Applying alum to litter is a relatively simple and cost effective way to help alleviate environmental concerns associated with the use of poultry litter as a fertilizer. Alum treatment resulted in an 80 percent reduction in mass loss of P from the site in the first year. It is effective at reducing P and trace metal concentrations in runoff from fields where poultry litter has been applied. The use of alum-treated litter also results in lower soil test P values compared to untreated poultry litter. Alum additions during the growout process also greatly reduces NH_3 volatilization, resulting in an economic benefit to the producer. BC

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