UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE
Cooperative Extension Service

Agriculture and Natural Resources

Soil Testing for Manure Management

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Introduction

Many livestock operations in Arkansas use nutrient-rich animal manure as fertilizer on pastures. Soil testing is a useful tool for determining animal waste application rates and sustaining profitable forage production. Soil test phosphorus (STP) levels on pastures have become a serious issue for livestock producers who use animal manure as fertilizer.

The University of Arkansas offers free soil testing services. Soil samples can be submitted through the local county Extension office. Lab results and recommendations are mailed to the user. Proper sampling is critical to ensure results that accurately characterize the plant nutrient status of the soil being tested. Step-by-step recommendations for soil sampling pastures amended with animal manures are listed in Table 1.

Table 1. Recommendations for Collecting Soil Samples From Pastures Amended with Animal Manures

1. Determine representative sampling areas that are uniform in soil and previous management history. Individual pastures make good representative areas if the above uniformity conditions are reasonably met.

2. If a representative area has been determined, proceed to Step 3. If a representative area has not been determined, refer to the section entitled “Defining Multiple Sampling Areas Within Pastures.”

3. Use a random zigzag pattern (Figure 1) to collect 15 to 20 individual 6-inch deep subsamples for an area up to 20 acres and 20 to 25 individual subsamples for an area greater than 20 acres. Avoid locations such as livestock feeding and loafing areas if these areas comprise less than 10 percent of the total sampling area. If using a shovel, avoid a wedge-shaped soil sample volume (Figure 3).

4. Combine individual subsamples in a bucket and mix thoroughly to form a sample that represents the entire area. Remove enough of the sample to completely fill the soil sample box (about a pint). Remove any plant debris and rocks before placing in box.

5. Repeat steps 3 and 4 for a given sampling area at least every three years during the same time of year.

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Soil Test Recommendations

Soil testing is the most reliable method for determining amounts of soil nutrients that are readily available for plant growth. Soil test procedures use chemicals to extract nutrients from soil samples. Different extractants vary in their ability to remove nutrients and will produce different soil test results. Soil test results from different labs cannot be compared unless the same extraction method and identical analytical procedures are used.

Extractants do not perfectly mimic the plant's ability to remove nutrients from the soil. To overcome this, soil test results are correlated to crop yield through field research. Fertilizer recommendations are subsequently developed based on crop response.

Research is continuously conducted to ensure that the best possible recommendations are made. Check with your county agent regarding questions about recommendations.

The University of Arkansas Soil Test Lab uses the Mehlich III universal extractant and a quality assurance program to ensure that errors due to laboratory analysis are minimized. A check sample is analyzed every 12 samples to detect equipment error. Even if an error is not detected, the equipment is automatically recalibrated before each batch of 96 samples.

Soil Testing for Manure Management

The Natural Resource Conservation Service (NRCS) uses soil test results in developing nutrient management plans for confined animal operations that use animal manure as a fertilizer. The objective of nutrient management planning is to make the best use of available fertilizer and land resources for crop and forage production while minimizing any damage to the environment.

Under Arkansas State Regulation 5, all liquid waste permit holders are required to obtain state-approved nutrient management plans that include soil test information. Many poultry and swine integrators require their producers to obtain state-approved nutrient management plans, and all livestock producers are encouraged to voluntarily obtain and use nutrient management plans.

Soil Testing and Environmental Quality

Recent research indicates that STP can be a reasonable predictor of the dissolved phosphorus concentration in runoff waters to streams and lakes. Phosphorus is generally considered the limiting nutrient in eutrophication in most fresh, clearwater streams and lakes. Very small increases in phosphorus levels can result in excessive algae growth in waterbodies.

Historically, recommended animal-manure application rates have been based on nitrogen content of the manure because nitrogen provides the greatest crop response. The phosphorus and nitrogen content of many animal manures are relatively similar. Unfortunately, applying enough animal waste to meet crop nitrogen needs results in applying four to five times the crop phosphorus needs. Repeated, long-term animal-manure applications based on nitrogen can lead to elevated STP levels.

Many states have proposed basing animal-manure application rates on phosphorus rather than nitrogen. The general concept is to apply animal waste at rates that do not exceed crop requirements for phosphorus as determined by soil test recommendations. Phosphorus based application rates imply 1) that crop nitrogen requirements will not be met and supplemental nitrogen fertilizers will be needed to maintain forage production and 2) more land will be needed to use the same amount of manure as compared to nitrogen-based rates.

Another proposed strategy promotes the use of STP threshold for governing animal-manure applications to pasture. For instance, in 1998 the Oklahoma Legislature passed new emergency regulations that set STP thresholds. When the STP level exceeds the threshold value, no additional phosphorus either through animal manure or commercial fertilizer is allowed under state law.

Others have proposed the use of vulnerability assessments to determine land suitability for receiving waste. One such concept is P-Indexing. In this approach, many factors associated with phosphorus, including STP, are used in a matrix format to determine the relative vulnerability of phosphorus leaving a field or pasture. A considerable amount of research is being conducted nationally to further develop the concept of phosphorus indexing.

Soil test phosphorus is a key consideration for any of these proposed strategies. Collecting representative soil samples to ensure accurate results is critical in light of these proposed environmental protection strategies.

Recommendations for Collecting Soil Samples

The first step in soil testing is to collect a representative sample from a defined sampling area. **Sampling procedures can influence the accuracy of results more than any other step of soil testing.** The objective is to obtain a small sample of soil that accurately describes the entire area that it represents. This can be difficult due to the fact that soil nutrient levels can vary across a given area. Variability naturally occurs but can be increased by agricultural practices, such as grazing, fertilizing, liming and the land application of animal wastes.

To obtain an accurate sample, follow the recommendations in Table 1. The logic behind these recommendations is explained in the following sections.

Defining a Sampling Area

To reduce variability, a sampling area should be chosen that is relatively uniform in soil and management properties. Select and separate fenced areas, hillsides, creek bottoms or other well-defined features for accurate and representative soil sampling.

Individual pastures should be further subdivided if more than one soil type exists or the pasture has been managed differently on greater than 25 percent of the area. Differences in soil types can be detected by either using the NRCS county soil survey report or by delineating observed differences in soil properties, such as color, texture and slope.

If differences in management or soil properties are known or suspected to exist, then refer to the section entitled “Defining Multiple Sampling Areas within a Pasture” for instructions on how to further subdivide the area.

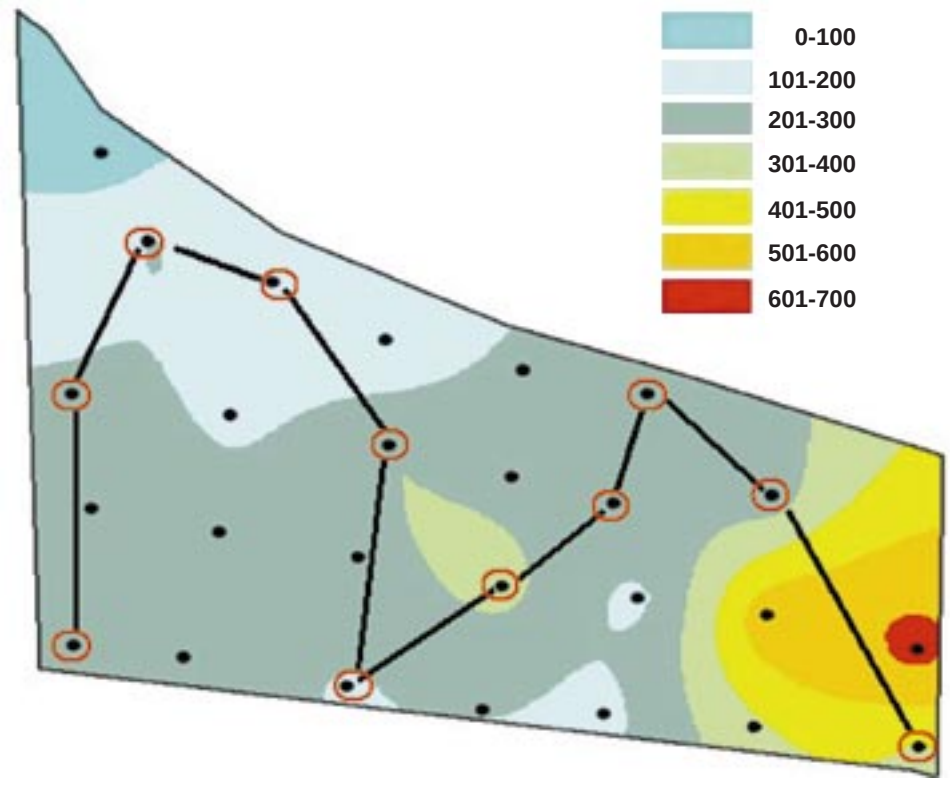

Figure 1. Soil phosphorus map for a 6-acre pasture developed from 26 separate samples taken at grid points (●). Black line indicates zigzag pattern where grid points encircled in red were composited into one sample to represent the entire field.

Sampling Pattern

The zigzag pattern (Figure 1) was chosen because it provides the most representative sample with fewest number of individual subsamples. For example, the average STP of all individual samples in Figure 1 is 265 pounds per acre compared to 257 pounds per acre for the zigzag pattern.

Other zigzag patterns may produce different results, but generally these differences are not large enough to affect the resulting recommendation. However, any sampling pattern can include individual locations with high or low soil test values. These can bias a sample, particularly if only a few locations are sampled.

Adjusting for Extreme High or Low Values

Individual samples from each grid location in Figure 1 were analyzed separately so that the distribution of STP levels across the pasture could be shown on a map. Soil test results reflect how the pasture has been managed over years of use. The area greater than 500 pounds per acre STP next to the eastern boundary is where cattle had been fed for many years because it was the only dry location during most winters. The area less than 100 pounds per acre in the extreme northwest corner is usually too wet for the litter spreader truck and had not received as much phosphorus as other parts of the field.

Both of these areas represent less than 5 percent of the field. However, because their STP results represent extreme high or low values as compared to the rest of the pasture, subsamples collected from these areas can influence the STP value that represents the entire sampling area.

For example, including subsamples from locations within the area greater than 500 pounds per acre results in a value of 306 pounds per acre while the same zigzag pattern that excludes these values results in a value of 244 pounds per acre. Although this difference is relatively small, inclusion of the high areas resulted in a STP value that exceeds a potential threshold of 300 pounds per acre.

Exclude known livestock feeding or loafing areas near gates from the zigzag pattern if this area represents less than 10 percent of the total sampling area. When areas like this are sampled accidentally in a zigzag pattern, they can bias the results towards the extreme value.

Following recommendations regarding the number of samples reduces the influence of any one sample location with high or low values As the number of individual subsamples decreases, the more severely an extreme high or low value will bias the result if included in the sampling pattern.

Defining Multiple Sampling Areas Within a Pasture

Although a zigzag pattern generally produces a representative sample, it does not identify differences in soil test results within a sampling area. If you suspect that an area of pasture has higher or lower STP values compared to the remainder of the pasture, it may be best to sample it separately. Use grid soil sampling where separate samples from each grid point are collected and tested separately (Figure 1). It is necessary to do grid sampling only once to show obvious differences that help subdivide the field into more uniform sampling areas. Apply the zigzag pattern separately to each newly defined sampling area.

Sample Depth and Size

The depth of sampling can significantly affect soil test results. The University of Arkansas bases its fertilizer and lime recommendations on a 6-inch deep sample. Six inches represents a large portion of the active root zone and average tillage depth. This depth refers to the mineral portion of the soil. Remove all surface litter such as thatch and other plant material from top of the soil surface before obtaining the sample.

Sampling depths of less than 6 inches is less critical where tillage operations have mixed the top 6 inches. But for typical pasture situations where tillage has not occurred, nutrient stratification can occur in the top 6 inches, especially for phosphorus (Figure 2). Phosphorus applied to the surface of pastures tends to be adsorbed by soil particles at the surface. However, when adsorption sites become saturated, phosphorus will move deeper into the soil profile until unoccupied adsorption sites are encountered.

Because of phosphorus stratification, samples collected from less than 6 inches can over estimate the phosphorus content as compared to a 6-inch sample (Figure 2). For the soil sampled in Figure 1, sampling depth influenced the results when the 6-inch sample was less than 300 pounds per acre. When the 6-inch sample was above 300 pounds per acre, the 2-inch sample was not different from the 6-inch sample.

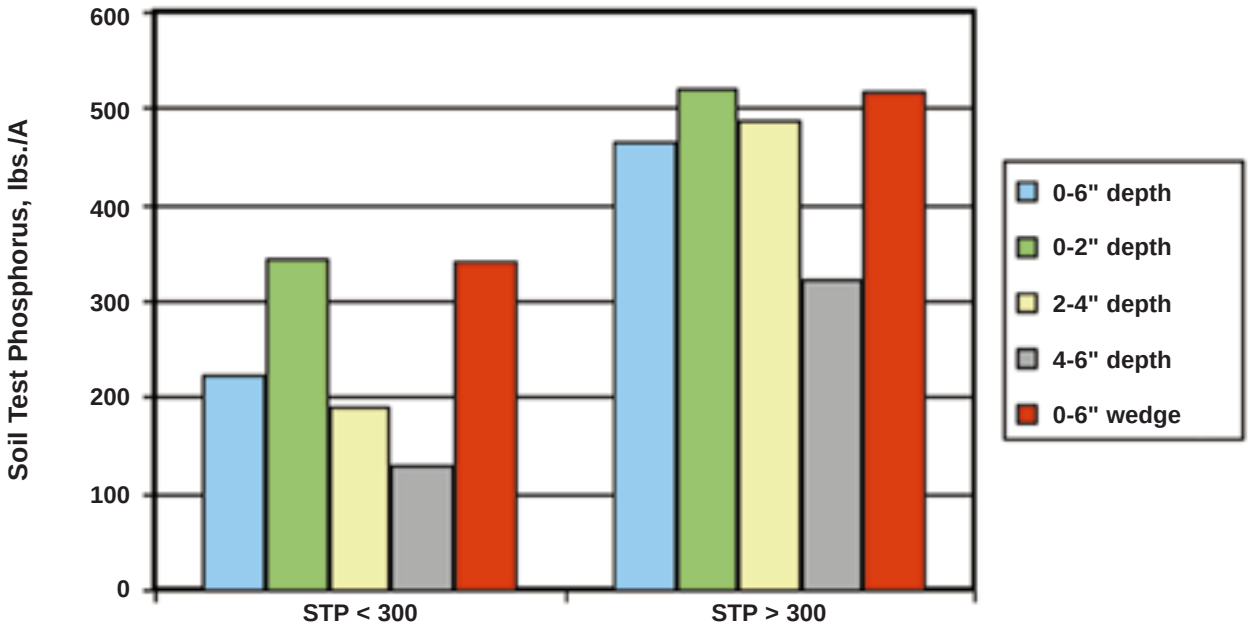

Figure 2. Distribution of soil phosphorus with depth as compared to a 6-inch sample collected with a cylindrical soil sampler and a 6-inch sample collected in a wedge shape with a shovel. STP <300 represents the average of samples whose 6-inch sample (collected with cylindrical soil sampler) was less than 300 pounds per acre soil test phosphorus. STP >300 represents the average of samples whose 6-inch sample was greater than 300 pounds per acre sol test phosphorous.

For this particular soil, phosphorus applications over the years had exceeded the phosphorus adsorption capacity in the top 2 inches allowing phosphorus to move deeper in the soil. It should be noted that phosphorus adsorption capacities vary with different soil textures. For example, sandy-textured soils adsorb much less phosphorus than more clayey soils.

The manner in which a 6-inch sample is collected can affect results if a uniform volume of soil is not collected through the sample depth. A cylindrical soil sampling tube collects a uniform volume of soil with depth.

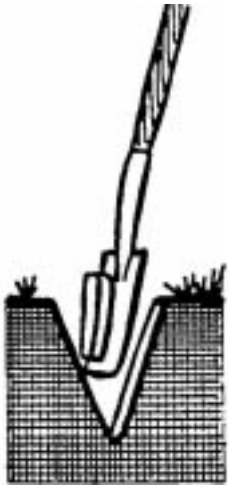

Figure 3. Illustration of wedge-shaped soil sample volume created with a shovel.

The use of a shovel can create a wedge-shaped sample (Figure 3) that can bias the results toward a 2-inch sample (Figure 2). In soils with stratified P levels, wedge-shaped samples taken with a shovel had P levels closer to the 2-inch sample than the full 6-inch sample. To avoid this effect when using a shovel, dig in a cylindrical fashion or use posthole diggers.

Sample Time

The time of year that a sample is taken affects the mobile nutrients (nitrate and sulfate) more than the less mobile nutrients (P and K). However, results can vary with seasons in row crop situations. Less is known about seasonal variability in pastures. To reduce seasonal differences, samples should be taken from the same sampling area during the same time of year at least every two to three years.

Other factors related to time of year such as weather and rainfall can affect how easy it is to collect samples. In rainy periods, soils can be water logged and difficult to sample while during summer months, soils can be hard to sample to 6-inches due to dry conditions.

Summary

Following proper sampling procedures will increase the reliability of the laboratory's results and, in turn, increase the value of the resulting recommendations. Sampling procedures are important due to newly proposed environmental strategies. For more information, contact your local county Extension office. Refer to fact sheets FSA1029, *Soil Phosphorus Levels: Concerns and Recommendations*, and FSA2144, *Managing Soil Phosphorus Levels in Pasture Soils*, for more information about soil phosphorus management and water quality.

References

Chapman, S. L. 1973. *Effect of Poultry Litter on Soils*. University of Arkansas Cooperative Extension Service Information Article 9-73.

Daniels, M.B., T.C. Daniel, D. Carman, R. Morgan, J.L. Langston and K. VanDevender. 1999. *Soil Phosphorus Levels: Concerns and Recommendations*. University of Arkansas Cooperative Extension Service Publication FSA1029.

Hodges, Steven C., and Dan Kirkland. 1991. "Pastures and Forages." *In* Soil Sampling Procedures for the Southern Region of the United States (Thom and Sabbe, eds.). Southern Cooperative Series, Bulletin No. 377, pp. 25-28.

Pote, D.H., T.C. Daniel, A.N. Sharpley, P.A. Moore, Jr., D.R. Edwards and D.J. Nichols. "Relating Extractable Soil Phosphorus to Phosphorus Losses in Runoff." *In* the Soil Science Society of America Journal, Vol. 60, No. 3, May-June 1996, pp. 855-859.

Rieck, A., K. VanDevender and J. Langston. 1993. *Regulation No. 5 – Liquid Animal Waste Management Systems.* University of Arkansas Cooperative Extension Service Publication FSA3004.

Sabbe, W. 1994. "Practical Aspects of Soil Sampling." *In* Soil Sampling Procedures for the Southern Region of the United States (Thom and Sabbe, eds.). Southern Cooperative Series, Bulletin No. 377, pp. 9-10.

Sandage, L.J. 1996. *Managing Soil Phosphorus Levels in Pasture Soils.* University of Arkansas Cooperative Extension Service Publication FSA2144.

Sharpley, A., T.C. Daniel, J.T. Sims and D.H. Pote. "Determining environmentally sound soil phosphorus levels." *In* Journal of Soil and Water Conservation, Volume 51, Number 2, March-April 1996, pp. 160-166.

Sims, J.T. "Environmental Soil Testing for Phosphorus." *In* the Journal of Production Agriculture, Vol. 6, No. 4, Oct-Dec 1993.

Snyder, C. S. and S. L. Chapman. 1994. *Test Your Soil for Plant Food and Lime Needs*. University of Arkansas Cooperative Extension Service Publication FSA2121.

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