SOIL TESTING ON IRRIGATED PASTURES

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INTRODUCTION

Pastures of perennial forage grasses and legumes can be largely sustainable with only limited inputs of fertilizer, since the only nutrients exported are in the body composition of the grazing animals when good management is utilized. However, some nutrients need to be replenished, especially nitrogen (N), when pastures are mostly composed of grasses. When properly managed, pastures will respond to fertilization and produce large quantities of high-quality forage and livestock products. For example, grass forage production may be increased from 35 to 80 pounds dry matter per acre for every 1 pound of nitrogen applied. Generally, balanced plant nutrition will provide a balanced diet to the animals.

Irrigated pastures in southern Idaho are composed of primarily grasses or grass-legume mixtures. The plant composition of the pasture can be changed by fertilizer management and grazing method. Continuous grazing will reduce sensitive plants -- generally the more palatable plants -- and promote resistant plants, whereas rotational grazing allows the palatable, more desirable plants to persist. The purpose of this publication is to describe a strategy for soil sampling pastures to assist in developing sustainable nutrient management to ensure a long-lived, high producing irrigated pasture. The rates in this publication are recommendations, and when combined with careful soil sampling can ensure a high quality pasture. The following guidelines are based on University of Idaho research results, experience, and relationships between soil test and yield responses.

NUTRIENT DISTRIBUTION AND CYCLING IN GRAZED PASTURES

Pastures have different fertilization requirements than, say, crops or lawns. For one thing, grazing livestock actually return most of the nutrients to the pasture. Grazing livestock return as much as 85 to 95% of the plant nutrients (nitrogen (N), phosphorus (P), potassium (K), and others) consumed back into the pasture system as urine and dung. However, these nutrients are not distributed uniformly, but are concentrated next to water sources, shade, bedding areas and trails. Concentrations of phosphorus and potassium within 30 feet of water sources have been reported to be 5 times greater than other areas of the pasture after 4 or 5 grazing seasons. In fact, when grazing activity is managed in a similar pattern for more than 20 years, phosphorus and potassium concentrations can be increased up to 100 feet away from the water source. Grazing management that uses a high stocking rate--many animals on a small area of the pasture--and movement of portable fence, water, and shade will improve nutrient distribution.

Another issue to consider is nutrient cycling. Nutrient levels do not remain constant throughout the year, but are continually cycling among atmosphere, soil, plant, and animal nutrient pools (Figure 1). Plants shed leaves and slough roots, and animals produce dung and urine. These are broken down by physical, chemical, and biological processes to ionic or mineral forms such as calcium, nitrate, and sulfate through a process called mineralization. The mineralized nutrients are taken up by plant roots for new plant growth or may be converted into organic matter by the soil microbes, through a process called immobilization. Some nutrients such as nitrate are highly water soluble and can be leached from the soil by water flow to the groundwater. Some nitrogen is also lost through volatilization to the atmosphere.

These two issues – nutrient distribution and nutrient cycling – affect when and where you should take your soil samples for testing.

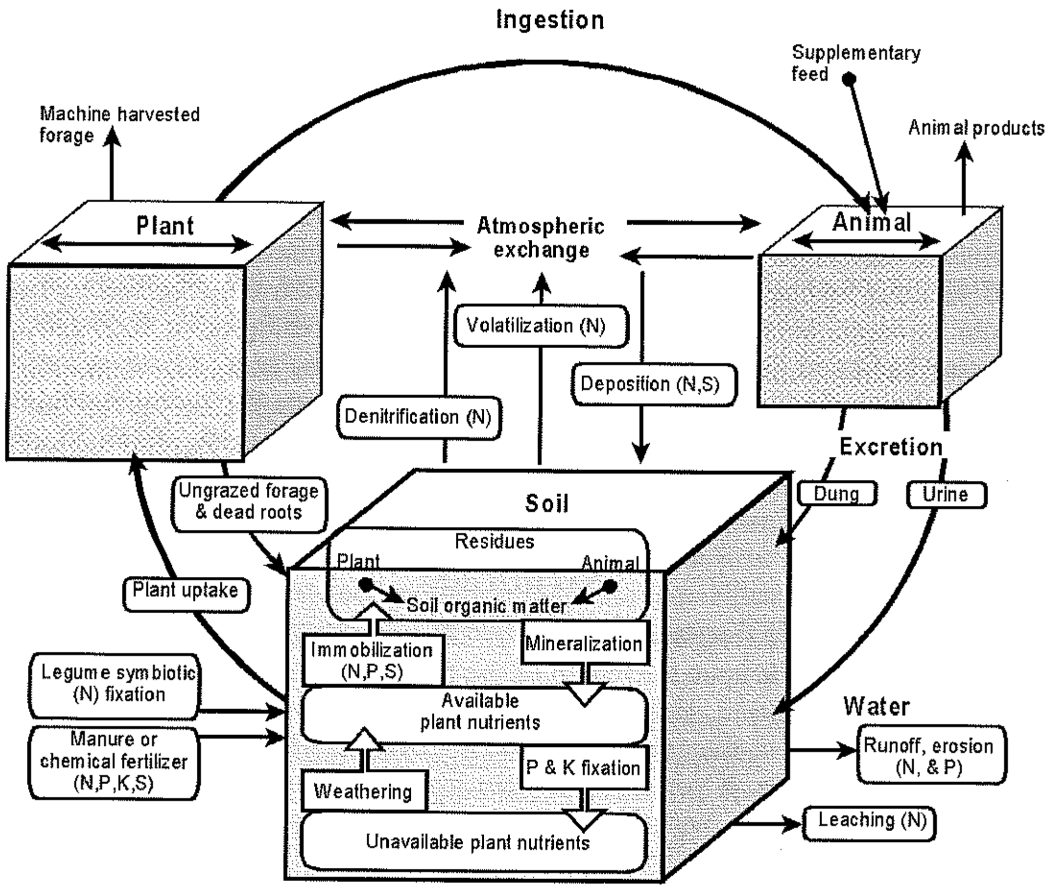

Figure 1. The nutrient cycle.

SOIL TESTING IN PASTURES

First, divide up your pasture into "zones" to account for manure concentrations, and test each zone separately, so that nutrients can be applied only at the rate needed and in areas where they are needed according to the soil test. Thus soil samples from around watering and shade areas should be taken separately from the remaining area of the pasture. Keep in mind that soil test results may include fertilizer recommendations based on assumptions made by the lab. The recommendations may be higher than necessary for grazing forage production because they may not take into account the recycling of nutrients by the grazing animals.

Soil tests should be taken on nearly the same calendar date, to account for the fact that nutrient levels naturally fluctuate due to cycling. Early spring is an ideal time for soil testing, because appropriate nutrients can then be applied at the beginning of the growing season. However, it is more important to be consistent about the time of year of soil testing – whichever time you choose.

Keep in mind that a plant available N, ammonium and nitrate soil test is generally not as useful for perennial forage crops and pasture as for annual crops. The primary reason is that most of the N released from organic matter over the growing season is used rapidly by grasses, so little nitrate accumulates in the soil. Also, available N is mobile in soils and can be leached beyond the root zone with spring precipitation or over-irrigation. Therefore, in addition to looking at the soil test results, producers should also evaluate fertilization needs based on their observations of forage productivity, as well as nutrient cycling in their paddocks. For example, if you see many persistent cow pies, this means the nutrients in the manure are not getting quickly into the soil, and perhaps a bit more nitrogen is needed.

Fertilization is most effective when previous fertilization rates and several years of soil sample results are taken into account. This enables the pasture manager to note how fertilization has changed soil test levels, and rates can be adjusted. Once nutrient levels are adequate, soil testing should be done every third year to monitor relative changes in soil nutrient levels. Multiples years of soil and tissue testing (see Plant Tissue Testing section below) combined with periodic visual observations, can enable the producer to fine-tune the recommendations in this guide for optimal pasture production. For more information, see "Soil Sampling" at http://info.ag.uidaho.edu/resources/PDFs/EXT0704.pdf.

NITROGEN

Grass pastures have responded well to nitrogen (N) fertilizer applications. The recommended N rate depends upon the length of the frost-free growing season, the availability of irrigation water or precipitation, and the number of cuttings or grazing periods. Production potential increases as the frost-free growing period is extended. The information in Table 1 refers to normal growing conditions. If you have a longer frost-free growing season one year, or if you have more cutting or grazing periods than normal, you may need more nitrogen than is recommended in Table 1. On the other hand, if you have less irrigation water one year, you may need less nitrogen.

Table 1. Nitrogen (N) recommendations for irrigated grass and grass-legume mixtures.

Plant composition	Yield potential of the site			
	1-2 tons/acre	2-4 tons/acre	4-7 tons/acre	6-8 tons/acre
	- - - - - - - - - - - N recommendation (lbs/acre) - - - - - - - - -			
100 % grass	50	75[1]	100-150[1]	150-200[1]
75% grass, 25% legume	25	50	75-100[1]	100-150[1]
50% grass, 50% legume	0	25	50	75
25% grass, 75% legume	0	0	25	50

[1]For pasture, split the total nitrogen rate into two or three separate applications. Apply one third to one half of the nitrogen in early spring, and one third to one half in June, and the remainder in late August. For hay-pasture systems, apply two thirds of the nitrogen in early spring and one third after the hay crop is removed.
Source: Koenig, R, M. Nelson, J. Barnhill, and D. Miner. 2002. Fertilizer management for grass and grass-legume mixtures. AF-FG-03. Utah State University Cooperative Extension, Logan, UT.

As the amount of legume increases in a grass/legume mixture, the need for N fertilizer decreases (Table 1). When the legume composes over 60 percent of the mixture, yield responses to N fertilizer are limited. In addition, nitrogen applications usually reduce the proportion of legume in a mixed species stand. Thus, excessive N will encourage grasses as the dominant species over legumes. To reduce the need for N fertilizer when legumes dominate the stand composition, inoculate the legume seed when the stand is established.

Split applications of N fertilizer maintain a more uniform level of forage production through summer and fall, and increase the nitrogen use efficiency. Broadcast 30 to 50 pounds N per acre per application after each cutting or grazing cycle, and irrigate to move N into the plant root zone. An irrigation or rainfall of 0.5 inches within 48 hours of application is sufficient to move soluble N fertilizers deep enough into the soil to minimize volatilization losses. Be cautious when applying over 160 pounds of N per acre because of economics, environmental stewardship, and possible nitrate accumulation in the forage. Nitrate accumulations in the forage can cause animal health problems. This is particularly an issue if you apply excess nitrogen to a drought-stressed pasture.

Dry forms of nitrogen should be used when topdressing. These forms include urea (46-0-0), ammonium sulfate (21-0-0-24), diammonium phosphate (18-46-0), monoammonium phosphate (10-48-0 to 11-55-0), and calcium nitrate (16-0-0). Non-pressure solutions containing both urea and ammonium nitrate (UAN or Solution 32 or 28) are also available. Urea is now the most common N fertilizer source. There appears to be a smaller response per unit of nitrogen from urea compared with ammonium nitrate. As urea absorbs moisture it is converted to the ammonium form and some ammonia is produced that may be lost into the air (volatilization). Nitrogen losses of 5 to 20 percent have been reported when urea is applied to grass growing on calcareous soils and/or during warm weather, and when several days elapse before rains or irrigation incorporates the fertilizer into the soil.

Controlled release urea fertilizers are now available and may match N supply with demand better than pulses of N that temporarily exceed demand. Ammonium sulfate is recommended when both N and sulfur (S) are deficient.

PHOSPHORUS

Intensively managed, high-producing pasture may respond to phosphorus (P) fertilization. Grasses generally have a low P requirement, and legumes generally have a high P requirement. Thus, P fertilization tends to increase legume composition of mixed pastures.

Phosphorus movement in soils is limited, so P fertilizer needs to be placed in the rooting zone. Apply P during seedbed preparation whenever possible. Topdress established pastures with P fertilizer, preferably in the fall. Rates of P needed for optimum forage production as determined by soil test are shown in Table 2.

Table 2. Phosphorus (P) fertilizer application rates based on soil test.

Soil test level[a] (0-12 inches)	P recommendation (lbs/acre)	
(ppm P)	(P_2O_5)	(P)[b]
0 to 3	160	70
3 to 7	120	53
7 to 10	60	26
10 and above	0	0

[a]Phosphorus test (P) is by $NaHCO_3$ extraction or Olsen method.
[b]Phosphorus is expressed as both the oxide and elemental forms: $P_2O_5 \times 0.44 = P$ or $P \times 2.29 = P_2O_5$.

POTASSIUM

Grasses have moderate potassium (K) requirements, and legumes have high K requirements. Idaho soils are variable in K fertility so a soil test is highly recommended. Irrigation water contains some K, except water from mountain streams.

Potassium movement in soils is limited, though not to the same extent as that of phosphorus. Incorporate K during seedbed preparation or broadcast in the fall on established stands. Rates of K needed for optimum forage production are shown in Table 3.

Table 3. Potassium (K) fertilizer rates based on soil test.

Soil test level[a] (0-12 inches)	K recommendation (lbs/acre)	
(ppm K)	(K_2O)	(K)[b]
0 to 40	200	166
40 to 75	140	116
75 to 110	80	66
over 110	0	0

[a]Potassium test (K) is by $NaHCO_3$ extraction.
[b]Potassium is expressed as both the oxide and elemental forms: $K_2O \times 0.83 = K$ or $K \times 1.20 = K_2O$.

SULFUR

Sulfur (S) demand is greater for legumes than grasses. Sulfur requirements for grass and legumes will vary with soil texture, leaching losses, S soil test level and S content of irrigation water. Apply 30 pounds of S per acre to soil testing less than 10 ppm sulfate-sulfur (SO_4-S) in the plow layer. Our recommendations are based on a water extractable test with analysis by $BaSO_4$ turbidimetric method. If you use a different test, these recommendations may not apply.

Areas irrigated with water from the Snake River and other streams fed by return flow should have adequate S. High rainfall areas, mountain valleys and foothill areas are possible areas for S deficiencies.

Sulfur sources should be carefully selected due to variation in this mineral's availability to plants. Elemental sulfur must be converted by soil microorganisms to an ionic form such as sulfate before it can be taken up by plants. Conversion of elemental S to sulfate may take several months in warm moist soils and even longer at higher elevations. Elemental S fertilizers cannot supply adequate levels of S the year of application. However, these elemental S sources can supply considerable S the year after the initial application. Sulfate-sulfur sources such as ammonium sulfate and potassium sulfate are recommended to alleviate deficiencies in the year of application.

MICRONUTRIENTS

Deficiencies of micronutrients such as zinc (Zn), copper (Cu), manganese (Mn) and iron (Fe) have not been observed on irrigated pastures in southern Idaho. Grasses and legumes are not as sensitive to low levels of micronutrients as are row crops such as beans and corn.

Boron (B) deficiencies may be observed on legumes in gravelly textured soils. Our recommendations for boron are based on the hot water extractable test with analysis by diazomethane method. If the soil tests less than 0.25 ppm B, apply 1 to 3 pounds of B per acre. Do not use higher rates because B is toxic to plants in excessive amounts.

PLANT TISSUE TESTING

Plant tissue analysis may provide useful information on soil fertility and the nutritional health of a grass crop. Most pasture managers do not use plant tissue testing, but this extra step can supplement soil tests and may be useful if you want know exactly what's going on regarding nutrients in your pasture.

Approximately 25 plants should be selected at random across a typical area and should be cut off just above ground level. Samples should be air dried and sent to a laboratory for analysis For optimum production, grass clipped just before heading should contain a minimum of the following:

* 2.0 per cent nitrogen
* 0.25 per cent phosphorus
* 1.5 per cent potassium
* 0.2 per cent sulphur

General Observations and Recommendations

1. Nitrogen and phosphorus are the nutrients needed most on Idaho irrigated pastures. Potassium, sulfur, zinc and boron may also be needed. Their need is best determined by soil and plant tissue tests.
2. Legume composition in a grass-legume mixture is reduced by nitrogen fertilization and increased by the addition of phosphorus when these nutrients are low in the soil.
3. Forage from properly fertilized grass or mixed grass-legume pastures may have higher crude protein, providing higher quality livestock feed than unfertilized pastures.
4. Irrigated pastures make good use of sloping land, stony soils and shallow soils, which are less desirable for row crops. Pastures reduce soil erosion during irrigation on sloping land.
5. Fertilization is only one part of pasture management. Pastures are most profitable when plant selection, irrigation and grazing or harvest techniques are not limiting production.
6. Rotational grazing will provide better nutrient distribution and thus more forage and greater returns than continuous grazing.