NEWS & VIEWS

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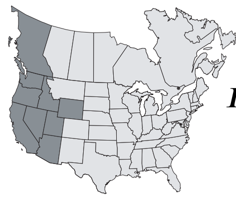

Dr. Robert L. Mikkelsen, West Region Director
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Managing Phosphorus and Potassium for Maximum Alfalfa Yield and Quality

MANY FACTORS are involved in producing a high-quality alfalfa crop. Although some (like rainfall and temperature) cannot be controlled, many other critical components of the production system can be carefully managed. High yields require maintenance of an adequate nutrient supply to meet the needs of the rapidly growing crop. As the demand for high-quality and high-yielding hay increases, closer examination of the role of proper plant nutrition is needed. **Figure 1** shows alfalfa production and yields in recent decades.

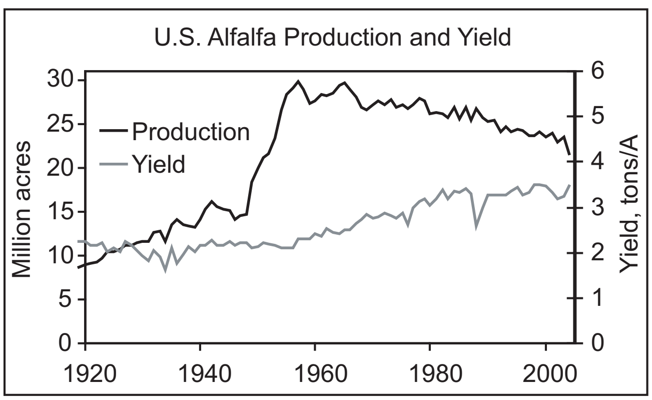
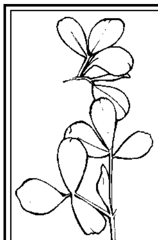


Figure 1. U.S. alfalfa production is valued at over $7 billion annually. Canada also produces about 11 million acres of alfalfa.
Source: USDA-NASS PEBS website and Statistics Canada.

It is not always simple to determine the "correct" amount of fertilizer to add to alfalfa. In most regions, alfalfa growth begins in the early spring and continues through the summer and into the late fall. This very long growing season places a continuous demand on the soil nutrient supply to provide essential elements for many months,



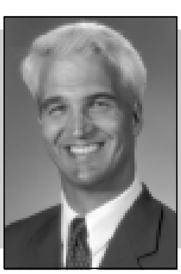
More information on P and K nutrition of alfalfa is available in two new PowerPoint presentations from the PPI website. These presentations review the role of P and K in building alfalfa yields, uptake, soil testing, and fertilizer management approaches. Each presentation, containing more than 30 slides with references, can be downloaded for free.

Go to >**www.ppi-ppic.org/palfalfa**< and >**www.ppi-ppic.org/kalfalfa**<.

under widely ranging environmental conditions. Due to this wide range of growing conditions, only general guidelines are presented here, and they must be adapted to meet local needs. It should also be noted that many experiments on alfalfa fertilization were done at low yield levels, by present-day standards. While these experimental results are helpful in establishing trends, they can be misleading when making precise fertilizer recommendations for modern alfalfa growers. For example, researchers at the University of Arizona produced over 24 tons/A in a carefully managed alfalfa field, demonstrating the high yield potential with near ideal growing conditions.

An essential component of profitable alfalfa production is achieving high yields. Lower costs of production (per ton), improved efficiency, and maximum profits are usually obtained when near maximum yields are grown. High-yielding alfalfa removes large amounts of nutrients from the field in each cutting. On average, alfalfa removes 60 lb N/ton, 15 lb P_2O_5/ton, and 60 lb K_2O/ton. While the N comes from biological fixation, rapidly declining concentrations of P and K are regularly measured in fields where nutrients are removed in alfalfa hay, but low replacement quantities do not match crop removal.

Fertilization with both P and K is essential for alfalfa production — they are the most common nutrient inputs for this crop. These nutrients are involved in many essential metabolic roles within the plant, and deficiencies result in slow growth, suppressed yields, and lost income. This brief review covers some of the recent work regarding P and K fertilizer management for achieving high alfalfa yields.



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Two new Powerpoint presentations are available from PPI and provide many more examples and references than can be given here. See box on front page.

Phosphorus for Alfalfa Nutrition

Phosphorus is involved in a variety of essential reactions within the plant. Higher P concentrations are generally measured in the meristematic regions of actively growing plants. Since P is mobile within the plant, it will translocate from older to younger tissue as required.

Most of the P entering the plant rapidly becomes converted into organic compounds, where it becomes involved in a variety of essential reactions. For example, P in alfalfa is essential for formation of nucleic acids, phospholipids, and ATP. It is also associated with functions such as photosynthesis, protein formation, and nitrogenase activity. Low plant P frequently results in high leaf starch concentrations, which is thought to decrease leaf photosynthetic rates. Reduced leaf expansion (especially the epidermal cells) is also seen in low-P plants. Alfalfa growing with sub-optimal P concentrations typically has high root starch and root protein concentrations. However, the plants are not able to utilize these organic reserves after cutting and cannot quickly regrow.

In addition to direct nutritional benefits, other positive plant responses come from maintaining adequate P supplies. For example, it was reported that in addition to increased alfalfa yields and tissue P concentrations, P fertilization also resulted in an increased number of rhizobia nodules, larger nodule size, and greater N fixation. Numerous other studies have documented the increase in water-use efficiency in properly fertilized crops compared with alfalfa lacking in nutrients such as P or K.

Phosphorus Fertilizer Management for Alfalfa Production

Soils vary in their ability to supply P. Visible nutrient deficiency symptoms in alfalfa are generally hard to detect, unless the deficiency becomes quite severe. Therefore, soil testing is generally the most effective way of predicting the available nutrient supply. The recommended procedure for soil sampling and laboratory analysis varies in different parts of the country based on regional differences, so local advice should be obtained on how to best do this. Tissue testing for P is generally recommended for crop diagnostic monitoring after the alfalfa is established.

Only a portion of applied P is available to the crop during the year of application, since it becomes involved in many soil reactions that tend to reduce its solubility. **Figure 2** illustrates the small percentage of total P in soils that is available for plant uptake at any one time.

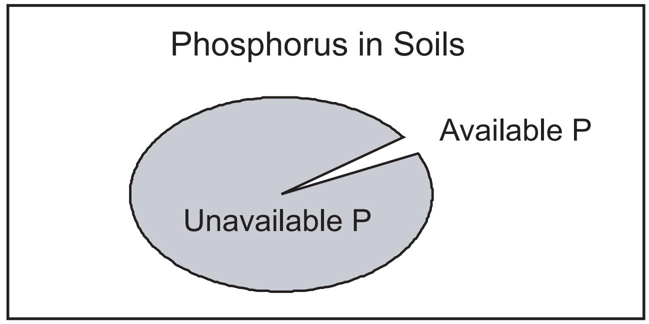

Figure 2. While total P in many soils may range from 400 to 2,000 lb/A in the 0 to 6 in. depth, only a fraction of that is available for plant uptake each season.

Fertilizer P is relatively immobile in soil when applied at normal agronomic rates, so initial P applications are most effectively placed below the soil surface in order to improve uptake by roots. Banding fertilizer P generally optimizes the P recovery, especially where the soil is very deficient and in non-irrigated conditions where moisture limitations may keep roots from utilizing surface-applied P. However, surface banding P fertilizer onto established irrigated alfalfa stands does not offer yield advantages over broadcast P applications.

Fertilizer guides generally recommend that P be applied prior to establishing the crop since an adequate supply of P is critical for rapid stand development. Adequate P is essential for development of strong root systems and fertilization benefits are most apparent in infertile soils and where cool weather restricts nutrient uptake. A beneficial response to added P will only occur when the roots are able to access it. This means having a well prepared root zone with soil moisture and other essential nutrients present in adequate supply.

On established stands, fall or winter applications of P are generally preferred since crop responses are often not seen until 2 to 3 months after application. Avoid applications when the soil is wet or frozen, and when physical damage to plant crowns is likely to occur from field machinery. It has been demonstrated that soil fertility for alfalfa can be maintained by either small annual P applications or larger single applications for a multi-year crop. Surface P applications are effective due to the zone of high root activity near the surface and P uptake directly by the crown. Sufficient soil moisture is essential in order for the plant to recover these surface-applied nutrients.

Many sources of fertilizer P are successfully used for alfalfa production, including both solid and liquid forms. A number of comparisons have shown that most P fertilizer sources are equivalent, when used properly. The selection of a specific P fertilizer form is generally based on local availability, ease of application, and the cost per unit of nutrient. Application of liquid P sources with irrigation water is an effective way of delivering frequent doses of nutrients, but care should be taken if applying P through sprinkler systems to avoid precipitation and plugging of pipes.

Animal manures can be a good source of nutrients, but application to alfalfa does not take full advantage of the added N and may make weeds more difficult to control. Manure applications onto alfalfa stands may burn leaves, reducing hay yield and quality. Field operations associated with manure application may also damage plant crowns and shorten the stand life.

Phosphorus fertilization is an essential component of alfalfa production. A soil test should be taken and the nutrient recommendation followed prior to planting to help improve seedling establishment and promote overall early vigor and competitiveness. The soil nutrient status should be monitored with tissue testing and the large amounts of P removed in high-yielding crops must be replaced when the soil P supply can not meet the plant demand. A variety of P sources can be successfully used and the application method should be chosen to maximize the efficiency of the applied fertilizer. Failure to monitor and replace the nutrients removed in the harvested hay will ultimtely lead to losses of yield, plant stand, and profit.

Potassium Fertilizer Management for Alfalfa Production

More K is removed in harvested alfalfa than any other soil nutrient (50 to 60 lb K_2O/ton of hay). Potassium deficiency is a relatively recent occurrence in many Western soils. For example, some Western fertilizer guides from the 1950s declared that only few K deficiencies existed due to high native levels of soil K and the presence of K in irrigation water. However, a long history of high-yield alfalfa production has now depleted much of the native soil in many places and regular soil testing is important to determine the fertilization required to replace the previously harvested K.

Potassium has many critical roles in plant growth and development. In addition to the well-recognized role of K in stomatal regulation and photosynthate transport, K has an important role in enhancing N_2 fixation in alfalfa. Adequate K also helps to reduce grass and weed invasion and to improve stand persistence and winter survival.

Alfalfa has lower root density than most grasses and generally a deeper rooting zone where soil moisture is available. Despite this deep root system, alfalfa absorbs K most heavily from near the surface soil, compared with the deeper horizons. This finding supports the efficiency of the common practice of topdressing K fertilizer onto existing stands of alfalfa when needed.

Alfalfa can accumulate greater amounts of K than are required for the level of hay production, sometimes called luxury consumption. The range between crop deficiency (and resulting yield loss) and slight luxury consumption may be difficult to precisely delineate and may also vary throughout the growing season based on environmental factors. Since maximum profitability is generally achieved by obtaining high efficiency and high yields, it is not beneficial for a farmer to grow hay with insufficient nutrient inputs. Do not wait until K-deficiency symptoms are visible (small white spots first appear around the outer edge of the older leaves) because yield, quality, and stand health have already decreased by this time.

Ruminant animals fed alfalfa hay have a higher K requirement than non-ruminants. Potassium is essential for rumen microorganisms. The most commonly observed effect of suboptimal K in the feed of ruminants is decreased feed intake. Lactating dairy cows, especially high-producing cows, require the highest levels of dietary K of most livestock. Under high heat stress, their optimal level of dietary K can be as high as 1.9%, but the normal National Research Council (NRC) recommendation is 1% K of the dietary dry matter. Less dietary K (0.65%) is suggested for dry cows, calves, and heifers. During the last several weeks before calving, excessive K in the dry cow diet can increase the occurrence of milk fever and retained placentas, leading to reduced milk production during the subsequent lactation. That's why high dietary K, including very high-K hay, should be avoided during this time.

Potassium nutrition should be considered in association with the other essential plant nutrients. For example, K will compete with other cations…such as calcium (Ca), magnesium (Mg), and sodium (Na)…for plant uptake. Many studies have shown that in acid soils, a proper liming program must be conducted before healthy root growth and the full value of K fertilization will result. Similarly, without the presence of adequate P, fertilization with K will not provide the expected stimulation in alfalfa growth.

There are several excellent K sources for alfalfa fertilization, most commonly potassium chloride (KCl), potassium sulfate (K_2SO_4), and potassium magnesium sulfate ($K_2SO_4 \cdot 2MgSO_4$). The selection of a specific K source is largely based on the need for the accompanying nutrients (such as sulfur and Mg) and price, since the actual K is identical in all these sources. Once soil K concentrations are adequate, moderate rates of K applied annually may be sufficient to maintain high levels of production. Use care when applying high-K animal waste to avoid excessively high tissue K concentrations. ■

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