IPNI INSIGHTS
International Plant Nutrition Institute

Consequences of Cutting Back on Potassium

May 2009

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Many growers in the Southeast reduced K fertilizer applications this season for economic reasons. Potassium is critical for plant water relations, enzyme activation, photosynthesis, protein synthesis, and resistance to various forms of plant stress. Failure to provide adequate amounts of this nutrient to the plant will result in reduced growth and yield loss. The answers to the following questions will outline the points that need to be considered when making future decisions about K fertilizer and monitoring the impact of past decisions.

What will happen if I don't apply K?

Well, it depends. Is a K application required for your cropping system? A soil test is the best way to determine your current soil nutrient status and the best piece of information you can use to evaluate your options regarding fertilizer applications. Several factors will affect soil K content, including parent material, climate, clay content, and CEC. Many soils in the Southeast are not naturally high in exchangeable K. This is especially true for the low CEC, deep sands found in the extreme Southeast where K leaching frequently occurs. The most recent IPNI soil test survey indicated that averaged across states, over half of the soil samples analyzed for K in the region required annual K fertilization for most major crops **(Figure 1)**. In these situations, typically where soil test K is medium or lower, choosing to not apply the recommended fertilizer rate can definitely result in lost yield and profit.

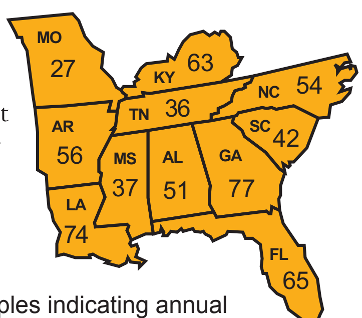


Figure 1. Percentage of soil samples indicating annual K fertilization needed for major crops, by state.

My soil test is high but K is recommended. Can I skip this application?

Most soil testing laboratories in the Southeast use a build-up/maintenance approach for making fertilizer recommendations. At soil test levels of medium or lower, the recommended fertilizer rate will include enough of the nutrient to satisfy crop requirements and to also build-up soil reserves and subsequent test levels. The fertilizer recommendation that is made when soil test levels are high is a maintenance application intended to replace some of the K that is removed in the harvested crop and sustain the soil at the high-testing level. Choosing not to make this maintenance application will probably not have a major effect on yield in the short term. Over time, however, continued removal of K without replacing any through fertilizer application will lower soil test levels to the point that yield loss will occur. How long this process will take depends on crop type, yield level, and initial soil test K level.

Typical K removal estimates for crops common to the Southeast are reported in **Table 1**. Potassium removal is tied directly to crop yield. The removal values listed in **Table 1** are based on an average yielding crop; so, greater amounts of K than shown will be leaving the system in higher yielding environments.

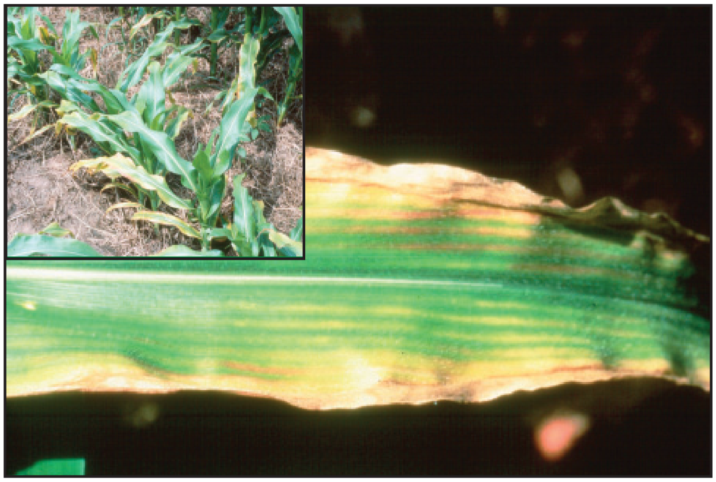
Table 1. Typical K removal estimates for crops common to the Southeast USA.

Crop	Yield	K_2O Removal
Corn	150 bu/A	44 lb/A
Soybean	40 bu/A	56 lb/A
Cotton	2 bale/A	40 lb/A
Wheat	65 bu/A	22 lb/A
Rice	150 bu/A	27 lb/A

How does crop K removal affect soil test K?

The rule of thumb used throughout much of the Southeast is that soil test K will be reduced by 1 ppm for every 8 to 16 lb K_2O/A removed on sandy loam to silt loam soils, respectively.

Abbreviations and notes: K = potassium; CEC = cation exchange capacity; ppm = parts per million.



Corn leaves showing K deficiency.

For example, a two-bale cotton crop grown on a sandy Coastal Plain soil can be expected to reduce soil test K by 4 to 5 ppm annually if K is not replaced. Another consideration regarding drawing down soil nutrient levels is that to build them back up, 8 to 16 lb K_2O/A will still be required to raise the soil K level by 1 ppm. However, this rate must be applied *above crop removal*, making it more costly in many situations to build soil test K levels back up after they have been allowed to decline than it is to maintain them at a high level with annual applications.

The reality in the Southeast is that many growers in the region have been skipping maintenance applications for 2 to 3 years already. It is in these situations where careful attention to nutrient balance and soil test levels needs to be directed.

I know I need to apply K. How much yield will I lose if I don't apply any?

Again, the answer to this question depends on the crop, location, climate, and initial soil test K level. Crop yield loss will occur when soil test levels fall below what is considered sufficient for plant growth. However, the upper limit of the K sufficiency range for a specific crop will vary from state to state. Responsiveness to fertilizer additions also varies across locations, which affects how laboratories categorize soil test K levels (e.g. low, medium, high). **Table 2** depicts a generalization for the Southeast of the expected response to fertilizer application and

Table 2. Generalization for the Southeast of expected response to fertilizer application and expected yield loss if fertilizer is not applied at different soil test levels.

Soil test category	Probability of response to	Expected yield loss without
VL	>80%	50%
L	60-80%	25-50%
M	40-60%	0-25%
H	20-40%	0-10%
VH	<20%	0%

expected yield loss if fertilizer is not applied at different soil test levels. If recommended K applications are not made, intensified field scouting can help detect deficiencies early and efforts can be made to minimize yield losses using an in-season K application.

What does K deficiency look like?

Symptoms common to crops in the Southeast typically include marginal chlorosis and bronzing of the lower leaves. Eventually, necrotic areas occur around the margins and between the veins. Leaves can also become brittle with buckling and crinkling between veins and cupping under of the leaf lobes. In cotton, late-season deficiency can also occur with symptoms appearing first on the younger leaves in the upper third of the canopy and can ultimately result in premature leaf shedding, early cut-out, poorly formed bolls, inferior lint quality, and reduced yield. The images shown on this page can aid in identifying K deficiency symptoms.

The best practice to avoid yield losses due to K deficiency is to prevent the problem from occurring by regularly testing the soil and applying the recommended fertilizer rates to maintain sufficient soil K levels. However, each grower must decide for themselves what makes the most economic sense for their operation. If the decision to cut back on recommended K fertilizer applications is made, then the decision to accept greater risk of yield loss must also be made. This risk can be managed, however, by early and thorough scouting of fields and a return to normal fertilization practices as soon as possible. ■

Cotton plants showing K deficiency.

Soybean plants showing K deficiency.

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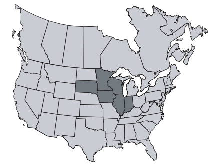

Keep an Eye on Potassium this Season

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In much of the Corn Belt, native soil K supplies are insufficient for crop growth. In the eastern Corn Belt, a common practice is to use fertilizer to build soil test K up to a level that will not limit crop development and yield, then maintain that level with application rates that are equal to crop removal. Historically, when economic conditions worsen, some farmers have used rates less than those required to build and/or maintain soil supplies or such applications have been omitted entirely.

The regularly scheduled K applications in this fertilization system are often used as a practical approach to managing the variability in soil test K, both across the field as well as over time. When these applications are omitted, variability in soil K supplies becomes more apparent and needs to be monitored closely, to ensure levels at various places within the field do not become yield limiting.

Suggestions for Monitoring K in the Soil-Crop System

Cutting back on K for short term economic reasons reinforces the need to monitor crop K nutritional status more closely, especially given the greater variability that is expected to result. The following are some tips:

- Sample at the same time of year. This helps take out some of the seasonal variability. Switching from fall to spring sampling can introduce significant changes from one sampling period to the next.
- Ensure samples are representative and composed of enough cores. This may require some strategizing. If areas of the field have been inexplicably variable from one year to the next, increasing the number of cores going into those samples may help stabilize some of the variation over time.
- Find a quality lab and stick with it. Staying with the same lab removes the lab to lab variability from the overall year to year variation.
- Find ways to control depth of sampling to ensure consistency. Adding stops to the probe or creating marks are possibilities.
- Keep track of nutrient additions and removals to calculate nutrient budgets. When additions exceed removals, soil test levels are expected to build. When removal exceeds additions, levels are expected to decline.
- Consider setting up some monitoring areas. Places to start are on soils that have been changing in unpredictable ways. Samples of these areas should be taken every year to gain a better understanding of soil test K dynamics. Keeping additional information on these areas, such as moisture conditions at sampling and nutrient budgets, may provide some further insights into the primary causes of variability.
- Scout fields to look for visible signs of nutrient deficiency. In both corn and soybean, deficient plants will typically begin to show yellowed tissue along the edges of lower, older leaves first. If the deficiency persists, more affected leaves will appear at progressively higher positions on the plant.

Causes of Soil K Variability

Variability in soil test K has many causes. A few of the more commonly encountered ones are listed below:

- **Time of year**. Studies in the Midwest have shown that levels are typically lowest in November, rise during the winter, and peak in March. During the cropping season, K levels decline, again reaching their minimum. In some areas of the Corn Belt, crop advisers report that growers are requesting a shift to spring, rather than fall, soil sampling. This shift could cause soil test levels to increase above expectations when compared to samples from previous years' fall samples.
- **Nutrient uptake and removal by crops**. Comparing the amount of K removed to the amount applied is often used as a way to predict the direction of soil test changes in the future. If more K is applied than removed, then a positive budget exists and levels are expected to increase. If application rates are less than removal rates, then soil test levels are expected to decline. How quickly and how much soil test levels will respond to budgets depends on the mineralogical properties of the soil, environmental conditions, and the magnitude of the K budget surplus or deficit.

Abbreviations and notes for this article: K = potassium; ppm = parts per million.

Photo by Terry Wyciskalla, Nashville, Illinois.

Potassium deficiency symptoms appear in these soybeans in an Illinois field in 2008.

Photo by Dr. Carl Crozier, North Carolina State University, and David Hardy and Brenda Cleveland, North Carolina Dept. of Agriculture and Consumer Services.

Potassium deficiency in corn.

- **Release of K from crop residues**. Potassium is not tied up in organic forms in the plant. Therefore, it is easily leached from plant residue with moisture. Consequently, the timing and quantity of precipitation relative to harvest and sampling can affect the K levels measured by a soil test. Soil samples taken immediately after harvest would not detect much of the K contributions from the recently harvested crop's residue. However, later sampling after more precipitation would be expected to capture more of the leached K, leading to higher soil test readings.
- **Soil moisture**. Many advisers have noticed that soil moisture at the time of sampling can greatly affect soil test K results. The reasons behind these changes are not clear, but have been linked to the release of K from interlayer positions of certain clay minerals. This mechanism is likely largely responsible for the seasonal variations discussed earlier.
- **Nutrient stratification**. Nutrient stratification is a gradient of soil test levels with depth. In reduced tillage systems, levels of K can be several hundred ppm greater at the surface than just a few inches down. An important aspect of stratification is the shift in soil test levels not only at the soil surface but throughout the soil profile. Some studies have shown that, relative to more aggressive tillage systems such as moldboard plowing, reduced tillage systems have relatively higher levels near the surface but relatively lower levels deeper in the soil profile.
- **Depth control during soil sampling**. Controlling sampling depth becomes more important as nutrient stratification increases. If samples are taken shallower than recommended, inaccurately high soil test K levels may result. If samples are taken too deeply, the opposite may occur.
- **Number of cores in a soil sample**. A representative sample is critical for assessing soil nutrient status. Soil test K levels can be highly variable within a field. Causes of variability include differences in landscape position, erosion, and management history. Taking a small number of cores results in reduced chances that the sample represents the average fertility of the area. In addition, smaller core numbers lead to greater variability among samples taken from the same area. Consequently, taking too few cores per sample can contribute significantly to the observed year-to-year variability in soil test results, producing random increases or decreases.

Soil test K is known to be variable, both across the field and over years. For this reason, it requires more careful management and a greater attention to detail, especially when regularly scheduled K applications are reduced or omitted. Doing a good job of monitoring K soil fertility is a good investment of time and resources to ensure crops are capable of yielding their full potential. ■

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There are four categories in the competition: **Nitrogen (N), Phosphorus (P), Potassium (K), and Other**. Entrants are limited to one entry per category (one individual could have an entry in each of four categories). Cash prizes are offered in each of the four categories as follows: First place = US$150.00; Second place = US$75.00; and a Grand Prize of US$200.00 will be awarded to the entry with the best combination of photographic quality and supporting evidence across all categories.

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Reference #09065

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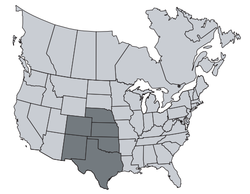
Potassium…Still Important in Bermudagrass Forage Production



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Bermudagrass is an important summer perennial crop for livestock grazing and hay production in the southern USA. It has several characteristics that make it attractive to producers, including high yield potential, drought resistance, and a degree of soil acidity tolerance. Hybrid bermudagrass is generally more productive than common. Coastal has been the standard hybrid over much of the southern part of the country; however, other hybrids such as Tifton 85 have made inroads over the past few years. Bermudagrass is highly responsive to N fertilization and requires comparable amounts of available K (**Table 1**).

Approximately 50 lb of potash (K_2O) is required to produce each ton of bermudagrass. Uptake of K can equal 4 lb/A/day in a rapidly growing crop. In a pasture situation, much of this (as much as 85%) is returned to the soil in animal excrement. But, in a hay meadow essentially all nutrient uptake is exported from the field. Considering this, it stands to reason that soil K may be rapidly diminished under intensive bermudagrass hay production, especially in coarser textured soils. This was well demonstrated in an east Texas study where on two sandy soils the level of soil test K was decreased after 3 years of Coastal bermudagrass production to about one-third the initial levels (**Figure 1**). Even with application rates of 300 lb K_2O/A/year, soil test levels were reduced with haying.

Potassium input is currently under considerable scrutiny in production agriculture because of price levels and, as a result, reductions in K input may seem expedient over the short-term. But the potential consequences of such reductions should be weighed and considered carefully. For example, consider that K nutrition can affect bermudagrass stand density and longevity, N input use efficiency, and of course yield level.

Table 1. Approximate total nutrient uptake by hybrid bermudagrass. (after Bade and McFarland. TAEX. SCS-1998-30.)

Yield, ton/A	N	P_2O_5	K_2O	S	Mg
	- - - - - - - -	- - - - - - - -	lb/A	- - - - - - - -	- - - - - - - -
6	300	60	270	36	18
8	400	80	360	48	24
10	500	100	450	60	30

Abbreviations and notes for this article: N = nitrogen; K = potassium.

K and Stand Density

Potassium input can have a substantial impact on bermudagrass (stand) density, which in turn affects other important production factors such as weed encroachment and longevity of production. Stand deterioration is frequently attributed to winterkill, disease pressure, and lack of "physiological hardening"—all factors that to some degree can be associated with K nutrition.

A classic study showing the impact of K input on Coastal bermudagrass stand density was conducted some years ago at the Texas A&M University Overton station. **Figure 2** shows results from this study, where stand density and rhizome production were measured in the summer/fall after 3 years of K applications were discontinued. Stand

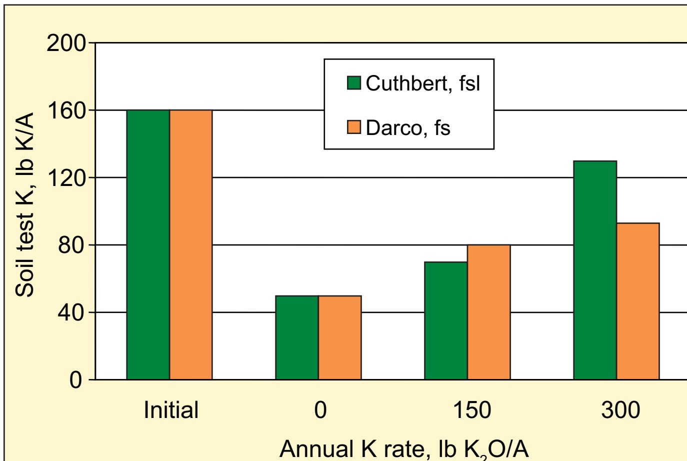

Figure 1. Effect of K fertilizer input on soil test K level after 3 years of bermudagrass production on two sandy soils in east Texas. Potassium was applied yearly as KCl. (Source: Nelson et al. 1983. Soil Sci. Soc. Am. J. 47: 963-965.)

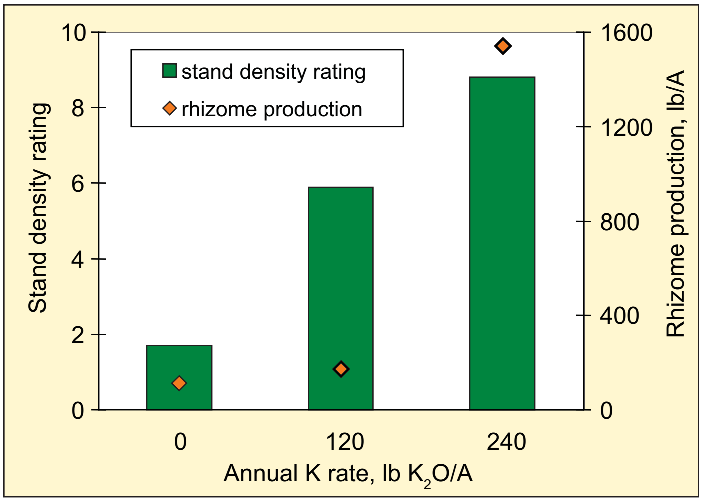

Figure 2. Effect of K fertilizer on stand density and rhizome production of Coastal bermudagrass (Cuthbert soil series). Potassium fertilizer was applied for 3 years. These measurements were made in late summer and fall the year after applications were discontinued. (Source: Keisling et al. 1979. Agron. J. 71: 892-894.)

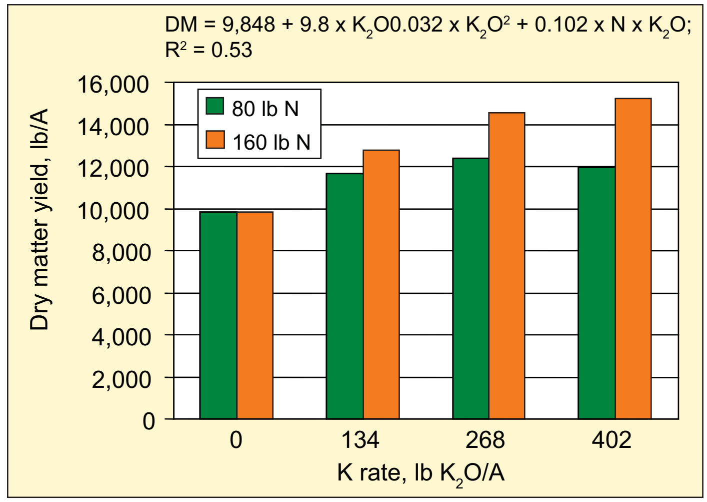

Figure 3. Effect of increased N rate on Tifton 85 bermudagrass response to K in 2004 (Overton, TX). The N rate was applied for each of 5 harvests and K rate was split into 3 in-season applications. (Source: Haby et al. 2008. Great Plains Soil Fertility Conf. Proceed. p. 134-139).

density rating in this work was improved by an order of three to five times by K input. Note also in **Figure 2** that rhizome production was dramatically improved by K fertilizer. The amount of rhizomes and the associated stored energy reserves are important factors in stand maintenance and the regeneration of top growth. It is worth noting here that overall root vigor generally paralleled rhizome production, and that this improved root vigor likely translates into better moisture and N use efficiency as well. The results of this study provide an excellent demonstration of the observation that what happens above-ground is a reflection of what's going on beneath the surface.

K and N Interaction

Potassium fertility has long been known to interact with N nutrition in crop production. To get the most out of N fertilizer inputs, it is necessary to have an adequate supply of available K. A recent study on Tifton 85 bermudagrass has helped demonstrated this (**Figure 3**). Notice in the figure that addition of some K improved yield response to N at the lowest N rate, thereby implying an improvement in recovery of applied N (actual efficiencies were not measured outright). This effect was not observed beyond the first increment of K at the lowest N rate. However, at the highest N rate there was a yield benefit to the higher levels of K. This interactive effect is such that K input can influence the effectiveness of applied N, and for that matter other inputs too. Indeed, for any production system to function at optimal efficiency, complete and balanced nutrition is essential.

One of the best ways to determine K need is with a representative soil sample. That said, keep in mind that soil test K can be variable, both across the field and over years. For this reason, it may require careful management and attention to detail, especially when regularly scheduled K applications are reduced or omitted. Doing a good job of monitoring K soil fertility is a good investment of time and resources to ensure crops, including bermudagrass, are capable of yielding their full potential. ■

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Reference #09070

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What Are the Consequences of Not Maintaining Soil Potassium?

May 2009

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There's no question that increases in potash prices have led to cutbacks in maintenance applications. Maintenance applications typically aim to replenish the K removed with the harvest of crops. Continuing cutbacks indefinitely will inevitably reduce yields, but producers want to know when and how much. This article attempts to answer those questions based on available data.

How fast will soil test K decline? A general rule of thumb is that K soil test declines by 1 ppm for each 8 lb/A of K_2O removed, if no fertilizer or manure is applied to replenish nutrients. (This rule assumes typical uptake for annual crops from the top 6 to 8 in. of soil. Some crops, particularly alfalfa, may take up a higher portion of their K from deeper soil, resulting in less change in soil test K than given below.) Using a crop removal chart and yield records, removals and consequent soil test declines can be calculated specifically. Generally, with good yields and assuming a decline of 1 ppm for each 8 lb/A of K_2O, here are the levels of soil test decline to expect annually, based on typical removals:

- Wheat grain: 4 ppm
- Corn grain: 5 ppm
- Soybeans: 8 ppm
- Potatoes: 20 ppm
- Corn silage: 20 ppm
- Alfalfa or legume hay: 36 ppm

At what point will the soil test decline reduce yields? Yields are reduced when soil test K declines into the responsive range. The upper limit of this range varies considerably by crop and by recommendation source. For example, the university-defined critical value for corn is 75 ppm in New York and 125 ppm in Ohio. Part of the reason for this may be that there is a wide range of soil test K in which responses occur, are often small, but are occasionally large. However, once well below the critical level, responses are more consistently large.

How much will the soil test decline reduce yields? Expected yield reductions are shown in **Table 1**, based on field response research conducted in Ontario, Canada. The median response to applied K is the best estimate of the expected yield loss when K fertilizer is not applied, for each of three soil test categories. The maximum is the largest response observed in the total number (n) of field trials represented in the database.

Can profitability of K use be improved with site-specific application? Within fields, there is spatial variation in the level of soil test K. The areas with low soil K can be identified with more intensive spatial sampling—either by zones or by grids—or by scouting for deficiency symptoms. If specific areas of the field are low in K, it will be more cost-effective to direct applications to those areas.

What do K deficiency symptoms look like? The pictures on the following page can aid in the identification of areas deficient in K. Generally, where deficiency symptoms occur, there is yield loss as well. Most plants will show chlorosis (yellowing) and necrosis (dead tissue) along the margins of leaves, beginning with the lower leaves.

Table 1. Response to applied K (or, expected yield reduction when no K is applied).

Soil test K	Corn, bu/A n=96		Soybeans, bu/A n=128		Alfalfa, ton/A n=53	
ppm	median	maximum	median	maximum	median	maximum
< 80	10	49	1.3	14	1.1	2.0
80-120	4	22	1.0	11	0.4	1.3
> 120	1	15	0.5	14	0.1	0.7

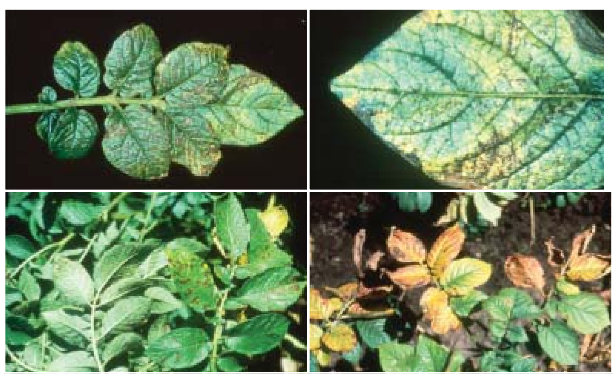
Abbreviations and notes for this article: K = potassium; ppm = parts per million.

Corn K deficiency.

Soybean K deficiency.

Wheat K deficiency.

Alfalfa K deficiency.



Potato plants showing K deficiency.

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