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POTASSIUM for minnesota soils

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Total potassium in the soil doesn't mean much to plants. Fine-textured soils could contain 40,000 pounds per acre but as little as 1 percent may be available for plant growth.

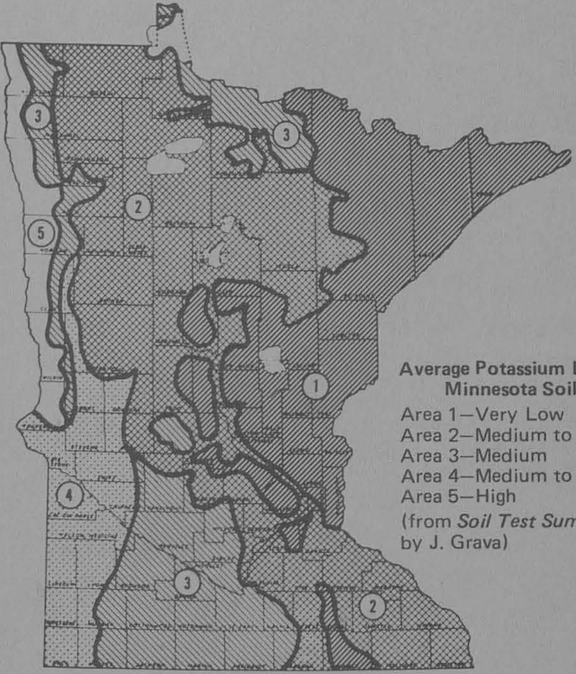
Reasons for adding potassium

The accompanying map shows that the eastern, north central, and northeast areas have the greatest potassium needs in Minnesota. Generally, potassium needs are for at least one of the following reasons: sandy texture; long-term, high rainfall; limited drainage causing wet and consequently cold soils in early season; crop species demand; and excessively high soil pH.

Sandy texture. The natural potassium supply in soils is primarily from clay size minerals. The sandy soils are low in these very fine-sized particles and consequently do not have an adequate reserve to replace what plants remove.

On fine-textured soils, potassium removal by intensive cropping may draw down on the potassium supply, but there is a replenishing from the clay mineral reserve. Potassium responses on coarse-textured soils can be dramatic, but on fine-textured soils, just moderate. The release from the clay mineral is slow, however, and potassium fertilizer is usually needed on most soils, where yields are high, to keep the plant in plentiful supply.

Long-term rainfall effects. Potassium in soils increases from east to west across the U.S. This is true, too, in Minnesota where soils in western counties have considerably more



Average Potassium Levels Minnesota Soils

Area 1—Very Low
Area 2—Medium to Low
Area 3—Medium
Area 4—Medium to High
Area 5—High
(from *Soil Test Summaries* by J. Grava)

potassium than eastern counties. There are exceptions discussed later, but some soils in western Minnesota have such quantities of potassium-bearing minerals it is doubtful that the supply will be exhausted for a long time.

Limited drainage and cold soil temperatures. During wet springs, where limited drainage is a factor, response to potassium is much greater than when conditions are moderately dry. Wetness means coldness during the early growing season. Studies in growth control chambers show that coldness restricts nutrient uptake.

Field trials on a fine-textured soil in Dodge County demonstrated that added potassium could partially offset the restricted nutrient uptake. After a cold spring there was a 3-fold corn yield increase from potassium, but the following year, again with corn, after a warm spring, very little yield increase was obtained. The "no potash" plots yielded 28 bushels per acre after the cold spring and over 100 bushels on the same area after the warm spring.

Potassium needs related to species. Plant species vary in the need for added potassium. Timothy, brome, bluegrass, and small grains need considerably less potassium than alfalfa or potatoes. Corn and soybeans demand less potassium than alfalfa but more than small grain or other grasses, perhaps because of larger yields. The fibrous roots of grasses obtain their nutrients more easily than other species. This explains why grasses soon take over in a grass-legume mixture if the potassium levels are low.

Excessively high pH. Certain western states and foreign countries sometimes report that their crops benefit from added potassium even when the soil test is very high. In Minnesota, potassium deficiencies with fairly high K tests sometimes are observed in "alkali" rims where the pH is above 7.5, and even higher at 2- or 3-foot depths.

If there is an *obvious production problem,* salts are low, the K soil test is below 300 pounds per acre exchangeable K, and pH is higher than 7.5, about 200 pounds per acre of 0-0-60 are recommended to correct the poor growth. Blanket potash applications for any field based on high pH are unwarranted unless there is evidence of restricted plant growth.

Corn growth depression in "alkali" rims has been corrected in field trials with potash applications. These problem areas are associated with an oversupply of magnesium or calcium in proportion to potassium. Poor growth and a high soil pH (7.8 or 8.0) are as good indicators for need as a magnesium or calcium soil test. In other cases the problem is a result of high soluble salts and will not be corrected by additional potassium.

Potassium materials

Potassium chloride (0-0-60) is by far the form in most common use, either for direct application or in fertilizer mixes. Potassium sulfate (0-0-50) and a combination of potassium, magnesium sulfate (called either sul-po-mag or K-mag) are used in some areas and contain about 22 percent potash. Potassium phosphate and potassium hydroxide are other materials in use, but in small quantities. All these materials are water soluble and all perform about equally pound-for-pound of potassium.

Expressions of potassium and potash are sometimes confusing. Legal descriptions write potassium content as K_2O: this is the oxide form and is called potash. The actual or effective ingredient is potassium (K) and is the expression used in soil test and plant test reports. The plant absorbs the potassium ion (K^+); K_2O is only an expression.

Potassium buildup

Table 1 shows the increasing tonnages of potash sold in Minnesota.

Table 1. Increase in potash use in Minnesota since 1945*

Year	K_2O tons/a	Year	K_2O tons/a
1945	6,802	1965	106,418
1950	18,981	1970	214,178
1955	43,784	1975	329,131
1960	68,298	1978	358,038

*TVA data

Soil testing summaries for the entire state over several years do not show an increase of potassium in the soil. High yields of such crops as alfalfa that remove considerable potassium may be the reason for this. In southern Minnesota on fine-textured soil, however, corn is the chief crop and there is evidence that farmers have built soil potassium to such high levels that annual broadcast treatments are unnecessary. Results from such trials are reported in *Phosphorus and Potassium Experiments on Well-Managed Soils in South Central Minnesota,* Miscellaneous Report 135. All publications mentioned can be requested from county agricultural extension offices.

Soil tests

Most soil tests report pounds per acre of exchangeable potassium (K). If a soil test is shown in parts per million (ppm), to convert to pounds per acre multiply by 2. Exchangeable potassium is the amount held on clay mineral and organic matter surfaces plus the dissolved portion in soil moisture. It is called exchangeable because it can be exchanged or replaced by other elements with a positive electrical charge. In the soil test process, a reagent (substance used to replace another substance) containing other positive materials is leached through the soil and then the content of potassium taken off the soil surfaces in this leaching is measured. Potash recommendations for all important crops are presented in *Guide to Computer Programmed Soil Test Recommendations in Minnesota,* Extension Bulletin 416 (formerly Special Report 1).

Plant Analysis

Plant analysis helps in trouble shooting. Since potassium levels decline as plants mature, and tops have a higher concentration than lower parts, knowing the proper plant part and timing for sampling is important. Table 2 gives plant analysis interpretation for best sampling time and specific plant parts sampled.

Table 2. Interpretation of percentages of potassium for some important crops in Minnesota*

Crop	Plant part and sampling stage	low	Threshold levels sufficient	high
			%K	
Corn	Ear leaf, silking	1.25	1.75	> 2.75
	Whole plant, 12-inch height		3.00	> 5.00
Small grains	Top leaves, boot stage	1.25	1.60	> 2.50
Alfalfa	Upper 1/3 early bloom	1.80	2.40	> 3.80
Sunflowers**	5th leaf, flowering	2.50	3.00	> 5.50

*Adapted from soil testing and plant analysis, SSSA '73.
**Values subject to modification as research develops.

Deficiency symptoms

The first symptoms of a potassium deficiency are short or dwarfed plants accompanied by a general loss of dark green color. Severe deficiences produce bronzing or scorched edges of lower leaves.

In corn the scorching along leaf edges is continuous from tip to stalk; in small grains bronzing appears mainly on the leaf tip. Diagnosis is difficult with small grains. On alfalfa little white dots show on lower leaf edges, but if severe these also appear on upper leaves and lower leaves die.

Other symptoms are lack of cell membrane strength, causing weak walls, leading to plant lodging. Slow top growth due to potassium deficiency usually means slow root growth which will result in root lodging of tall plants like corn and sunflowers.

Potassium deficiency affects photosynthesis. With a deficiency, the sugar supply is reduced and nitrogen compounds build up. The nitrogen excess becomes toxic and is most common on leaf edges; the toxic materials apparently cause the scorching. Carbohydrates normally combine with nitrogen compounds that eventually form protein. Protein gives the dark green color and affects growth. A shortage of carbohydrates because of potassium deficiency means less protein and shorter and lighter green plants.

Other points

Unlike other plant nutrients, potassium doesn't become part of the organic compounds. This means stalks and straw don't have to decompose before their potassium becomes available for a succeeding crop. In manure too, potassium can be entirely available the year it is spread while only 30 to 60 percent of phosphorus and nitrogen are available. Peat soils can release and lose their potassium rapidly. Potassium is possibly the most important nutrient added to organic soils.

There is a balance between the exchangeable-potassium on clay and organic matter surfaces and a nonexchangeable form. The nonexchangeable form is located within minerals where it is difficult for plants to get at. If no potash is added, the exchangeable portion can be used up but soil surfaces will be slowly replenished, thus some plant growth can be maintained even though no potash fertilizer is added. Where very heavy fertilization with potassium has been practiced there can also be a conversion the other way: from the exchangeable to the nonexchangeable form. This is one reason why soil tests do not show an increase in direct proportion to the amount of potash added.

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