Iron: An Essential Plant Nutrient
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IRON:
An Essential Plant Micronutrient

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Iron (Fe) is indispensable for both animals and plants. They cannot grow normally or reproduce unless sufficient Fe is absorbed and utilized. Fe is called an essential micronutrient because only trace amounts are required. For example, only three pounds per acre are needed to obtain the highest crop yield.

IRON IN ANIMALS

Iron is a component of every animal cell and is a part of most body fluids. It is concentrated as a chelate[1] in the hemoglobin part of blood. Deficiencies of Fe are associated with blood loss or the inefficient utilization of dietary Fe. Deficiencies in pigs are common with poor management, when they are confined to concrete or slotted floors, or when sows' milk is low in iron. Injecting Fe compounds into muscle usually prevents a deficiency. Animals on pasture almost never suffer from Fe deficiency unless parasites are present.

Most of the Fe in livestock is derived from feed. There is little or no direct relationship between Fe deficient plants and Fe deficient animals. Iron deficiencies in plants must be corrected in order to obtain satisfactory yields. Iron deficiencies in people can be corrected with balanced diets of foods that are well supplied with Fe.

IRON IN PLANTS

As in animals, Fe is a part of every plant cell. It is essential for the formation of chlorophyll and is closely related to photosynthesis. It is also involved with nitrogen fixation and respiration.

The Fe content of plants is variable, ranging on the average between 25 and 500 ppm. An inadequate supply of Fe causes light-colored leaves because chlorophyll fails to develop. Deficiencies are most noticeable in younger leaves, which develop yellow interveinal strips. Under extreme conditions leaves may develop a bleached white or whitish-yellow color.

[1]*Chelate — a term derived from a Greek word meaning claw. Certain organic compounds hold elements, especially metals, with more than one chemical bond.*

While Fe deficiency in field crops is uncommon in Michigan, it can occur with poor management. The responsiveness of several crops to Fe is shown in Table 1. Those crops classed as highly responsive are those that first develop a deficiency. Of those listed, the grasses show deficiencies more frequently than others.

Plant analyses for Fe are difficult to interpret even under the best circumstances. As in soil, total Fe in plants is considered a poor indicator of needs. Despite this, some agronomists analyze plant tissue for Fe and, if the levels are extreme, recommend remedial treatments. Values for the Fe "sufficiency range" are reported in Table 2. Caution is urged in using this information unless the levels are well above or below those shown. If not washed off, dust can be a serious Fe contaminant on plant tissue used for testing.

Table 1. Relative response of selected crops to iron.*

Highly responsive crops		
Barley	Grass	Sudan grass
Beans	Sorghum	Sugarbeet
Broccoli	Soybean	Table beet
Cauliflower	Spinach	Tomato
Medium responsive crops		
Alfalfa	Cabbage	Oats
Asparagus	Corn	Sweet clover
Low responsive crops		
Peppermint		
Wheat		

**Data from MSU Ext. Bul. E-486 (1973).*

Table 2. Iron sufficiency range for selected crops*

Crop	*Sampling Recommendations*	*Sufficiency Range*
		ppm
Corn	Ear leaf prior to initial silking	21-250
Soybean	Upper mature leaf prior to first flowering	51-350
Alfalfa	Top 6 inches prior to initial flowering	30-250
Wheat	Upper leaves prior to initial bloom	11-300
Sugarbeet	Center fully-developed leaf at midseason	51-200
Vegetables	Top fully-developed leaves	50-250
Potatoes	Petioles of most recently matured leaf — midseason	30-300

**Data from MSU Ext. Bul. E-486 (1973).*

Genetic differences are related to a plant's ability to utilize Fe. One hybrid may not show deficiency symptoms while another grown under identical conditions may display characteristic symptoms. As with other nutrients, visual symptoms of Fe deficiency sometimes develop when roots are damaged by diseases, insects or cultivators. The use of an iron containing fertilizer will not solve such problems.

IRON IN SOILS

There are many Fe compounds in soil, including both organic and inorganic forms. The mineral forms include the broad groups of oxides, sulfides, carbonates, sulphates, and silicates. Iron is also adsorbed onto the surface of soil colloids,[2] is a part of the structure of certain clays, and occurs as a small fraction of the soil solution.

The color of many Michigan soils is due in part to the total Fe content and the degree of oxidation of this element. Brilliant red or yellow colors indicate naturally well-drained soil and a high degree of oxidation. The dark colors, especially the grays, indicate reduced Fe or poor drainage.

The total Fe content of soil is likely to range between 1 and 10 percent (10,000 - 100,000 ppm). However, total content is a poor indicator of Fe supplying power. It is the small amount of chemically active Fe that is important. The quantity of this fraction varies greatly between soils and during the growing season. For example, Fe availability in acid soil increases when the soil is saturated with water but decreases in alkaline soils. Compaction of calcareous soils by farm implements and tractors when soil moisture levels are high is known to contribute to reduced aeration and reduced root growth. The compact soil condition can result in an iron deficiency when root growth is limited.

A number of soil testing laboratories test for "extractable Fe". Correlation between extractable Fe and responses from Fe-containing fertilizer is low. Several extractants are used to evaluate Fe availability to plants including 0.1 *N* HC1. Average levels of extractable Fe involving 0.1 *N* HC1 are reported in Table 3. Extremely wide ranges within any soil group have been observed. Despite this, the data show definite trends. For example, in the surface soil samples, Fe tended to increase with natural poor drainage conditions. Also, Fe levels tended to decrease with an increase in sand.

A number of soil conditions are closely associated with Fe deficiencies. Soils that are low in total Fe sometimes produce Fe deficient plants because such soils also tend to have low levels of available Fe. Some of the very young soils in the state may contain free calcium carbonate (Ca CO_3) in the surface and therefore may be Fe deficient. This is because Fe tends to precipitate out of solution as pH levels increase. Above pH 7.5, very little Fe is in the soil solution.

Extremes in soil moisture may also cause Fe deficiency symptoms because plants need both air and water to grow. Too much or too little water retards root growth rates and, therefore, nutrient uptake. This situation can cause deficiencies of many nutrients. Low soil and air temperatures may also cause Fe deficiencies.

Large amounts of phosphorus (P) and heavy metals may limit uptake of Fe. As more municipal sludge with significant quantities of heavy metals is used, this situation conceivably could become important. In addition, soils that are low in organic matter may not supply ample Fe to plants. Organic matter acts as a chelating agent for Fe and thus prevents it from being "fixed" or precipitated from acid solutions where it is available to plant roots.

[2]*Colloid—organic or inorganic matter having very small (submicroscopic) particle size and a correspondingly high surface area per unit of mass.*

Table 3. Average extractable iron levels in the profiles of selected soil groups.*

Dominate Texture of Soil Profile	*Soil Management Group Symbol*	*Profile Symbol*	*Well Drained* a	*Somewhat Poorly Drained* b	*Poorly Drained* c
				ppm Fe[1]	
Clay and clay loam	1 & 1.5	A	88	69	119
		B	165	139	120
		C	41	9	63
Loam and sandy loam	2.5 & 3	A	54	61	145
		B	94	111	183
		C	67	62	58
Loamy sand and sand	4 & 5	A	48	58	150
		B	36	81	60
		C	44	45	150

**MSU Agr. Exp. Sta. Res. Rpt. 384*
[1]*0.1 N HC1 — extractant.*

IRON IN MANURE

Iron levels in livestock manure range between 0.5 pound per ton to as high as 5.0 pounds, depending both upon the kind of animal and feeding program. Manure from broiler hens varies between 1.0 and 2.5 pounds per ton, while the levels in hen manure range between 0.6 and 3.0 pounds per ton. The Fe in manure is usually sufficient to meet crop demands, assuming that other factors do not limit growth.

IRON IN WATER

Iron concentrations in water vary considerably with the source. Levels in Michigan's streams are very low. Pond and lake waters are generally low in Fe, but are quite variable. Many well waters in Michigan contain significant quantities of Fe. The Fe in water readily reacts in the soil to form compounds which are unavailable for plant uptake, so water supplies cannot be considered a corrective source for Fe deficient plants.

IRON CARRIERS

Some common sources of Fe used in crop production are shown in Table 4. Most of these materials are available from fertilizer manufacturers. Many are well adapted for foliar sprays.

RECOMMENDATIONS FOR IRON

Iron deficiencies in field and vegetable crops are *not* common in Michigan, but may be a problem with certain woody plants, with bedding plants grown in certain soil mixes, and with some turf grasses.

Where deficiencies are expected or observed on aid soil, 0.5 to 1.0 pound per acre of Fe as a chelate, applied with a planting time fertilizer, usually is sufficient to correct a deficiency. On alkaline soils, such a treatment may be ineffective due to Fe fixation. Foliar applications of Fe chelates, Fe citrate, or Fe sulfate are recommended. Follow the printed recommendations of the supplier. Be certain to thoroughly wet all of the foliage since Fe is not easily translocated within the plant.

Growing medium and low responsive crops and using the best-known soil and crop management practices will minimize Fe deficiency problems. Soil testing is an aid in eliminating potential deficiencies associated with the use of excessive amounts of phosphate and/or lime.

SUMMARY

Iron deficiencies are not common in Michigan. Nevertheless, they do occur under certain circumstances such as compact soil, soils with free lime, moisture extremes, and on soil with high P and heavy metal levels.

Manures and irrigation water contain variable levels of Fe and are not dependable sources of Fe. Crops vary in Fe requirements and in abilities to utilize this essential element. Fe deficiencies on calcareous soil are most easily corrected with foliar sprays, while on acid soils Fe may be included as a part of a banded planting time fertilizer.

Table 4. Common fertilizer carriers of iron.*

Source	*Formula*	*% Fe*
Ferrous ammonium phosphate	$Fe(NH_4)PO_4 \cdot H_2O$	29
Iron ammonium polyphosphate	$Fe(NH_4)H\,P_2O_7$	22
Iron frits	Frit	30-40
Ferric sulfate	$Fe_2(SO_4)_3 \cdot 4\,H_2O$	23
Ferrous sulfate	$FeSO_4 \cdot 7\,H_2O$	19
Iron chelate	NaFeEDTA or FeHEDTA	5-15
Reax Iron	FeMPP	10-12
THIS Iron	FeMPP	5
Iron Silviplex	FeMPPP	6
Rayplex Fe	FePF	9-9.6

**Information from the Fertilizer Handbook — The Fertilizer Institute*

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