"How much fertilizer do I need ?"
Soil testing and Alfalfa fertilization

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Abstract

Abstract: Soil testing is useful for alfalfa production, but in limited ways. It is best used in a combined effort with plant tissue and water analysis. Proper fertilization practices can correct nutrient deficiencies. Phosphorus is the most important nutrient; potassium and sulfur can also be important.

Keywords: Alfalfa, soil testing, fertilization practices

Introduction

To grow top yields of high-quality hay requires many considerations. One of them is to create the most favorable soil environment for alfalfa plants. How is this determined? How do you make this environment more favorable?

Soil testing is a useful tool to evaluate current conditions. The object of this paper is to discuss soil testing and its use in alfalfa production and how to develop effective fertility programs.

Soil Testing

Alfalfa, like all crops, requires many nutrients to grow. When one or more of these nutrient elements are lacking, reduced growth or yield results.

Where do these nutrients come from? Most come from the soil, some from irrigation water and some from cultural practices. The best way to measure the nutrient content of plants is by directly analyzing them. This is the topic of another presentation . Sometimes, prior to planting for example, it may not be possible to use plant tissue analysis. And for some nutrients it is helpful to know how much is in the soil for future use by the plants. Some items such as pH, salinity and toxic elements need to be measured by soil analysis to understand the total effect on the alfalfa environment.

Soil testing, along with plant tissue and water testing is needed to develop the clearest possible understanding of what is happening in the field. Some nutrients can be accurately tested in the soil, while others are much better measured by plant analysis.

How often should soil testing be done? It is a good idea to test the soil prior to planting, after that, every 2 to 3 years is probably enough if there are not problems that need more frequent analysis. Plant tissue should be done every year. Water analysis depends on the source. If there is variability, annual testing will be needed.

How deep should the soil be tested? If it is a preplant test, focus on the top foot of the soil profile. If it is an established field, usually only the top foot is sampled, although for some situations it may be desirable to take samples deeper in the root zone.

Fertilizer applications can influence where samples should be taken. Most topdressed phosphate will be near the soil surface. If fertilizer was applied in bands, its distribution in the soil will not be even. Sampling procedures have been well covered in past

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symposia. Suffice it to say that the sample must be representative of the field it is taken from. Some fields have so much variability in soil distribution that sampling is almost impossible. Grid sampling and variable rate technology are modern approaches to solve this problem. Distinctly different areas should be sampled separately. Samples should be composites of the area they represent. Organic debris and plant material should not be in the sample. It is a good idea to sample the same locations in the field to look for changes in the nutrient status of those areas. Areas of good and poor growth may also be sampled separately for comparison of soil nutrient status.

The number of samples needed will be determined by uniformity of the soil. The individual nutrients will be considered for alfalfa in regards to: testing and interpretation, agronomic effects and correction of deficiencies or effects of excess levels.

Nitrogen

Nitrogen is a major component of alfalfa. Alfalfa requires large amounts to produce high-protein hay. Yet for most producers nitrogen is not a major concern. This is because alfalfa is a legume and has the ability to live in a symbiotic relationship with nodule-forming bacteria. These bacteria , which live on the roots, provide the alfalfa plant with an abundance of nitrogen. The main concerns about nitrogen for alfalfa are centered on these nodules. First, the bacteria must be present. They usually are in older fields but may be lacking in newly-developed soils. To prevent problems, add the bacteria to the seed, either by directly inoculating the seed with an in-planter box treatment or using seed that has been coated with a coating that includes the proper inoculant. The cost of seed inoculation is a very minor cost to prevent problems. Secondly, create or maintain a favorable environment for the nodule bacteria. This begins with seed storage, store the seed in a cool place, out of direct sunlight and high temperatures. Remember that the bacteria has an expiration date , after which it will be less effective. In the field, the bacteria are sensitive to soil pH. Acid soils, below pH 6.5, can limit survival of the bacteria.

In the Western states, this is usually not a problem, but is a serious problem in the Midwest and East. Acid soils can occur where rainfall is significant or low salt irrigation water is used. It can also develop where ammonium fertilizers are used, especially on sandy soils. There are soil acidity problems in some parts of California. Liming soil is the correction for a pH that is too low or too acid.

If the rootzone of the alfalfa plants is restricted to the upper part of the soil profile, the nodules may be limited enough so that they cannot meet the nitrogen demands of the plants. Supplemental nitrogen might be helpful under those conditions, but it would be better to correct the problem causing the restricted root growth. Some growers apply small amounts of nitrogen at planting time, in the belief that this helps the plants get started. Normally, this does not help and, in fact, can slow down the establishment of effective nodulation. The alfalfa plants will use available nitrogen in the soil first, then turn to the nodules to make up any shortfall. This also means that if alfalfa is grown in a soil high in nitrogen, it will use it first. This fact is being used to develop alfalfa as a plant to clean up nitrogen-polluted soils. Alfalfa may be one of the best plants to remove nitrates from effluent water. The soil nitrogen status in an alfalfa field may test very low.

This can be an advantage, in that weed growth is discouraged by the low nitrogen levels. Also note that use of nitrogen only occurs during the growing season, if water is applied during the dormant season, little if any of the nitrogen will be used by the plants.

And finally, when alfalfa is plowed under it releases the nitrogen in the plant back to the soil. A crop that can use this nitrogen should follow alfalfa in a rotation.

Phosphorus

Phosphorus is the most important nutrient for growers to be concerned about because it is the one which is most likely to be deficient. Soils vary in their ability to supply phosphorus. Deficiency of phosphorus is hard to detect visually, unless it is very severe.

Soil testing for phosphorus is reasonably accurate. The Olsen method is the preferred method in most western states. This method uses sodium bicarbonate as the extractant. This method is good for neutral to high pH and high calcium soils, poor for organic soils. High free lime content in the soil can interfere with accurate interpretation of results. Water extraction is an alternate method for unusual soils. Other states and countries, may use different extractants.

The phosphorus content of the extract is measured and expressed in parts per million. Guidelines have been developed for interpretation:

Phosphorus soil test guidelines: $NaHCO_3$ method

California
0 to 6 PPM = low
6 to 10 PPM = marginal
10 PPM + = adequate

Other states (Colorado,Utah,Idaho)
0 to 3 PPM = very deficient
4 to 7 PPM = deficient
8 to 10 PPM = marginal
11 to 15 PPM = adequate
15 PPM+ = high

Phosphorus Application Guidelines

Test Value	Pounds of P_2O_5 per ton of Hay*
Very Deficient	20 – 25 lbs.
Deficient	15 – 20 lbs.
Marginal	10 – 15 lbs.
Adequate	5 – 10 lbs.
High	0 – 5 lbs.

* Tons of dry alfalfa hay (projected yield).

These guides are intended for general interpretation. Individual soils may differ from these values.

If the soil is very deficient, it is probably better to make a substantial application of fertilizer to correct the deficiency. Once an adequate level is achieved it can usually be maintained by replacing crop usage. Yield is an important factor in this calculation. An average number for phosphate use is about 12 pounds P_2O_5 per ton of hay, the reported range is 10 to 14 lbs.P_2O_5 per ton.

Unfortunately, not all of the applied fertilizer phosphorus is available to the crop. Some is "fixed" by the soil, changed chemically to a non-useable form. The amount that is fixed varies with soils.

Several fertilizer products can be used to supply phosphorus to alfalfa:

0-45-0 (treble superphosphate) – a dry , granular product that is 45% P_2O_5. This material is non-burning, easy to spread, applied by broadcast or band application and contains no nitrogen. It is becoming harder to get and may be phased out in the future because it is more difficult to make, and less profitable, than other phosphorus fertilizer.

11-52-0 (ammonium phosphate) – a dry, granular product that contains 52% P_2O_5. This material is the most popular source of dry phosphorus. It contains 11% nitrogen along with the phosphorus. It is applied broadcast or banded.

10-34-0 (ammonium polyphosphate) – a liquid source, containing 10% nitrogen and 34% P_2O_5. This product is widely used and available. It is broadcast,dribbled,water-run , banded and applied with weed control materials. This product is sold by weight, a gallon weighs approximately 11.4 pounds. It is also used to make mixed liquid fertilizers of other concentrations.

0-52-0 (phosphoric acid) – a liquid source, containing 52% P_2O_5. This material is used to make mixed liquids and directly applied by broadcast, dribble, banding and water-run. It is also used as a carrier for weed control materials, although compatibility needs to be carefully checked. It is an acid, so precautions must be taken in its use, storage and handling.

When liquid materials are water-run, several factors must be considered to make it most successful. When applied through sprinkler systems, precipitation may occur in the system. This can result in plugging small sprinkler nozzles and coating the inside of pipe. This can change the hydraulic properties and harm efficiency of the system. These problems do not occur with flood or border systems. The application uniformity will only be as good as the water distribution is. Water-run applications can permit frequent light applications of phosphorus, which is helpful in dealing with soils which have strong fixation tendencies and where extra applications are needed to make it through the hay season.

Manures are also good sources of phosphorus. They provide phosphorus in organic forms. They tend to provide phosphorus for a longer period. Waste water from animal facilities and water treatment plants can also be a good source of phosphorus. These sources should be considered in planning a phosphorus fertilization program.

Manures are best used in alfalfa as a pre-plant, plowed-in application in a preceding crop. It is best to grow a cereal or grass crop which can use the nitrogen in the manure, and is not as sensitive to free ammonia as alfalfa. Surface-applied manures are used in alfalfa production, but can make weed control very difficult to accomplish.

Phosphorus in the soil is virtually immobile. It stays where it is put. It can be a pollutant if it is washed away by erosion. It is better to plow, disc or inject phosphorus into the soil when making pre-plant applications. Banding, placing the material in concentrated strips, is the most efficient method of all. Banding is preferred where soil is very deficient. If it is only a minor deficiency, the trouble of banding may not be justified. Banding phosphorus into established alfalfa is not needed, top-dressing works.

Phosphorus excess can occur, usually the problem is reduced availability of other nutrients, especially zinc or copper. 60 to 90 days may be needed to get a response from applied phosphorus, so apply it early in the season. Alfalfa quality is impaired by a deficiency of phosphorus, but excess phosphorus will not improve it more.

The sources mentioned are mostly equal in terms of plant response. Economics is an important factor in making fertilizer decisions. Truckload quantities will usually be cheaper than less than truckload quantities. Liquids require more special equipment, but can be combined with other operations to save costs. Liquids are easier to spread uniformly, but dry materials can also be used successfully if applicators are properly maintained and set up correctly.

Potassium

Potassium is the second most common deficiency in alfalfa in California.
Many parts of California and most of Nevada have soils which can supply the needs of alfalfa without supplemental potassium fertilization. Potassium deficiency can cause distinct symptoms in the foliage. Even when symptoms appear, economic response may not occur from potassium fertilizers. Soil testing for potassium is fairly good, but with a catch. The standard extractant, Ammonium Acetate, may not accurately reflect available potassium status of some soils. A second method, acid extraction, should be used where potassium deficiency is suspected. If the Ammonium acetate method shows adequate levels, no further test is needed. Plant tissue testing is again the best way to assess potassium status in the plants. Potassium deficiency is a common problem in other parts of the United States. Lack of potassium is associated with poor disease resistance, loss of stands and poor quality.

Potassium soil test guidelines	**(Ammonium Acetate) extract**	**(Sulfuric Acid) extract**
Deficient	**less than 50 PPM**	**less than 300 PPM**
Marginal	**50 – 80 PPM**	**300 – 500 PPM**
Adequate	**80 PPM+**	**500 PPM+**

Potassium Application Guidelines

Test value	Pounds of K20 per ton hay*
Deficient	**37.5 to 50 lbs.**
Marginal	**18.7 to 25 lbs.**
Adequate	**0 to 12.5 lbs.**

*Tons of dry alfalfa hay per acre (projected yield).

If potassium deficiency is detected and confirmed, supplemental fertilization can correct the problem. Several issues need to be addressed first. If adequate potassium already exists in the soil, the alfalfa will still pick up added potassium. This is termed "Luxury consumption", taking the available potassium without increasing yield. There has been speculation that extra potassium will improve forage quality, however as we learned last year, extra potassium in the hay may be harmful to dairy cows. There is a balance that should be maintained between deficiency and excess. Tissue testing should be used to guide decision making on this topic. If fertilization is called for, excessive rates should be avoided. Sources of potassium include:
Potassium Chloride, Potassium Sulfate, Potassium Nitrate, Sulfate of PotashMagnesia, and manures. Water can also be a significant source of potassium in some areas. Potassium thiosulphate can also be used, this is a liquid source.

Potassium movement in the soil is slight. It should be plowed down in preplant applications. Established alfalfa can be top-dressed successfully.

Sulfur

Sulfur is an important nutrient for alfalfa . Deficiencies do occur in parts of California, usually where there is substantial rainfall or very low-salt irrigation water is used. These areas are mostly in the northern portion of California. Most areas irrigated with ground water or Colorado river water will get adequate sulfur from those sources. Soil testing is a poor method to determine sulfur status.
Where this deficiency is a historical problem, it is wise to apply elemental sulfur when planting new fields. Several years worth can be applied and plowed in. Deficiencies in existing fields may require a faster acting source of sulfur, to supply sulfate quickly. Elemental sulfur is the most economical source but must be converted to sulfate to be effective. Gypsum, (calcium sulfate), supplies sulfur in the sulfate form, but has low solubility.

When looking at water samples, remember that 2.7 times the PPM of a nutrient will give you the pounds per acre foot in the water in question.

Sulfur can also change the soil pH, avoid acidifying below 6.5. Excess sulfur can cause problems with Selenium availability also. Selenium deficiency is an animal nutrition problem important in many parts of California and Nevada.

Micronutrients

Micronutrients are those nutrients that are essential but needed in only small amounts. They include: Zinc, Manganese, Boron, Copper, Iron, Chlorine, Molybdenum for plants. Animals have micronutrients needs. They include these along with Cobalt, Selenium and others.

Boron is deficient in a few places in California. It is important in seed production, less so in hay production. Excess Boron is a problem in several areas of California and Nevada. Excess boron causes leaf burn and reduces yield. Soil testing is not very accurate for Boron status, as a nutrient. Use plant tissue for this nutrient. Water should also be sampled when looking at Boron status. If using Boron fertilizers, be very cautious. Too much, and you have a herbicide.

Molybdenum is also deficient in a few places. Plant tissue again is the best way to determine if this is a problem. Molybdenum excess is a problem in parts of California and Nevada. This is a serious problem because it makes the hay toxic to animals. If Molybdenum fertilization is needed, use caution and be accurate in application.

Iron deficiency is sometimes seen in alfalfa. It usually is because of high pH, limey soils, cold soils or saturated soil conditions. Most soils contain adequate iron, but it is not available under those conditions. Alfalfa is more tolerant to this problem than many other plants. Reducing the soil pH level can be helpful, but on soils high in lime, this is not economically feasible. "Strip Acidification" may be helpful in those situations. Strip Acidification is the application of acid materials in bands or surface strips, to lower pH in a localized area. The intent is to make a zone where iron is available to the plant. Water amendments are also used to lower pH.

Zinc deficiency is a big problem in many crops in California and Nevada. Alfalfa isn't one of them. Soils which test extremely low for zinc can produce high yields. There are some reports of deficiencies but this is very rare.

The content of other micronutrients may be important to the animals which are eating the alfalfa. Tissue testing will be the best method to assess these elements.

pH, Salinity and Boron hazards

These items are usually included in a soil test for alfalfa. Some general guidelines are:

pH - should be between 6.5 and 8.0

If the pH is too low, nutrient imbalances will occur and the rhizobia will not work well.

If the pH is too high, solubility of nutrient elements is very low and growth will be reduced. Water penetration problems are also possible. Liming is the correction for acid soils. A lime requirement test can be done where this is needed. Sulfur or acids are the correction for soils which are alkaline.

Soil Salinity – E.C. should be 2.0 mmhos or less

Higher salt content soils can be used to grow alfalfa, but as the salinity increases, yield will be reduced. 50% reduction in emergence will occur at 8-13 mmhos. 10% yield loss at 3.4 mmhos, 25% yield loss at 5.4 mmhos, 50% yield loss at 8.8 mmhos for established alfalfa. Leaching is the only cure for salinity problems. Water quality and drainage are major factors.

Exchangeable Sodium Percentage – should be less than 15
Too much sodium will cause water penetration problems. Actual range is 10 to 20 depending on soil texture. Sodium absorption Ratio is another way to measure this hazard. To determine sodium status, it will be necessary to know the magnesium and calcium levels in the soil too. Soil amendments are the usual correction for excess sodium. Water quality and drainage are major factors.

Boron – should be less than 1.0 PPM
Soil testing of Boron as a toxic element is useful. Higher boron level soils can be used for alfalfa production, but will have reduced yields. Leaching is the correction for excess boron, but water quality is a major factor. Boron is much more difficult to leach out than salt.

Summary

Soil Testing can be a useful tool in making alfalfa management decisions. It should be employed along with plant tissue and water analysis to develop economically and environmentally sound practices. Fertilizers can be used to correct or prevent nutrient deficiencies which can reduce yields. Improper fertilizer use can harm forage quality, cause nutrient imbalances, cause environmental degradation and waste money.

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