Soil Nutrient Analysis—TEACHER GUIDE

Duration: Variable

Group Size: Small to large class

Setting: Classroom

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Goal:

Students will:

- Interpret the results of a soil analysis
- Make fertilizer recommendations based on analysis

Materials Needed:

- "Fertilizer—The Basic Materials": Activity Sheet A-2,3
- Using Soil Analysis Results: A-4,5
- Further Practice: A-6
- Soil Analysis Results: A-7 to 10
- Idaho Fertilizer Guides for Grass Pastures, Alfalfa, and Irrigated Alfalfa: A-11 to 20
- Soil analysis interpretation resources--recommended (See Resources below)

Process:

1. Teacher should introduce lab by outlining the importance of fertilizing:
    1. Increasing forage production & quality
    2. Risks of over-application—water contamination, toxicity to plants and animals.
2. Using "Fertilizer—The Basic Materials", the class can discuss together how nutrient analyses of fertilizers are described.
3. Using the fertilizer guides for alfalfa and grass pastures, students will be able to see how legumes differ from grasses in terms of nitrogen fertilizer needs.
4. Students will have to use the scenario handout, soil analysis results, and fertilizer guides to answer the questions on the scenario handout.

Resources:

- University of Idaho Fertilizer Guides:
  http://www.cals.uidaho.edu/edComm/results.asp?category1=Fertilizers%20and%20Soils&category2=Northern%20Idaho%20Fertilizer%20Guides

  http://www.extension.uidaho.edu/resources2.asp?title=CROP%20PRODUCTION&category1=Fertilizers%20and%20Soils&category2=Southern%20Idaho%20Fertilizer%20Guides&color=91A967&font=4B5F27

- Interpreting Soil Analysis Results:

  "Soil Test Interpretation Guide"—http://www.koin.com/Sites/KOIN/pdfs/2008_watershed/soil_test_interpretation.pdf

  "Soil Testing and Nutrient Management," slideshow—http://www.puyallup.wsu.edu/soilmgmt/Slideshows/SS-SoilSampTilth/sld001.htm

- Fertilizer blends—"Fertilizers: The Basic Materials":
  http://instruct1.cit.cornell.edu/Courses/css412/mod5/ext_m5_pg8.htm

Fertilizers: The Basic Materials (from Cornell University)

The formulation of N, P_2O_5, and/or K_2O in a bag of fertilizer is made from a small set of basic fertilizer materials. The fertilizer is either a single basic fertilizer material or a blend of basic materials. Dry fertilizers also contain fillers, carriers, and/or other materials to help improve the flowability of the fertilizer, make the nutrient analysis possible, or condition the fertilizer to have special traits.

Consider the major basic fertilizer materials in the table below. Take notice of the nutrient analysis, major uses, and traits and consider the link between fertilizer materials and application methods.

The nutrient content of fertilizer materials is always presented in the percentage of N, P_2O_5, and K_2O, in that order!

Fertilizer Blends

The basic fertilizer materials, below, are often combined to make blends of N, P_2O_5, and/or K_2O that are tailored to crop needs.

Due to the concentration of the N, P_2O_5, and/or K_2O in the basic fertilizer ingredients, the blend with the highest possible concentration of N, P_2O_5, and K_2O is 19-19-19. So a 25-25-25 blend is impossible to formulate.

Fertilizers: The Basic Materials (from Cornell University)
Accessed from: http://instruct1.cit.cornell.edu/Courses/css412/mod5/ext_m5_pg8.htm

Material	$N-P_2O_5-K_2O$ Analysis	Major Uses	Traits
Anhydrous Ammonia	82-0-0	Sidedressing N in corn. Used to make other N fertilizers, like urea.	Most concentrated N source, liquid under pressure, highly caustic – if exposed can “burn” plants and people.
Urea	46-0-0	Topdressed N on perennial grasses and included in blends (e.g. 19-19-19).	$, volatile, hydroscopic (absorbs water from the air), can cause high pH near seed, concentrated N source, salt toxicity potential.
Ammonium nitrate	33-0-0	Used to topdress, in starter, and in blends.	$$, hydroscopic (absorbs water from the air), salt toxicity potential, cannot purchase in bulk.
Ammonium sulfate	21-0-0 24-S	Mild N source for starter fertilizers. Also supplies sulfur Used in blends.	$$$, reduces soil pH, flows well thru planter, less salt toxicity potential.
Diammonium phosphate (DAP)	18-46-0	Used in blends for broadcasting and banding.	Can cause high pH near seed.
Monoammonium phosphate (MAP)	11-52-0	Used in blends for broadcasting and banding.	Easy on seeds, but do we need the P in the field? More mild in starter blends than DAP.
Muriate of potash	0-0-60	Used for topdressing K on legumes and included in blends.	Salt toxicity potential.

Using Soil Analysis Results

Scenario 1

Rolling Acres Farm, Moscow, ID

Farm Manager Luke manages the Rolling Acres Farm near Moscow, Idaho. Luke wants to rejuvenate forage quality and improve erosion control by seeding meadow brome in one of the farm's pastures (100 acres) that will be rested from grazing this year. This area receives an annual precipitation of 26 inches. This pasture produced 4.2 tons/acre of forage last year and Luke hopes to increase that to 5.2 tons/acre in the next two years. Luke came to you with the soil analysis results of Rolling Acres Farm. As the Latah County Extension Agent, it is your job to interpret the soil analysis results and make fertilizer recommendations to Luke. **Note: µg/g is equivalent to ppm.**

Interpreting soil results

1. How much of the important nutrients required by grasses do the soil samples from the Rolling Acres pasture have? What is the pH?

2. What fertilizer recommendations should you give to Farm Manager Luke and why? (Be specific—how much of what nutrient?)

Exploring further

3. If Luke decided to plant alfalfa instead of grass, how would the fertilizer recommendation change? Why?

4. The nutrient analysis of fertilizers is often described with three numbers such as 10-20-20. What does this mean? (*Hint: read "Fertilizers: The Basic Materials."*)

5. Let's say Luke needs to fertilize his pasture with 120 lb/acre of nitrogen. He chooses to use urea. How much urea does he need to apply per acre? Show your calculations.

6. What would you recommend to Luke if his soil pH was 4.9?

7. Soil nutrient analyses can be performed with several different procedures: sodium acetate (NaOAc), the Bray method, or sodium bicarbonate ($NaHCO_3$). The method used by a soil analysis lab can depend on the ***location*** of where the soil sample originates. The results from these tests vary from each other so when making fertilizer recommendations, you must make note of which analysis method was used in order to make the correct recommendations.

   Refer to Luke's soil analysis results—what method was used to analyze his soil samples?

Soil Analysis—Further Practice

Goal:

Students will:

- Practice interpreting soil analysis results and making fertilizer recommendations

Materials needed:

- Soil analysis results for Scenario 2
- Southern Idaho Fertilizer Guide—Irrigated Alfalfa

Scenario 2:

The Rocking R Ranch, Burley, ID

Rancher Roberts wants to improve forage production of one of her alfalfa fields. This 250-acre field produced 3.0 tons/acre of alfalfa hay for her cows last year without applying any fertilizers. Rancher Roberts wants to improve her yield to 6.0 tons/acre. The average annual precipitation for the Rocking R Ranch is 9.4 inches so Rancher Roberts irrigates her fields. Before Rancher Roberts plants her alfalfa seed, she wants to know what fertilizers she may have to apply this year. Rancher Roberts came to you with her soil analysis results because you are known all over Cassia County as the expert on forages and fertilizers.

Interpreting soil results

1. How much of the important nutrients required by alfalfa do the soil samples from the Rocking R Ranch have? What is the pH?

2. What fertilizer recommendations should you give to Rancher Roberts? (Be specific—how much of what nutrient?) Assume free lime content of 4%.

3. What analysis method was used for the Rocking R Ranch's soil samples?

Analytical Sciences Laboratory
University of Idaho
Holm Research Center
2222 West 6th Street, P.O. Box 442203
Moscow, Idaho 83844-2203
Phone: (208) 885-7081 FAX: (208) 885-8937
email: asl@uidaho.edu http://www.agls.uidaho.edu/asl/

Certificate of Analysis

Prepared For: Farm Manager Luke
Rolling Hills Farms

Moscow, ID 83843

Case ID: SAPR10-035
Report Date: 27-Apr-10
Date Received: 27-Apr-10
Client Ref.:
Project ID:
County: Latah

1st Level QC: ______________________ Date: ______________

2nd Level QC: ______________________ Date: ______________

Case Comments:

Client Phone:

ND = Not Detected NA = Not Applicable RL = Reporting Limit QNS = Quantity Not Sufficient

Analytical Sciences Laboratory
Certificate of Analysis

Client SampleID: **Rolling Acres Farm** Site/Location:
ASL Sample ID: **S1000350** Matrix: Solid - Dry Weight

Available Potassium Method: AA Prep: Na Acetate Extraction Analysis Date:

	Results	RL	Pres.: None
Available Potassium	**>200 µg/g**	10	

Comment:

Available Phosphorus Method: Colorimetric, ASA 24-3.4 Prep: Na Acetate Extraction Analysis Date:

	Results	RL	Pres.: None
Available Phosphorus	**16 µg/g**	0.50	

Comment:

Nitrogen-Nitrate + Nitrite Method: Colorimetric, ASA 33-8.3 Prep: KCl Extractable, ASA 33-3.2 Analysis Date:

	Results	RL	Pres.: None
Nitrate-N + Nitrite-N	**20 µg/g**	0.80	

Comment:

Nitrogen-Ammonium Method: Colorimetric, ASA 33-7.3 Prep: KCl Extractable, ASA 33-3.2 Analysis Date:

	Results	RL	Pres.: None
Nitrogen-Ammonia	**3.5 µg/g**	0.80	

Comment:

Organic Matter Method: Colorimetric Prep: Dichromate/H2SO4 Analysis Date:

	Results	RL	Pres.: None
Organic Matter	**4.2 %**	0.30	

Comment:

pH Method: Electrode, ASA 12-2.6 Prep: Saturated Paste Analysis Date:

	Results	RL	Pres.: None
pH	**6.0**	—	

Comment:

Sulfate Sulfur Method: IC Prep: Ca Phosphate Extr., ASA 28- Analysis Date:

	Results	RL	Pres.: None
Sulfate Sulfur	**12 µg/g**	1.3	

Comment:

FIELD INFORMATION

Irrigation: 26" precipitation

Comments: Wants to improve forage quality, improve soil erosion, and increase production to 5.2 tons/acre in the next 2 years.

	This Year	Previous Year
Fertilizer:		
lb/acre:		
Crop:	meadow brome	pasture
Yield:		4.2 tons/acre

Samples will be discarded one month after date of final report unless otherwise requested

ND = Not Detected NA = Not Applicable RL = Reporting Limit QNS = Quantity Not Sufficient

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University of Idaho
Holm Research Center
2222 West 6th Street, P.O. Box 442203
Moscow, Idaho 83844-2203
Phone: (208) 885-7081 FAX: (208) 885-8937
email: asl@uidaho.edu http://www.agls.uidaho.edu/asl/

Certificate of Analysis

Prepared For: Rancher Roberts
Rocking R Ranch

Burley, ID 83318

Case ID: **SAPR10-035**
Report Date: 27-Apr-10
Date Received: 27-Apr-10
Client Ref.:
Project ID:
County: Cassia

1st Level QC:		Date:	
2nd Level QC:		Date:	

Case Comments:

Client Phone:

ND = Not Detected NA = Not Applicable RL = Reporting Limit QNS = Quantity Not Sufficient

Analytical Sciences Laboratory
Certificate of Analysis

Client SampleID: **Rocking R Ranch** Site/Location:
ASL Sample ID: **S1000352** Matrix: Solid - Dry Weight

Available Potassium Method: AA Prep: Na Bicarbonate Extr., ASA 2 Analysis Date:

	Results	RL	Pres.: None
Available Potassium	**66 µg/g**	40	

Comment:

Available Phosphorus Method: Colorimetric, ASA 24-3.4 Prep: Na Bicarbonate Extr., ASA 2 Analysis Date:

	Results	RL	Pres.: None
Available Phosphorus	**4.9 µg/g**	2.0	

Comment:

Nitrogen-Nitrate + Nitrite Method: Colorimetric, ASA 33-8.3 Prep: KCl Extractable, ASA 33-3.2 Analysis Date:

	Results	RL	Pres.: None
Nitrate-N + Nitrite-N	**19 µg/g**	0.80	

Comment:

Nitrogen-Ammonium Method: Colorimetric, ASA 33-7.3 Prep: KCl Extractable, ASA 33-3.2 Analysis Date:

	Results	RL	Pres.: None
Nitrogen-Ammonia	**2.0 µg/g**	0.80	

Comment:

Organic Matter Method: Colorimetric Prep: Dichromate/H2SO4 Analysis Date:

	Results	RL	Pres.: None
Organic Matter	**2.1 %**	0.30	

Comment:

pH Method: Electrode, ASA 12-2.6 Prep: Saturated Paste Analysis Date:

	Results	RL	Pres.: None
pH	**7.1**	—	

Comment:

Sulfate Sulfur Method: IC Prep: Ca Phosphate Extr., ASA 28- Analysis Date:

	Results	RL	Pres.: None
Sulfate Sulfur	**5.0 µg/g**	1.3	

Comment:

FIELD INFORMATION

Irrigation: 9.4" precipitation
Comments: Wants to improve forage production in this 250 acre field.

	This Year	Previous Year
Fertilizer:		0
lb/acre:		0
Crop:	new alfalfa	alfalfa
Yield:		3.0 tons/acre

Samples will be discarded one month after date of final report unless otherwise requested

ND = Not Detected NA = Not Applicable RL = Reporting Limit QNS = Quantity Not Sufficient

University of Idaho
College of Agricultural and Life Sciences

CIS 447

Northern Idaho Fertilizer Guide

Alfalfa

by Robert L. Mahler

These fertilizer guidelines have been developed by the University of Idaho based on relationships obtained from soil tests and crop yield responses. The suggested fertilizer rates are designed to produce above-average yields if other factors are not limiting production. Thus, these fertilizer guidelines assume good management.

The suggested fertilizer rates will be accurate for your field provided that (1) the soil samples are properly taken and are representative of the field to be fertilized, and (2) the crop and fertilizer histories supplied are complete and accurate. For additional information on how to collect and process a soil sample, see University of Idaho Bulletin 704, *Soil Sampling*.

Harvested alfalfa removes large quantities of nutrients from the soil. Each ton of alfalfa removes about 60 pounds of nitrogen (N), 12 pounds of phosphorus (P), and 60 pounds of potassium (K). Incorporate fertilizer into the soil as you prepare the seedbed. Apply additional amounts periodically over the life of the stand to maintain optimal nutrient levels based on tissue or soil analysis.

Alfalfa is a desirable forage legume suitable for many areas of northern Idaho. However, alfalfa is not well adapted to low, wet areas; cutover forest soils; or acid soils (pH below 5.8). Whenever one of these conditions occurs, consider planting an alternative forage legume, such as birdsfoot trefoil, clover, or a grass pasture, in lieu of planting alfalfa.

Nitrogen

Alfalfa is a legume that should fix most of its own N requirement if it is sufficiently nodulated by viable *Rhizobium meliloti* inoculum. For additional information on inoculation and methods of inoculum application, see University of Idaho CIS 838, *Inoculation of Legumes in Idaho*. Efficiency of N fixation depends on adequate plant levels of other nutrients—especially P, sulfur (S), and molybdenum (Mo)—and nontoxic levels of aluminum and manganese.

Excessive soil acidity and soil pH values less than 5.8 for alfalfa can disrupt N fixation. Consider seed inoculation with rhizobia when the soil pH is less than 6.2 or when alfalfa has not been grown on a field for more than 10 years.

At seeding, applying 30 to 35 pounds of fertilizer N per acre will aid seedling growth while root nodules are forming. However, excessive levels of inorganic N (NH_4^+ and NO_3^-) in soils will promote invasion by grassy plant species and also reduce nodulation and the quantity of N fixed by the alfalfa crop.

Phosphorus

When establishing seedlings, incorporate P fertilizer into the top 3 to 6 inches of the seedbed. An adequate amount of P is critical for rapid, successful stand establishment.

On established stands, fall or winter surface applications of P are preferred. Phosphorus may be incorporated into the seedbed or applied on established stands in large enough quantities to last for 1 to 3 years.

Phosphorus needs can be effectively determined with the aid of a soil test (Table 1). The P fertilizer application rates suggested in Table 1 should be increased by 25 percent if your soil contains large amounts of volcanic ash.

Tissue analysis can help to determine adequate levels of P in alfalfa. Samples should be collected from the top one-third of the plant before the first cutting. Tissue P concentrations should range between 0.30 and 0.35 percent. If tissue values are less than 0.22 percent, P fertilizer should be applied. Visual P deficiency symptoms are difficult to diagnose; consequently, tissue analysis is preferred.

Table 1. Phosphorus fertilizer rates for alfalfa based on a soil test.

Soil test P (0 to 12 inches)[1]			P_2O_5 application rate[2]		
NaOAc	Bray I	$NaHCO_3$	1-year supply	2-year supply	3-year supply
(ppm)	(ppm)	(ppm)	(lb/acre)	(lb/acre)	(lb/acre)
0 to 2	0 to 20	0 to 8	60	105	150
2 to 4	20 to 40	8 to 14	40	66	92
4 to 8	40 to 80	14 to 20	15	25	50
over 8	over 80	over 20	0	0	15

[1] Soil test P can be determined by three different procedures: sodium acetate (NaOAc), Bray I method, or sodium bicarbonate ($NAHCO_3$). Sodium bicarbonate should not be used on soils with pH values less than 6.2. Use the column indicated by your soil test report.

[2] P_2O_5 x 0.44 = P, or P x 2.29 = P_2O_5.

Potassium

Alfalfa removes large amounts of K from the soil. When establishing seedlings, incorporate K fertilizer into the seedbed. On established stands, fall or winter topdress applications of K are preferred, but spring applications are acceptable. Potassium may be incorporated into the seedbed or applied on established stands in large enough quantities to last for 2 to 3 years. A soil test can effectively determine K needs (Table 2).

As with P, tissue analysis can determine the status of K in alfalfa. Collect tissue samples from the top one-third of the plant prior to cutting the alfalfa. Tissue K concentrations should range between 1.7 and 2.0 percent. If concentrations of K are less than 1.5 percent, consider applying fertilizer in the fall.

Table 2. Potassium fertilizer rates based on a soil test.

Soil test K (0 to 12 inches)[1]	K_2O application rate[2]		
	1-year supply	2-year supply	3-year supply
(ppm)	(lb/acre)	(lb/acre)	(lb/acre)
0 to 35	90	165	240
35 to 75	60	110	150
75 to 100	40	70	90
over 100	0	re-sample soil	

[1] Sodium acetate-extractable K in the 0- to 12-inch depth.

[2] K_2O x 0.83 = K, or K x 1.20 = K_2O.

Sulfur

Sulfur is essential for maximum production of alfalfa. Northern Idaho soils are often S deficient. Sulfur deficiency appears as a yellowing of the entire plant early in the growing season and resembles N deficiency. Sulfur deficiency can cause reductions in both alfalfa yield and quality.

Test soils annually for plant available S content. Do not use elemental S since it becomes available too slowly for plant growth and also acidifies the soil. Sulfur can be applied as gypsum or with liquid or dry fertilizer materials containing S. Gypsum is the most commonly used S source on alfalfa in northern Idaho. Sulfur needs of alfalfa based on a soil test are shown in Table 3. The S application rates suggested in Table 3 should be increased to 35 from 25 pounds per acre if your soil contains large amounts of volcanic ash.

Table 3. Sulfur fertilizer needs of alfalfa based on a soil test.

Soil test S (0 to 12 inches)		S application rate
(ppm SO_4-S)	(ppm S)	(lb/acre)
0 to 10	0 to 4	25
over 10	over 4	0

Boron

Alfalfa grown in northern Idaho occasionally responds to applications of boron (B). Determine the need for B with a soil test. Treat a soil testing less than 0.5 ppm of B with 1 to 1.5 pounds of B per acre. Do not exceed B application rates of 2 pounds per acre.

Boron should be broadcast and not banded because it is toxic and could damage the alfalfa if banded. Use of borated gypsum is an effective and economical method of applying needed B and also S. For additional information on boron and boron fertilizer materials, see University of Idaho CIS 1085, *Boron in Idaho*.

Molybdenum

Alfalfa responses to molybdenum (Mo) have been frequently reported in northern Idaho. However, no soil test is available for Mo. Do not apply Mo unless there is evidence (such as rotation history or visual deficiency symptoms) that it is needed, since excess Mo in forage is toxic to many animals consuming the forage.

Since a soil test for Mo is not available, Mo fertilization is based on the cropping history of a field. Basically, Mo applications are recommended once every 5 to 7 years on fields where a legume (alfalfa, clovers, peas, lentils, chickpeas, birdsfoot trefoil) is in a rotation with small grain crops. When Mo is needed, apply 1 pound of either sodium molybdate or ammonium molybdate per acre. The fertilizer should be surface broadcast and incorporated into the seedbed prior to seeding. If the alfalfa is already established, rainwater will move surface-applied Mo into the root zone. For additional information on molybdenum and molybdenum fertilizer materials, see University of Idaho CIS 1087, *Molybdenum in Idaho*.

Other micronutrients

Zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), cobalt (Co), and chlorine (Cl) deficiencies have never been observed in northern Idaho alfalfa. Consequently, adding these micronutrients to soils is not recommended for alfalfa production.

Lime

On acid soils (pH values less than 5.8), apply lime to obtain maximum alfalfa yields. An acid soil reduces the nitrogen-fixing potential of alfalfa root nodules. Soil pH values between 5.8 and 6.5 are desirable for alfalfa production on acid Idaho soils. In northern Idaho, pH values higher than 6.5 may promote P nutrition problems.

If soil pH is between 5.5 and 5.8 apply 1 ton of lime per acre and thoroughly incorporate into the soil prior to seeding alfalfa. If the soil pH is less than 5.4, apply 2 tons of lime and incorporate it into the soil prior to seeding alfalfa. For additional information on lime and liming materials, see University of Idaho CIS 787, *Liming Materials*.

Agronomy/Water quality considerations

- Weeds, insects, diseases, and environmental stress can influence the effectiveness of a fertilizer program and reduce yields.
- Alfalfa does not grow well in wet, poorly drained soils. Avoid planting alfalfa in this situation.
- Alfalfa grown in northern Idaho soils most often needs the elements P, S, and B. At times, applying K and Mo will also improve plant growth.
- Since P and K are relatively immobile in soils, incorporate these nutrients into the seedbed prior to seeding. Apply up to 3 years of the P requirement for alfalfa before seeding.
- Nitrogen fertilizer should be used only at the rate of 30 to 35 pounds per acre at seedling establishment. Nitrogen fixation should provide all the N required for the alfalfa crop after establishment.
- Inoculating the alfalfa seed with *Rhizobium meliloti* is essential to ensure good nitrogen fixation. Apply the inoculum either directly to the seed or to the soil. All fields planted to alfalfa in northern Idaho should be inoculated with this bacterium. Note that the rhizobia that produce nodules on the roots of alfalfa are different from the rhizobia found to produce nodules on peas, lentils, or chickpeas.
- Alfalfa grows poorly in acid soils. For satisfactory alfalfa growth, soil pH values greater than 5.7 are needed. Liming materials can be used to modify soil pH.

Further reading

CIS 787, *Liming Materials*, 50 cents
CIS 838, *Inoculation of Legumes in Idaho*, 35 cents
BUL 704, *Soil Sampling*, $2.00
CIS 1085, *Essential Plant Micronutrients: Boron in Idaho*, $3.00
CIS 1087, *Essential Plant and Animal Micronutrients: Molybdenum in Idaho*, $1.00

To order copies of these or other University of Idaho Extension publications, contact the University of Idaho Extension office in your county or write to Publications, University of Idaho, P.O. Box 442240, Moscow, ID 83844-2240, call (208) 885-7982, email calspubs@uidaho.edu, or go online at http://info.ag.uidaho.edu

Northern Idaho fertilizer guides are available online and may be downloaded from http://info.ag.uidaho.edu/catalog/catalog.html. Look under Fertilizers and Soils:

CIS 447, *Alfalfa*
CIS 453, *Winter Wheat*
CIS 785, *Winter Rapeseed*
CIS 788, *Bluegrass Seed*
CIS 815, *Blueberries, Raspberries, and Strawberries*
CIS 820, *Grass Seedings for Conservation Programs*
CIS 826, *Chickpeas*
CIS 851, *Legume and Legume-Grass Pastures*
CIS 853, *Grass Pastures*
CIS 911, *Northern Idaho Lawns*, also available in print for $1.00
CIS 920, *Spring Barley*
CIS 954, *Winter Barley*
CIS 1012, *Spring Canola*
CIS 1083, *Lentils*
CIS 1084, *Spring Peas*
CIS 1101, *Soft White Spring Wheat*

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University of Idaho Extension

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University of Idaho
College of Agricultural and Life Sciences

CIS 853

Northern Idaho Fertilizer Guide

Grass Pastures

by Robert L. Mahler

These fertilizer guidelines have been developed by the University of Idaho and Washington State University based on relationships obtained from soil tests and crop yield responses. The suggested fertilizer rates are designed to produce above-average yields if other factors are not limiting production. Thus, these fertilizer guidelines assume good management.

The suggested fertilizer rates will be accurate for your field provided that (1) the soil samples are properly taken and are representative of the field to be fertilized and (2) the crop and fertilizer history supplied is complete and accurate. For help in obtaining a soil sample, see University of Idaho Bulletin 704, *Soil Sampling*, or consult your county extension educator.

Harvested grasses remove large quantities of nutrients from the soil. Incorporate fertilizer into the soil as you prepare the seedbed; apply additional amounts periodically over the life of the stand to maintain optimum nutrient levels.

Established grass pastures

Nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) are nutrients essential for plant growth but are often deficient in northern Idaho grass pastures. Conversely, calcium (Ca), boron (B), copper (Cu), chlorine (Cl), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn) deficiencies are rare in northern Idaho grass pastures.

Animals foraging for grass in the spring may suffer grass tetany, caused by low levels of soil magnesium (Mg).

Nitrogen—Soil sampling for N fertilizer recommendations is generally not practical; available N is mobile in soils and can be leached beyond the root zone with spring precipitation or irrigation.

Grass pastures will usually respond to N applications in northern Idaho. Table 1 lists suggested N application rates based on annual precipitation. Highest recommended N application rates are on irrigated grass pastures. These suggested rates are yearly requirements and should be split into at least two applications for nonirrigated and three to five applications for irrigated grass pastures.

Table 1. Nitrogen fertilizer rates for grass pastures based on annual precipitation.

Annual precipitation	N application
(inches)	(lb/acre)
less than 20	80 to 110
20 to 22	100 to 130
22 to 25	120 to 145
more than 25	135 to 160
irrigated pastures	140 to 170

On nonirrigated land, make one of the two recommended applications as early in the spring as possible (February to April) and the second application in early June. On irrigated grass pastures, apply the first of the three to five applications as early in spring as possible and make subsequent applications every 5 to 7 weeks.

Phosphorus—Conduct a soil test to assess the P status of grass pastures. Table 2 lists P application rates required for optimal forage production, as determined by a soil test. On established stands, fall broadcast applications of P fertilizers are more effective than spring applications. On established stands, you may apply enough P to last for 2 or 3 years. The P fertilizer application rates suggested in Table 2 should be increased by 25 percent if your soil contains large amounts of volcanic ash.

Table 2. Phosphorus fertilizer rates for grass pastures based on a soil test.

Soil test P (0 to 12 inches)[1]			P_2O_5 application rate[2]		
NaOAc	Bray	$NaHCO_3$	1-year supply	2-year supply	3-year supply
(ppm)	(ppm)	(ppm)	(lb/acre)	(lb/acre)	(lb/acre)
0 to 2	0 to 20	0 to 8	50	90	110
2 to 4	20 to 40	8 to 14	35	45 to 55	70 to 80
4 to 8	40 to 80	14 to 20	0	10 to 20	20 to 40
over 8	over 80	over 20	0	0	0

[1] Soil test P can be determined by three different procedures: sodium acetate (NaOAc), Bray I method, or sodium bicarbonate ($NaHCO_3$). Sodium bicarbonate should not be used on soils with pH values less than 6.2. Use the column indicated by your soil test report.

[2] $P_2O_5 \times 0.44 = P$, or $P \times 2.29 = P_2O_5$.

Potassium —Grass pastures remove large quantities of K from the soil. On established stands, applying K as a fall topdress application is most beneficial. Most northern Idaho soils contain enough K for optimal forage production, but deficiencies can occur in localized areas. Use a soil test to determine K needs (Table 3).

Table 3. Potassium fertilizer rates based on a soil test.

Soil test K[1]	K_2O[2]
(ppm)	(lb/acre)
0 to 35	80
35 to 75	55
75 to 100	35
more than 100	0

[1]Sodium acetate-extractable K in the 0- to 12-inch depth.

[2]K_2O x 0.83 = K, or K x 1.20 = K_2O.

Sulfur—Northern Idaho soils are often S deficient, causing yield and quality reductions. When an S deficiency occurs, the entire plant yellows early in the growing season. This symptom is indistinguishable from an N deficiency.

Sulfur can be applied as gypsum or with liquid or dry fertilizer materials containing S. Use materials containing sulfate (SO_4). Since S is mobile and subject to leaching in soils, apply S early in the spring. Do not apply S in fall. Sulfur needs of grass pastures based on a soil test are shown in Table 4. The S fertilizer application rates suggested in Table 4 should be increased to 30 from 20 pounds per acre if your soil contains large amounts of volcanic ash.

Table 4. Sulfur fertilizer needs of grass pastures based on a soil test.

Soil test S (0 to 12 inches)		S application rate
(ppm SO_4-S)	(ppm S)	(lb/acre)
0 to 10	0 to 4	20
over 10	over 4	0

Magnesium—Grass tetany is a cattle and sheep disorder caused by low levels of Mg often resulting from low Mg in their forage. Grass tetany occurs when lush grass pastures grow rapidly in areas with cool, wet springs.

Low Mg levels are found in cool-season grasses, such as bluegrass, brome, fescue, orchardgrass, and timothy. Under cool, wet spring conditions, these grasses contain such low Mg levels that grazing animals may not obtain enough Mg to meet their nutritional requirements.

Supplement improved grass pastures that are prone to developing low Mg levels in the spring by using one or more of the following practices:

- Add legumes, such as ladino and alsike clovers or alfalfa.
- Fertilize pastures with Mg (e.g., dolomitic limestone or potassium-magnesium sulfate).
- Avoid heavy N and K applications.
- Supplement animal rations or water with Mg.

Micronutrients—Grass pastures have never been observed to respond to micronutrient applications in northern Idaho. If you are in doubt, test the soil and consult the extension educator in your county.

Lime—Test lime applications on highly acid soils (soil pH less than 5.1) to determine if there's an economical response. When needed, apply lime at a rate of 1 to 2 tons per acre, and where possible, mix it thoroughly into the soil. Surface applications will work but will be slow to react. Fewer than 5 percent of the grass pastures in northern Idaho have soil pH values less than 5.1.

New grass seedings

Consider soil fertility needs before establishing new pastures. Both P and K are particularly important as these nutrients are immobile in the soil and are more available when worked into the seedbed before seeding.

At establishment, work 60 pounds of P_2O_5 per acre and appropriate amounts of K (see Table 3) into the seedbed. Add S when a soil test indicates a need (Table 4). Sulfur does not need to be incorporated into the seedbed because it is mobile in soils and will reach plant root zones with normal precipitation or irrigation.

Adding 20 to 30 pounds of N per acre at seeding will help establish a pasture. Add 50 percent of the recommended N rate listed in Table 1 during the first season.

Agronomy/Water quality considerations

- Weeds, insects, diseases, and environmental stress can influence the effectiveness of a fertilizer program and reduce yields.
- Nitrogen, phosphorus, and sulfur are the elements most often needed for grass pasture production in northern Idaho. In some situations applying potassium and lime will also improve plant growth.
- Since nitrate nitrogen and sulfate sulfur are mobile in soils, make fertilizer applications of these two nutrients in the spring. Never apply N or S in the fall.
- Since phosphorus and potassium are relatively immobile in soils, work these nutrients into the seedbed before seeding.
- Grass tetany can occur in pure grass pastures during cool, wet springs in northern Idaho counties because of low magnesium levels in the forage.
- Grasses grow poorly in soils with pH values less than 5.1. In such situations, you may need to apply lime to correct soil acidity. Apply and incorporate lime into the soil before the pasture is established.

- When seeding, select the best-adapted grass varieties for your area.
- Sulfur and nitrogen fertilization increases forage protein content, greatly improving its quality.

Further reading

BUL 704, *Soil Sampling*, $2.00

To order copies of this or other University of Idaho Extension publications, contact the University of Idaho Extension office in your county or write to Publications, University of Idaho, P.O. Box 442240, Moscow, ID 83844-2240, call (208) 885-7982, email calspubs@uidaho.edu, or go online at http://info.ag.uidaho.edu

Northern Idaho fertilizer guides are available online and may be downloaded from http://info.ag.uidaho.edu/catalog/catalog.html. Look under Fertilizers and Soils:

CIS 447, *Alfalfa*
CIS 453, *Winter Wheat*
CIS 785, *Winter Rapeseed*
CIS 788, *Bluegrass Seed*
CIS 815, *Blueberries, Raspberries, and Strawberries*
CIS 820, *Grass Seedings for Conservation Programs*
CIS 826, *Chickpeas*
CIS 851, *Legume and Legume-Grass Pastures*
CIS 853, *Grass Pastures*
CIS 911, *Northern Idaho Lawns*, also available in print for $1.00
CIS 920, *Spring Barley*
CIS 954, *Winter Barley*
CIS 1012, *Spring Canola*
CIS 1083, *Lentils*
CIS 1084, *Spring Peas*
CIS 1101, *Soft White Spring Wheat*

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Southern Idaho Fertilizer Guide

Irrigated Alfalfa

Jeffrey Stark, Brad Brown and Glenn Shewmaker

The following fertilizer recommendations are based on university and USDA-ARS research that relates crop yield response to nutrient application rates at different soil test values. The recommendations are designed to produce above average yields if other environmental or cultural factors are not limiting. Good crop management is assumed.

The suggested fertilizer rates also assume that soil samples are properly collected, processed, and analyzed, and that they represent the areas to be fertilized. Many fields have appreciable variation in residual soil fertility and potential productivity. Areas within fields that differ appreciably should be sampled and fertilized separately if they are large enough to allow nutrient application rates to be conveniently adjusted and if the differential application would be cost effective.

Precision ag technology and variable rate applicators currently provide options for differentially fertilizing field areas. For information on mapping soil nutrient concentrations and variably applying fertilizer, contact an extension soil fertility specialist, your local county extension educator, or reputable fertilizer dealers/consultants.

Soil Sampling

Representative soil samples are essential. Each soil sample submitted to a soil test laboratory should consist of a composite of at least 20 individual cores from within the area of interest. Collect separate samples from the 0- to 12-inch and 12- to 24-inch depths. Skip areas that represent only a small portion of the field such as gravelly areas, saline or sodic areas, wet spots, and turn rows.

Do not store moist samples under warm conditions because microbial activity can change the extractable N in the sample. Samples that are not air-dried should be sent to the laboratory as quickly as possible.

Fertilizer Recommendations

Nutrient requirements for alfalfa are relatively high compared to many other crops commonly grown in Idaho. Each ton of alfalfa hay removes about 60 lb nitrogen (N) per acre, 50 lb potassium (K) per acre, 30 lb calcium (Ca) per acre, 8 lb phosphorus (P) per acre, and about 6 lb per acre of both sulfur (S) and magnesium (Mg). Requirements for phosphorus and potassium fertilizers are much higher than for S, manganese (Mn), zinc (Zn), iron (Fe), and boron (B).

Nitrogen

Essentially all N required by established alfalfa is provided by the symbiotic relationship with N-fixing Rhizobium bacteria and N mineralized from soil organic matter. Topdressed N usually does not improve yield, quality, or vigor of established stands. However, applications of 20 to 40 lb N per acre may be helpful during stand establishment prior to nodulation of the roots. Applied N would most likely be needed following small grain production in which the residue is returned to the soil. Application of larger amounts may inhibit nodulation, decrease symbiotic N fixation, and encourage grass weeds, thereby reducing alfalfa growth or quality when harvested. Alfalfa receiving appreciable amounts of animal manures, dairy effluent, or other organic N sources will also have reduced N fixation. The probability of an N response is usually greatest on coarse-textured soils with low organic matter content.

Nitrogen fertilizer may be required for maximum alfalfa production and quality if the roots are poorly nodulated. Poor nodulation as well as poor Rhizobial activity and N-fixing capacity can result from a number of factors, including lack of proper seed

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inoculation at planting, diseases, insects, water deficits, nutrient deficiencies or toxicities, or other soil physical or chemical conditions that reduce the effectiveness of the Rhizobium inoculant. Poor inoculation results from not using inoculant, using inoculant that has lost its viability (expired shelf life), or using Rhizobium inoculant strains that are not effective. Poor inoculation, nodulation, or Rhyzobial effectiveness is indicated when alfalfa protein is low (less than 18%) when cut at the early bloom stage. Healthy Rhizobium nodules should be pink when cut open if they are effectively fixing atmospheric N.

If nodulation or Rhyzobial effectiveness is limited by pests, water deficits, or soil conditions such as salinity, sodicity, nutrient deficiencies, or soil compaction, then attempts should be made to correct the problem through appropriate management practices. For more information on proper inoculation of alfalfa, refer to CIS 838 *Inoculation of Legumes in Idaho*.

Alfalfa is sometimes used to scavenge nutrients from soils receiving excessive animal manure or other biological waste applications. An alfalfa crop yielding 6 tons per acre can remove up to 360 lb of N per acre. However, excessive nitrogen uptake can increase the forage nitrate toxicity hazard for dairy and beef cattle. In addition, animal manure applications can promote grass and weed growth, which in turn can also increase the potential for nitrate toxicity if the population of the noxious weed Kochia increases.

Producers sometimes plant a companion crop when establishing alfalfa in order to increase the productivity of the first cutting. However, this practice is not recommended because the alfalfa stand typically is reduced by competition from the companion crop. If growers plant alfalfa with a companion crop, both crops compete for the available N. Under these conditions, N rates of 30 to 40 lb per acre are suggested if available soil N does not exceed 60 to 80 lb per acre.

Phosphorus

Adequate P availability is important for maintaining plant health, winterhardiness, and optimum root, stem, and leaf growth. Since phosphorus is relatively immobile in soil, P fertilizer should be incorporated into the soil prior to planting to raise soil P concentrations to optimum levels for early plant growth. The phosphorus recommendations presented in Table 1 are based on the soil test P concentration and free lime content in the top foot of soil, and the yield potential. Significant amounts of free lime in the soil will make less phosphorus available to plants as it precipitates soil solution P.

Table 1. Recommended P fertilization rates for irrigated alfalfa based on soil test P and free lime content.

Soil test P[1]	Free Lime Content (%)			
(0 to 12 inch)	0	4	8	12
ppm P	P_2O_5 (lb/acre)			
0	300	340	380	420
3	250	290	330	370
6	200	240	280	320
9	150	190	230	270
12	100	140	180	220
15	50	90	130	170
18	0	40	80	120
21	0	0	30	70

[1]$NaHCO_3$ extraction

NOTE: Add 10 lb P_2O_5 per acre for each 1 ton per acre increase in yield goal above 6 tons per acre.

Topdressed P applications can also be effective but should be made following harvest in the fall or in the spring before regrowth in order to maximize soil contact. Knifing ammonium polyphosphate (10-34-0) into the soil or applying surface bands in the fall or spring are also effective P fertilization methods for alfalfa.

As the stand ages and plant density decreases, the ability of the alfalfa root system to take up P diminishes due to decreased soil P concentrations and root activity. Under these conditions, smaller P rates applied more frequently may increase P uptake efficiency.

Effective sources of P for alfalfa include monoammonium phosphate (11-52-0), triple superphosphate (0-45-0), ammonium polyphosphate (10-34-0), and phosphoric acid. Fertilizer P can be broadcast as 11-52-0 or applied through the irrigation system as 10-34-0 with equal effectiveness. Phosphorus sources should be selected on the basis of cost, local availability, and equipment requirements.

Potassium

Alfalfa has a high K requirement. A crop of 8 tons per acre will remove about 480 lb of K_2O per acre. Most Idaho soils and surface irrigation waters are naturally high in K. However, K deficiencies can develop in intensively cropped fields, particularly those fields cropped to alfalfa for many years. Sandy soils are generally more prone to developing K deficiencies than silt loam or clay soils and therefore have a higher probability of responding to K fertilization.

Potassium movement in soils is limited, although it is more mobile than P. Like phosphorus, potassium fertilizer recommendations are based on calibrated relationships between soil test concentrations in the top foot of soil and yield response (Table 2). Soil test K should generally be in the range of 160 to 200 ppm for optimum alfalfa yield. Potassium fertilizer should also be incorporated during seedbed preparation prior to establishment, or broadcast in the fall or early spring on established stands. Potassium chloride (0-0-60), potassium sulfate (0-0-52), K-Mag, and various liquid K fertilizers are all effective K sources for alfalfa.

Table 2. Recommended K fertilization rates for irrigated alfalfa based on soil test K concentrations and yield goal.

Soil test K[1]	Yield goal (tons/acre)			
(0 to 12 inch)	6	7	8	9
ppm	K application rate (lb K_20/acre)			
0	240	300	360	420
40	180	240	300	360
80	120	180	240	300
120	60	120	180	240
160	0	60	120	180
200	0	0	60	120
240	0	0	0	60

[1]$NaHCO_3$ extraction

Potassium applications exceeding 300 lb K_2O per acre should be split between fall and spring to avoid salt damage. Excessive K applications should be avoided since alfalfa will remove substantially more K than it needs for maximum yield. Excessive K concentrations in alfalfa can contribute to milk fever in dairy cattle.

Sulfur

Sulfur is a key contributor to alfalfa yield and quality. Sulfur requirements for alfalfa vary with soil texture, leaching losses, soil test SO_4-S concentration, and S content of the irrigation water. About 30 to 40 lb of SO_4-S should be applied before planting to soils containing less than 10ppm SO_4-S in the top foot of soil. This amount should provide adequate soil S for several years, provided the SO_4-S is not leached from the rooting depth. The SO_4-S form is mobile and can be leached to lower soil profile depths. For established alfalfa, sampling to a depth of two feet will provide a more accurate indication of S availability to alfalfa roots beyond the first foot.

Areas irrigated with water from the Snake River or streams fed by return flow should have adequate S for alfalfa production. High rainfall areas, mountain valleys, and foothills are more likely to have S deficiencies, particularly on course-textured soils with low organic matter content.

Sulfur fertilizer sources should be carefully selected because elemental S must be converted to SO_4-S by soil microorganisms before plant roots can take it up. Conversion of elemental S to SO_4-S may take several months in warm, moist soil. Consequently, elemental S fertilizers usually cannot supply adequate levels of S to alfalfa in the year that it is applied. However, elemental S fertilizers can supply considerable S during the year following application. Sulfate-sulfur sources such as gypsum (calcium sulfate), ammonium sulfate (21-0-0), or potassium sulfate (0-0-52-18) are recommended to correct S deficiencies during the year of application.

Secondary Nutrients and Micronutrients

Calcium and magnesium deficiencies in alfalfa are rare in the irrigated areas of southern Idaho. Most soils in the Snake River plain have adequate amounts of Ca and Mg for alfalfa production, although low soil Mg concentrations are sometimes encountered on very sandy soils that have been heavily fertilized with K for long periods. Under these conditions, applications of $MgSO_4$ or K-Mag at 20 to 40 lb of Mg per acre may provide a benefit.

Micronutrient applications should be based on recent soil test results (Table 3). Boron deficiencies can usually be corrected by applying 2 to 3 lb of B per acre for the duration of the crop. However, on very sandy soils, or high rainfall areas where soils are subject to excessive leaching of B, annual applications of 1/2 to 1 lb of B per acre may be more effective. Commonly used forms of B include boric acid, Borax, and sodium borate.

Zinc, Mn, and Fe deficiencies can be corrected by applying 5 to 10 lb per acre of the required nutrient using Zn, Mn, or Fe sulfates or other soluble forms. Molybdenum availability is generally adequate in the alkaline soils that are prevalent in the irrigated areas of southern Idaho.

Table 3. Adequate soil test micronutrient concentrations for alfalfa.

Nutrient	Adequate concentration (ppm)[1]
Boron	> 0.5
Zinc	> 1.0
Manganese	> 1.0
Iron	> 5.0

[1]DTPA extractable zinc, manganese, and iron

Table 4. Sufficiency ranges for alfalfa stem tissue sampled at early bloom.

Nutrient	Sufficiency range
	------%------
Nitrogen	3.00-5.00
Phosphorus	0.25-0.75
Potassium	2.50-4.00
Calcium	0.50-3.00
Magnesium	0.30-1.00
Sulfur	0.25-0.50
	----ppm---
Boron	30-80
Zinc	20-70
Manganese	30-100
Iron	30-150
Copper	5-25
Molybdenum	1-5

Tissue Testing

Plant tissue testing provides an effective means of evaluating the nutrient status of an established alfalfa stand. Samples should be collected from about 20 to 30 plants at early bloom in representative areas of the field that are free from water stress or obvious pest problems. The top six inches of the stem should be sampled and sent immediately to a soil testing lab for analysis. Sufficiency ranges for the various nutrients are presented in Table 4. Nutrient concentrations below these ranges indicate a need for supplemental fertilization.

When nutrient deficiencies are identified during the growing season, the deficiencies can often be corrected by injecting water-soluble fertilizers through the sprinkler system. Liquid forms of N, P, K, S, and micronutrients are commonly available in Idaho and should be selected on the basis of cost relative to dry fertilizers and ease of application. If alfalfa is furrow irrigated, foliar sprays can be used to correct micronutrient deficiencies but avoid foliar applications of N, P, K, and S at high rates that can cause foliar burning.

For Further Reading

You may order this and other publications about fertilizers and crops in southern Idaho from the University of Idaho Cooperative Extension offices in your county or Ag Publications, P.O. Box 442240, University of Idaho, Moscow, ID 83844-2240, phone (208) 885-7982, fax (208) 885-7982, email *agpub@uidaho.edu*, or *http://info.ag.uidaho.edu* on the internet.

CIS 838 *Inoculation of Legumes in Idaho, $0.35*

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