Potassium Reduces Stress from Drought, Cool Soils, and Compaction

Why does water stress often cause plants to look like they are suffering from K deficiency?

Potassium deficiency can be the most harmful effect of dry weather. In a drought, water films surrounding soil particles become very thin. Because most K moves to plant roots through these films, drought makes it much more difficult for crops to take up enough K to satisfy their needs.

> Higher levels of potassium (K) in the soil help crops withstand stress conditions.

Higher K concentrations in the soil solution help to speed K delivery to the root. This is why it is so important to have high levels of K fertility in dry years. With higher levels of K in the soil, the crop doesn't have to work as hard to take up the K it needs.

In dry years, crops often contain lower amounts of K than in years with adequate rainfall. For example, Iowa scientists measured sharply lower amounts of K in corn leaves under drought conditions (**Table 1**). Applying 160 lb/A of K_2O raised leaf K concentrations in the dry year but did not entirely compensate for the harmful effects of water stress. Most agronomists feel that corn leaves must contain at least 1.7 percent K in the ear leaf at tasseling to allow the crop to produce maximum yields.

Research in several states and provinces has shown that the largest yield increases from applied K often occur in dry years.

One example is a long-term K study in Ohio (**Table 2**). A good weather year was followed by a dry year on two occasions. Corn was the test crop over the first two-year period and soybeans over the second period. For both crops, yields and profits from adding K were greatest in the year with water stress.

Another 18-year experiment in Indiana showed soybean response to K to be greater in dry years. **Figure 1** shows a higher yield increase from K in years with the lowest rainfall during the critical 12-week period after planting.

Potassium cannot protect against extreme droughts, but it does help maintain yields in years with moderate water stress, typical of Corn Belt conditions.

Another way that K helps drought-stressed plants is to lower the amount of water lost through the leaves. Plants have tiny openings in their leaves called stomates through which water transpires to the atmosphere. Closing the stomates is a defense mechanism

TABLE 1. Stress caused by dry weather reduces the amount of K taken up by corn (Iowa).

K_2O rate, lb/A	K in corn leaves, % No stress	K in corn leaves, % Stress
0	1.1	0.7
160	1.6	1.2

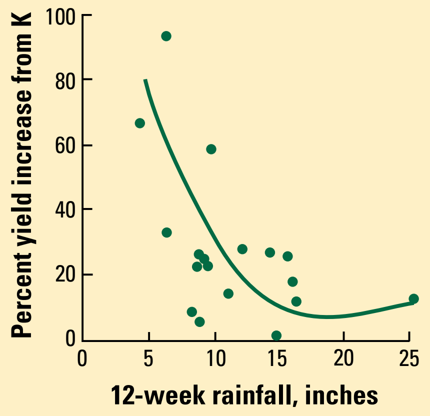


Figure 1. Soybean response to potash was greatest in years with lower rainfall during the critical 12-week period after planting (18-year study, Indiana).

to conserve water. Plants with inadequate K can be slower (and incomplete) in closing their stomates. For example, a Montana experiment showed that barley plants exposed to hot, windy conditions were able to slow water loss within 5 minutes when they had adequate K. But without adequate K, about 45 minutes were required for water loss to be reduced.

TABLE 2. The greatest profits and the biggest yield responses to K occurred in the stress years of this long-term experiment (Ohio).

K_2O rate, lb/A	Good year	Stress year	Good year	Stress year
	Corn yield, bu/A		Soybean yield, bu/A	
0	163	81	56	35
50	163	113	59	44
100	167	121	60	52
Response to K, bu	4	40	4	17
Profit from K, $/A	-5	76	11	92

Corn, $2.25/bu; soybeans, $6.25/bu; K_2O, 14¢/lb; medium K soil.

Additionally, K in plant cells helps keep photosynthesis going. Plant cells that lose too much water slow down in photosynthesis because of distortion of their internal parts. Potassium within plant cells has an osmotic effect that helps retain water. For this reason, tissue K concentrations that are above optimum for normal conditions can be necessary for stress conditions.

In cool soils, root growth is less, and roots are less able to absorb nutrients. Crops growing in cool soils often have reduced K uptake. If the K shortage is too severe, yields can be reduced. Higher K soil tests may be necessary in cooler climates. For example, it required a 50 percent higher level of soil K in northern Wisconsin than in southern Wisconsin to obtain a 2 percent level of K in alfalfa plants.

Early planting situations, where the crop grows in cooler soils, may require higher K fertility. Extra K increased corn yields 26 bu/A when planted April 26, but only 12 bu/A when planted June 2 on a low-K soil in Indiana. Plants receiving inadequate K are also more susceptible to frost damage. A higher yield potential is another factor that may increase K need with earlier planting.

Soil compaction stresses plants by restricting root growth and making it more difficult for the roots to take in adequate amounts of K and other nutrients.

On soils that are low to medium in K, some of the yield loss from compaction may be reduced by added K. In a Wisconsin experiment, 45 lb/A of row-applied K_2O reduced corn yield lost to compaction to 5 bu/A from 22 bu/A without K (**Table 3**). Yield response to K and profits were greater on the compacted soil.

Compaction is one of the reasons why responses to K occur more frequently in no-till and ridge-till cropping systems. Other reasons include stratification of K near the soil surface, cooler soil temperatures, and greater likelihood of anaerobic soil conditions. Anaerobic conditions can increase the fixation of K by soil minerals, making it less available to plants. Roots also depend on oxygen and are less active in taking up K when soils become anaerobic.

TABLE 3. Row-applied K partially reduced yield losses due to compaction on a soil testing low to medium in K (2-year average, Wisconsin).

Row K_2O, lb/A	Compaction: Low	Compaction: High	Compaction: Loss
	Corn yield, bu/A		
0	151	129	22
45	169	164	5
Response to K, bu/A	18	35	
Profit from K, $/A	39	81	

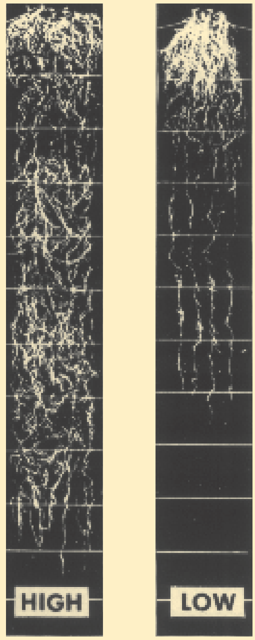
Low compaction: < 5 tons/A. High compaction: 19 tons/A.
Soil test K: 204 lb/A. Corn, $2.50/bu; K_2O, 14¢/lb.

Higher K levels clearly help get crops through periods of stress. Many observations show the need to plan a strong K soil fertility program to make crop yields more certain in an uncertain environment. BC

Effective Water Use

Potassium helps crops use water more effectively. The positive benefits of adequate K fertility are:

- **Deeper roots.** Potash helps plant roots penetrate to access deeper soil water, as illustrated at right.
- **Faster closing of the crop canopy**. When the crop canopy closes, the ratio of transpiration to evaporation increases, which means more of the water available is used by the crop.
- **Greater osmotic gradient**. The more K inside the plant cell, the more strongly it can attract water from the soil – and better control its water loss.
- **Earlier maturity**. Adequate K helps ensure plants will get through the critical pollination period earlier – before drought.



Soil Fertility

Potassium in Animal Nutrition… *(continued from page 33)*

other factors, but generally forage K should be less than 2.5 percent. Cool-season forages tend to contain more K than warm-season grasses. Thus, problems of excess occur less frequently in southern than in northern regions.

The RDA of beef cattle is about 0.5 to 0.7 percent of dry ration (**Table 2**). Several studies have been reported with weight gains of steers on rations containing optimum levels of K. In Texas and Tennessee, elevating K levels to 1.4 percent of dietary dry matter helped reduce the stress of shipping calves and lambs to feedlots.

Grass tetany and wheat pasture poisoning are metabolic diseases of lactating cattle. These occur most frequently in animals grazing cool-season forages in which magnesium (Mg) concentration or availability is low (less than 0.2 percent). High levels of K, unbalanced with Mg, can increase risk of grass tetany. Milliequivalent ratios of K/(Ca+Mg) above 2.2 in forage dry matter are considered hazardous. Grass tetany risk is reduced by feeding Mg supplements. Also, fertilizing with phosphorus (P) can enhance plant uptake of Mg. BC

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