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Boron for Minnesota Soils

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Boron (B) is classified as a micronutrient because it is used in relatively small amounts for crop production. Most Minnesota soils are capable of supplying adequate amounts of boron for crop production. Research in Minnesota has shown, however, that using boron fertilizers will improve the yield of alfalfa and vegetables on some sandy soils. Where needed, use of boron can be profitable.

Boron's Role in Plants

The specific function of boron in plant growth has not been well defined, but boron is known to function in the use of carbohydrates. In addition, boron plays an important role in the movement (translocation) of water and plant nutrients from the root to the plants' growing portion. The total amount of boron used by plants is very low. For example, a good alfalfa yield will remove from .1 to .2 pound of boron per acre.

Deficiency Symptoms

Boron is not mobile in plants so deficiency symptoms will occur as stunting on the upper part of plants.

With alfalfa, stunting of the new growth gives the plant a bushy, umbrella-like appearance. The lower (older) leaves stay green. Severely affected plants do not produce blossoms; an extensive yield loss occurs; and plants winterkill easily. When the deficiency is severe in alfalfa, the growing point dies. If boron becomes available at this stage, side branches will grow, extending above the stunted main stems (figure 1).

Figure 1. Boron-deficient alfalfa. Arrow on left shows a dead growing point. Arrow on right shows some recovery when boron is supplied; a side branch may extend above the dead main stem. (Photo from Pine County)

A mild boron deficiency in alfalfa may result in many short-growing plants among tall, healthy ones. No deficiency symptoms show unless one leans the taller plants to the side and looks beneath. Such a boron shortage can reduce yields 15 to 20 percent.

In corn, a boron shortage causes barren stalks and small, twisted ears. There are, however, many factors that can cause small, twisted ears of corn; it is important to have both soil and corn plant samples analyzed for boron before confirming a deficiency.

Symptoms of boron deficiency in vegetable crops are varied. Often, there is restricted terminal growth with wilted, curled leaves. Roots, tubers, and fruits show rotting, cracking, and discoloring.

Soils Where a Response to Boron Could Be Expected

In Minnesota, a response to boron use might be expected on soils that have a sandy loam, loamy sand, or sand texture with a low organic matter content (figure 2). Most of the boron in soils is contained in the organic matter. As decomposition of organic matter takes place, boron is released for plant growth. Breakdown of organic matter is nearly stopped during dry weather.

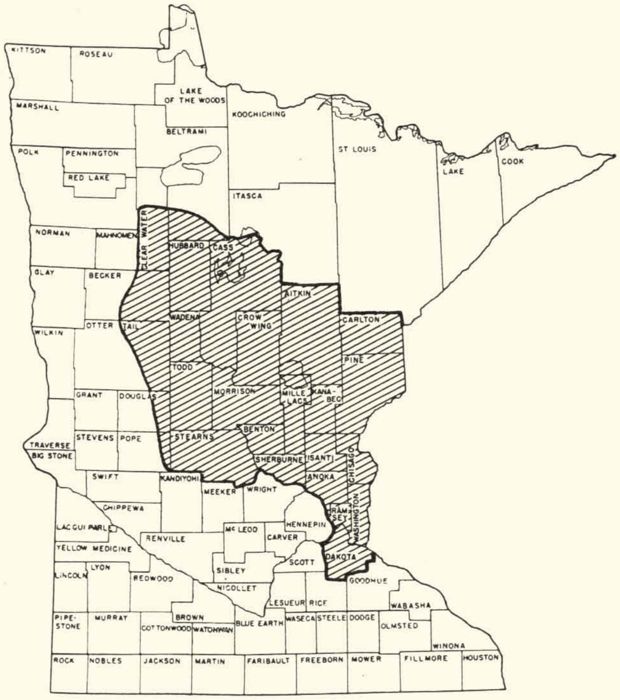

Figure 2. Possible boron deficient area (cross-hatched).

Crops That Respond to Boron

Crops vary in boron need. Table 1 shows the response to boron that might be expected from various crops.

Table 1. Relative differences of several crops' response to boron applied to boron deficient soils

Large Response	
Alfalfa	Cauliflower
Sugar beets	Celery
Moderate Response	
Tomato	Clovers
Cabbage	Lettuce
Carrots	Radish
Small Response	
Field corn	Pasture grasses
Sweet corn	Rye
Wheat	Potatoes
Barley	Soybeans
Oats	Blueberries

Leaching of Boron

Boron is readily leachable in sandy textured soils. Therefore, boron deficiencies might occur more often on sandy soils under irrigation.

Special attention should be given to boron levels when alfalfa or vegetable crops are grown on Minnesota's irrigated sandy soils.

Table 2 shows soil test boron readings by depth when two rates of boron were applied to an irrigated sandy soil. These data show downward movement to 24 inches when boron was applied at 1 and 2 pounds per acre for two years.

Table 2. Concentration of boron in parts per million (ppm) on irrigated soil at various depths at the end of the 1986 growing season: Staples, Minnesota

Treatments 1985 and 1986	Depth (in.) 0-6	6-12	12-24	24-36
	ppm B			
Control	.24	.18	.10	.06
1 lb. B/acre (single)	.48	.41	.19	.09
2 lb. B/acre (single)	.49	.43	.22	.10
1 lb. B/acre (split)	.42	.32	.18	.10
2 lb. B/acre (split)	.56	.51	.28	.14

DATA BY REHM, ET AL.

Soil Testing for Boron

A boron soil test, available through most soil testing laboratories, is especially appropriate for sandy soils where a response to boron might be expected. Table 3 lists current suggestions for boron use in a fertilizer program.

Table 3. Relative boron levels in soil and suggested application rates in parts per million (ppm)

Boron soil test	Relative level	Alfalfa	Vegetables	All other crops
ppm		lb. B to apply		
0-.9	low	2-4	0.5-1.0	0*
1.0-5.0	adequate	0	0	0
more than 5.0	excessive	0	0	0

*Although the boron test is low, research has shown that crops other than alfalfa and vegetables have not responded to boron application.

Plant Tissue Analysis for Boron

The boron status of crops can be monitored through tissue analysis. Table 4 lists the relative boron levels in plant tissue for some major agronomic crops. Excessive amounts of boron can cause problems with some crops; boron application in a fertilizer program should be stopped if the boron concentration in the plant tissue is in the sufficient or high range.

In corn, 1 to 1.5 pounds of boron per acre near the seed have reduced corn yield.

Table 4. Relative levels of boron in parts per million (ppm) for major crops

Crop	Plant part	Time	Deficient	Low	Sufficient	High
			ppm B			
Alfalfa	Upper 1/3	Harvest (1/10 bloom)	<20	20-30	31-80	>80
Corn	Leaf opposite ear	Silking	<2	2-5	6-40	41-55
Soybeans	Fully developed set; upper trifoliate	Before pod	—	<20	21-55	56-100
Sugar Beets	Leaf		<10	11-20	21-50	>50
Sugar Beets	Petiole		< 8	9-15	16-200	>200

Experiments in Minnesota with Added Boron on Several Crops

Alfalfa

In Minnesota, alfalfa is more responsive to boron than any other crop. Boron treatments have resulted in improved alfalfa growth on demonstration plots throughout the area outlined in figure 2.

Boron content will appear low when soil moisture supply is low because rotting and the release of boron from soil organic matter is reduced under these conditions. It is difficult to be sure whether lowered yields are due to low available boron or just low rainfall. It has often been demonstrated that boron in plant tissue increases after rains occur. In this situation added boron would likely not have been helpful. Plant tests would appear to be more reliable when soil moisture supply is normal.

Table 5. The effect of four levels of boron on yield, plant analyses, parts per million (ppm) and soil test: Dakota and Goodhue counties, 1981-1984

Dakota County[1]

	Yields, bu/A				Plant analysis, ppm				Soil test, ppm			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
Boron lb/A annually	corn	soybeans	snap beans	corn	corn	soybeans	snap beans	corn	corn	soybeans	snap beans	corn
0	155	36	12[2]	159	7	43	21	9	0.3	0.2	0.2	0.3
1	159	34	14	169	8	52	48	10	—	0.3	0.3	0.6
2	147	32	12	162	12	67	72	13	—	0.5	0.4	0.8
4[3]	160	27	14	165	18	112	60	8	—	0.9	1.4	0.9
Significance	NS	**[4]	NS	NS								

Goodhue County[1]

Boron lb/A annually	corn	soybeans	corn		corn	soybeans	corn		corn	soybeans	corn	
0	170	49	127		4	38	8		0.6	0.8	0.7	
1	178	42	124		5	44	9		—	1.1	1.2	
2	175	47	128		5	51	10		—	1.5	1.7	
4[3]	174	42	131		7	61	12		—	2.5	2.2	
Significance	NS	+[4]	NS									

[1]Dakota County irrigated loamy sand with low organic matter. Goodhue County non)irrigated silt loam, with medium organic matter.
[2]Thousand pounds per acre. Snap beans were grown in 1983 because of government program restricting corn acreage (PIK).
[3]The 4 lb/A rate was not applied in 1983 and 1984.
[4]Two stars indicate differences in yield are highly significant. A + indicates a significant difference only at the 10 percent level of confidence.

Corn and Soybeans

In southeast Minnesota experiments, plant boron content was measured as less than adequate, according to standards listed in table 4, but boron application did not increase corn yields (table 5). The plant samples were collected when rainfall was limited but subsequent rains most likely had replenished boron from the soil organic matter which reduced the need for added boron.

Table 5 shows results from field trials initiated by Fenster on corn and soybeans. These experiments were conducted in Dakota and Goodhue counties using four replications and four levels of broadcast boron. The sites were selected to determine if the soil boron test could predict boron needs in a fertilizer program. No significant increase in yield was obtained when boron was applied, but significant decreases due to the higher rates of added boron were observed on soybeans in both Dakota and Goodhue counties. The sandy textured soil in Dakota County had low boron tests and yield increases had been expected. The moisture supply on this irrigated land may have kept adequate boron available from soil organic matter sources.

Table 6 shows results from other trials by Fenster where an added mix of all essential micronutrients were compared to the same mix with one micronutrient omitted. No yield increases were obtained from the 1 pound per acre treatment although boron soil tests were quite low.

Table 6. The effect of boron treatment on yield, plant analyses, parts per million (ppm) and soil test on three crops on 11 site years: 1981-1984

	Yield bu/A		Significance	Plant analyses ppm		Soil test ppm	
	+*	−		+	−	+	−
			Corn				
Martin County	Clay loam soil, high organic matter						
	184	178	NS	5	5	1.8	1.2
	141	148	NS	7	8	1.7	2.2
Goodhue County	Silt loam soil, medium organic matter						
	169	177	NS	7	6	—	0.6
	129	128	NS	6	6	1.7	0.8
Dakota and Pope counties	Irrigated sandy loams, low organic matter						
	156	152	NS	9	5	—	0.3
	164	167	NS	8	6	0.8	0.8
	129	126	NS	4	4	—	1.0
			Soybeans				
Martin County	Clay loam soil, high organic matter						
	54	52	NS	50	50	2.4	2.1
	49	46	NS	48	46	2.0	2.0
Goodhue County	Silt loam soil, medium organic matter						
	47	44	NS	44	41	3.2	1.0
Dakota County	Irrigated sandy loam, low organic matter						
	33	34	NS	54	39	2.4	2.2

* Plus (+) means 1 lb. of boron added per acre was included in the micronutrient mix. Minus (−) means boron in mix was omitted. Data by Fenster et al.

Method of Application

Boron can reduce germination when it comes in contact with the seed. Broadcast applications instead of row treatments are recommended. The broadcast applications should be made one to two weeks before seeding.

The boron applied to alfalfa will usually last for more than one year. A common practice, on known boron-deficient soils, is to use a borated fertilizer mixture once every three years.

It is better to withhold boron from a new seeding of alfalfa until after the first year of production, if oats is the companion crop. Oats is sensitive to rates of boron needed for alfalfa.

Foliar sprays can be used on severely deficient fields. Use 0.1 to 0.3 pound of boron per acre for foliar sprays. CAUTION: do not spray on hot days when the crop is under moisture stress.

Boron Fertilizers

Boron fertilizers can be easily blended with other common fertilizers. Table 7 lists some common boron sources along with concentrations.

Table 7. Boron sources that can be used in Minnesota

Material +	Percent boron	Quantity needed to supply 1 lb. B/acre
	%	*lb.*
Fertilizer Borate Granular	14.3	7.0
Fertilizer Borate 48	14.9	6.7
Solubor	20.5	4.9

\+ Mention of brand name materials does not constitute endorsement by the University of Minnesota over similar products that might be commercially available.

Boron in Sewage and Manure Wastes

Boron in manure is usually very low, ranging from .02 to .12 pound per ton. At the highest concentration, a rate of 20 tons per acre would barely meet the boron needs where boron deficiencies are known. Sewage sludge is not considered a good boron source.

Summary

Soil tests and plant analyses have been developed as management tools to predict where and when boron will be needed. Using boron in a fertilizer program can produce substantial production increases of some crops, resulting in improved net profit to the grower.

On sandy soils, especially if not irrigated, boron is frequently needed for best alfalfa yields. It appears that irrigation assists or hastens decomposition of soil organic matter and releases boron—reducing the need for boron fertilizer additions on some soils.

The beneficial effect of boron fertilizer on corn and soybean yield has been inconsistent. It appears that soybeans are more susceptible to yield reduction than corn, especially at rates above 1 pound per acre of added boron.