



John Grove, Ph.D. is currently the Director of the Research and Education Center at Princeton and a Professor in the Department of Plant and Soil Sciences at the University of Kentucky. His areas of interest include soil science, soil fertility, soil management, and plant nutrition in plant production systems. Dr. Grove has numerous publications on topics ranging from soil mineralogy, soil aggregates, and soil properties. He has been recognized by the UK Alumni Association for the Great Teacher Award. He has had a tremendous impact on soil science education through the training of over a thousand undergraduate and graduate students during his career. Dr. Grove earned his Ph.D. in Agronomy from the University of Georgia.

Getting the Full Benefit of Your Lime/Fertilizer Dollar

John H. Grove

University of Kentucky Professor for Plant and Soil Sciences

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Start with a soil test, even if soil testing is not a perfect way to identify nutrient needs. There are no one-size-fits-all formulas for starting a field of alfalfa – every field is ‘fertility unique’. Your prior knowledge of the field will cause you to make your initial soil test either well ahead of, or rather closer to, alfalfa seeding. The major driver of the timing of the initial soil test is soil acidity. If field soil acidity is suspected, soil test well ahead of seeding – 6 to 12 months ahead. Lime takes time to more thoroughly neutralize higher amounts of soil acidity (soil pH < 5.8). Otherwise, make the soil test 3 to 6 months ahead of seeding. UK lime and fertilizer rate recommendations are intended to maximize lime and fertilizer value to the alfalfa grower – and are nuanced (especially in the splitting of the high rates of phosphate (P₂O₅) and potash (K₂O) associated with low testing fields.

The unique nature of individual established alfalfa fields means that there is also no one-size-fits-all formula for fertilizing an established stand of alfalfa – you need to sample each and every year. And for many situations, fall soil testing just after the next to last cutting, so as to

guide fertilizer application just ahead of the last cutting, is the optimal soil testing time. Needed lime, phosphorus (P) and potassium (K) can then be applied in time to help maintain alfalfa stands through the upcoming winter.

When you get a soil test report, remember that each and every number on the report is not of equal value to you. For alfalfa, the main items of value are soil pH and soil buffer pH (these two combine to give the lime recommendation); and both soil test P and K – if measured using the Mehlich III extraction method of determination. Soil test boron (B) may have some value, if the lab uses the ‘hot water’ method. Measures of soil cation exchange capacity (CEC), and soil test sulfur (S), copper (Cu), iron (Fe), (Mn) have much less value, for different reasons.

Luxury consumption is the essence of an alfalfa constituent that producers don’t get paid for. The particular problem is K. Fertilizer K prices are hovering between \$300 and \$500 per ton – considerably less than the \$850/ton reached 8-10 years ago, but considerably greater than the former steady state of \$125/ton two to three decades back. Luxury consumption of K by forage crops, especially alfalfa, is a challenge that should be understood by growers. In essence, luxury consumption of K by alfalfa means that the crop’s uptake of K is in excess of the crops need in order to make dry matter (yield). Luxury consumption happens when the crop is supplied with more than adequate K, whether from soil or added fertilizer.

When alfalfa has adequate K nutrition, the tissue (upper 6 inch whole stem sample taken between late bud and one-tenth bloom) K concentration is usually between 2.0 and 3.5%. When K supply is greater than crop need, tissue K concentrations can rise to 4.5%. With alfalfa, where the entire above-ground portion is harvested, excessive K uptake is removed as hay or silage. Luxury consumption can increase K removal to ~ 90 lb K₂O per ton of hay (55 lb K₂O per hay ton is normal removal for high-yield alfalfa). The important management issue with luxury K consumption is that fertilizer applied to increase soil test K can be mostly and immediately removed with the first harvest after K application, resulting in lower soil test K levels supporting alfalfa growth for subsequent harvests.

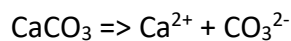
There are several ways to limit the risk of luxury consumption. First, try to maintain soil test K between 300 and 450 lb per acre (150 to 225 ppm K). This soil test K range generally prevents plant available K over-supply to the alfalfa crop. When soil test K values drop below 450 lb per acre (225 ppm), a fertilizer K recommendation/application is triggered – with the objective of maintaining a soil test K level at/near 450 lb per acre. This will provide adequate K for optimum yield while limiting the opportunity for luxury consumption. Soil test levels between 300 and 450 lb per acre usually require relatively modest fertilizer K application rates (60-120 lb K₂O/acre). Second, avoid applying any K fertilizer between the previous year’s last fall harvest and next year’s first spring cutting if soil test K is between 300 and 450 lb per acre range. Overwinter soil freeze/thaw cycles winter months usually loosen enough ‘fixed’ soil K to supply K needed to support alfalfa’s first cutting – usually the highest yielding cutting – without causing luxury consumption. If soil test K values fall below 250 lb per acre, well into the ‘medium’ range, then split fertilizer K applications may be needed during the summer months in order to increase/maintain available soil K/alfalfa K nutrition but minimizing luxury

consumption. In a four/five cuttings per year production system, alfalfa producers can split K fertilizer application between just after the first cutting and just after the third cutting. This is a practical way of reducing springtime luxury K consumption, enhancing alfalfa yield in later cuttings, and improving overwinter stand survival.

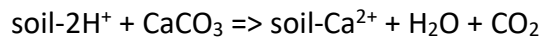
In Kentucky's alfalfa fields, soil acidity/pH management is intimately linked to calcium and magnesium management via liming. High yields of quality alfalfa require near neutral soil pH values – both at seeding and for the duration of the stand. Alfalfa removes about 30 lb of calcium (Ca) and 6 lb of magnesium (Mg) per dry matter ton – about the amount of Ca and Mg found in 100 pounds of dolomitic ag lime. How does this happen and what does it mean? Alfalfa growth causes both Ca^{2+} and Mg^{2+} cations to be removed from the soil. To preserve charge balance, a good deal of that Ca and Mg uptake is balanced by excretion of acid hydrogen protons (H^+) into the soil – residing on soil cation exchange sites formerly occupied by the Ca and Mg taken up by the alfalfa. Both existing (at seeding) and on-going soil acidification must be neutralized in order to establish and maintain a high yielding alfalfa crop. How do we neutralize soil acidity?

Bases are used to neutralize acid soil H^+ . Bases include hydroxides (OH^-), oxides (O^{2-}), bicarbonates (HCO_3^-) and carbonates (CO_3^{2-}). Acid soil H^+ cannot be neutralized by chlorides (Cl^-), nitrates (NO_3^-) or sulfates (SO_4^{2-}). In soil, the neutralization of acid soil H^+ by calcitic ag lime (calcium carbonate, CaCO_3) goes as follows:

- 1) First, CaCO_3 dissolves in the water in the soil:



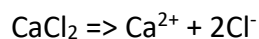
- 2) Second, acid H^+ is neutralized by CO_3^{2-} , and simultaneously replaced by Ca^{2+} :



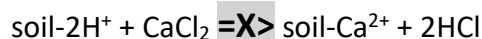
Note that acid H^+ is neutralized by the base CO_3^{2-} , not by the Ca^{2+} . Also note, sadly, that 100 lb of CaCO_3 is required to neutralize 2 lb of H^+ . This 50 to 1 weight ratio means that effective lime additions are in hundreds of pounds/tons per acre. Why is acid H^+ not neutralized by CaCl_2 ?

If we **could** react acid soil H^+ with CaCl_2 , the reactions (comparable to reactions 1 and 2, above) would be as follows:

- 3) First, CaCl_2 dissolves in the water in the soil:



- 4) Second, acid H^+ is neutralized by 2Cl^- , and simultaneously replaced by Ca^{2+} :



Note that the reaction cannot proceed. In fact, the reaction would form a very strong acid, hydrochloric acid (HCl), and HCl is unstable in the soil. So, this reaction cannot happen – can't happen with $\text{Ca}(\text{NO}_3)_2$ or CaSO_4 , either. Both nitric acid (HNO_3) and sulfuric acid (H_2SO_4) are also very strong acids and are unstable in the soil. Chlorides, nitrates and sulfates are simply salts – and you get salts from the reaction of a base with a strong acid. This means that a simple salt can never be either an acid or a base. So, if the label indicates that the product is “derived from calcium chloride”, then there is no chance that the product will neutralize soil acidity and thereby raise soil pH. It's not going to happen. Loss of money and time. Liquid calcium chloride is most often used as tire ballast and as first-deployed road salt – and works as intended in these applications. So, why not use liquid/suspension limestone (finely ground calcium and magnesium carbonates)?

First, let's consider how much material we need – 50 pounds of effective CaCO_3 for each 1 pound of acid H^+ . We buy a liquid/suspension product weighing 14.8 lb/gallon with a calcium carbonate equivalence (CCE) of 64% (is only 65% because the product is about 70% solids and 30% water, by weight) and a relative neutralizing value (RNV) that is also 64% (same number because all the limestone in the product is ground to pass a 200 mesh screen). This is a good quality product, so we pay \$10/gallon, bulk rate (2.5 gallon jugs cost a bit more than \$20/gallon). We paid $\$10 / (0.65 \times 14.8) = \1.04 per pound of effective CaCO_3 with this purchase. We get agricultural limestone with a reasonably mediocre RNV of 50% for \$30/ton, delivered and spread on the alfalfa field. We paid $\$30 / (0.50 \times 2000) = \0.03 (3 cents) per pound of effective CaCO_3 in this comparison purchase. Enough said.

Foliar products can serve as a source of both macronutrients and micronutrients. Almost all of these materials are liquids, though there are a few that may be 'dusted' onto plant foliage. Foliar micronutrients are very effective if used at recommended rates and timings, though a good cost comparison includes both the cost of the different materials/forms and the cost of the different application methods that may be involved. Ease of application favors foliar liquid materials, but the need, in some cases, for repeated applications can weigh heavily against them in favor of a single heavy soil application of either dry solid or liquid materials.

Foliar macronutrients suffer from two problems. First, and remembering that foliar materials are higher in quality/more soluble in water relative to their dry granular competitors, is the cost per pound of delivered nutrient. Economic comparisons for foliar products proposing to deliver N, P_2O_5 and K_2O with equivalent nutrient delivery via dry fertilizers almost always yield the same results as those observed for the comparison between liquid/suspension lime and agricultural lime shown above. Foliar macronutrients are often twenty times (20X) more expensive.

Second, crop demand for macronutrients is somewhere in the tens and hundreds of pounds per acre. Foliar macronutrient sources consist of soluble fertilizer salts dissolved in water. Soluble salts tend to scorch/burn crop foliage when applied to deliver rates of needed macronutrients. One or two applications that do not result in burn will deliver macronutrients at too low of a rate to eliminate a macronutrient deficiency, even a hidden hunger discovered by plant tissue

analysis, though they can cause 'temporary greening' in a crop. Multiple applications of low macronutrient rates can be delivered via irrigation (fertigation), but that option is limited to the ~3% of Kentucky crop acres that are sprinkler irrigated.

In summary, there are a number of ways to make sure that you are getting the most bang for your lime/fertilizer dollar. Alfalfa nutrient/pH management is well informed by a good soil testing program that starts before seeding and continues for the life of the stand. Luxury consumption of K can and should be avoided – again, soil testing helps guide the alfalfa grower. All producers should use lime/nutrient products that are best able to cost effectively deliver soil acidity control/nutrient needs. Some product claims are simply untrue and purchase of these is a total waste of money and time.