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Identifying nutrient deficiency and toxicity in

RED RASPBERRY

K.L. Wilder and T.L. Righetti

The Pacific Northwest leads the United States in red raspberry production. Many factors affect yield, including nutrition, weather, pests, and water. Most nutritional problems can be quickly solved once you know the specific problem, but an accurate diagnosis is difficult.

Foliar nutrient symptoms can be helpful, if you recognize specific nutritional disorders and if you're aware of the limitations involved in basing a diagnosis solely on these symptoms.

Different nutritional disorders can produce symptoms that are very similar to each other. Some diseases and pests also produce symptoms that mimic nutritional disorders. Other nutritional problems only produce symptoms when the problem is so severe that corrective measures may be too late.

Nutrients typically found to be deficient in Pacific Northwest red raspberries are nitrogen, phosphorus, potassium, sulfur, magnesium, copper, boron, and zinc.

Manganese is the nutrient most likely to be present in toxic quantities because levels increase under the acid conditions that commonly occur. Boron toxicity can result from overfertilization. Other toxicities are rare in the Pacific Northwest.

This publication is intended to help you diagnose nutritional problems. What follows is a brief summary of the roles each element has in plant growth or development and each element's normal level in red raspberries.

Also included are summaries (in percentages) from the Oregon State University Plant Analysis Laboratory for nearly 500 Pacific Northwest red raspberry samples analyzed in the last 15 years.

These summaries are included to give you an idea of how common or rare specific deficiencies or toxicities are in Oregon and neighboring states. Photographs and descriptions of common foliar symptoms are also presented.

For fertilizer recommendations, contact your county Extension office.

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Key: Nutrient problems in red raspberry

Use this key to diagnose nutrient problems in your raspberries. Check the symptoms you observe (column 1) against the nutrients in column 2. The page number (column 3) tells you where that nutrient is discussed.

Symptom	Nutrient	Page
Leaves are yellow	Nitrogen	3
	Potassium	5
	Sulfur	6
	Magnesium	6
	Copper	7
	Zinc	10
Less than normal growth	Nitrogen	3
	Phosphorus	4
	Potassium	5
	Sulfur	6
	Copper	7
	Boron	8
Low yield; low fruit quality	Phosphorus	4
	Copper	7
	Boron	8
Wilts easily	Potassium	5
Brown, dead spots in leaves	Potassium	5
	Magnesium	6
	Manganese	8
	Boron	8
Stems thin and brittle	Sulfur	6
Early leaf fall	Nitrogen	3

Nitrogen

Normal leaf level: 2.26–3.00% dry weight

Leaf symptoms

Nitrogen (N) is an important component incompounds that promote plant growth including amino acids, proteins, and nucleic acids. When N is applied to plants, it's transported to the upper plant parts. When a plant is N-deficient, N is transported from the older leaves to the younger leaves.

Thus, N deficiency symptoms occur in the older leaves first and are characterized by a loss of chlorophyll (green pigment). See figure 1. Nitrogen-deficient plants typically have older leaves that are chlorotic (yellowed) and have less than normal growth. Leaves may be smaller than normal and may fall prematurely.

Excessive nitrogen levels may occur, and leaf analyses can reveal problems. However, evaluate apparent nitrogen toxicities carefully. Consider total shoot growth. A plant with high N levels and little growth may not necessarily have excessive N: The N is concentrated in the fewer leaves the limited growth produces.

Similarly, a plant with low N levels and substantial growth may simply indicate that the N is spread out over a larger pool. Vigor and crop load must be considered when making fertilizer decisions.

Nitrogen: % of PNW red raspberries that are:

Deficient	1
Below normal	9
Normal	56
Above normal	27
Excessive	7

Symptoms of deficiency

- Chlorosis in older leaves
- Decreased growth
- Small leaves
- Leaves may fall early

Figure 1.—N deficiency. Although these symptoms have been confirmed with leaf analysis, they differ somewhat from N deficiency on many other plants. Often the veins don't remain as green, and a more uniform yellowing may occur.

Phosphorus

Normal leaf level: 0.19–0.45% dry weight

Leaf symptoms

Many plant metabolic processes depend on phosphorus (P) for energy and growth. Therefore, P deficiency is characterized by less than normal (or a complete absence of) growth, low yields, and low quality fruit (figure 2).

Low P values can be caused by disease or other stresses, or a very low soil pH. Soil pH can influence the

Figure 2.—P deficiency. A darker green color is sometimes apparent in P-deficient plants, but leaf appearances can be subtle even under the severe conditions shown above. Color differences are detectable, but the overall stunting is far more noticeable.

Figure 3.—K deficiency. Classical marginal chlorosis symptoms weren't induced with low K applications. Plants were extremely sensitive to wilt, but otherwise normal in appearance. However, in some of our work with other elements that resulted in above-normal Mn, the more characteristic K deficiency symptoms appeared as shown here.

plant's uptake of P, making both a soil and plant analysis very useful for accurate diagnosis.

Phosphorus toxicities haven't been documented in the Pacific Northwest.

Phosphorus: % of PNW red raspberries that are:

Deficient	7
Below normal	24
Normal	69
Above normal	0
Excessive	0

Symptoms of deficiency

- Low growth rate
- Lower than normal yield
- Low fruit quality

Potassium

Normal leaf level: 1.26–2.00% dry weight

Leaf symptoms

Plant water uptake is directly affected by potassium (K) content. Plants low in K are susceptible to drought, and are quick to wilt. Potassium is also important in photosynthesis. Symptoms include slow growth and chlorosis in the older leaves.

Leaves may have dead spots, brown margins and tips; or leaves may cup upwards (figure 3). Low soil pH, drought, or certain soil textures (light, sandy acidic soils, or organic soils) may aggravate a K deficiency.

In our greenhouse trials, severe marginal chlorosis did not develop. However, even though the plants were well watered, they were very susceptible to wilt.

Leaf potassium concentrations may vary considerably from year to year, making a cautious interpretation of leaf levels wise. Trial applications monitored over several seasons

are suggested before making a large investment in K fertilizer.

Above-normal K levels are usually not a concern unless accompanied by low magnesium levels, which could suggest a potential imbalance.

Potassium: % of PNW red raspberries that are:

Deficient	16
Below normal	25
Normal	52
Above normal	7
Excessive	0

Symptoms of deficiency

- Wilt easily
- Reduced growth rate
- Chlorosis in older leaves
- Leaf margins dead
- Dead spots in leaves

Sulfur

Normal leaf level: 0.11–0.20% dry weight

Leaf symptoms

Sulfur (S) is an essential element for plant proteins and amino acids. Sulfur and nitrogen deficiency symptoms can be very similar—both elements alter proteins and chlorophyll metabolism and result in a general yellowing of leaf tissue.

Both deficiencies also limit growth. However, S is not remobilized in the plant nearly as well as N; thus, symptoms appear in different locations.

In contrast to nitrogen, sulfur deficiency symptoms occur in the younger leaves first—N deficiency is more limited to the older leaves. Stems may also be thin and brittle.

Even though subtle differences between N and S deficiency symptoms exist, diagnosis is difficult. A leaf analysis can be very helpful in determining the exact cause of leaf chlorosis.

Above-normal S levels have not been seen in this region.

Sulfur: % of PNW red raspberries that are:

Deficient	2
Below normal	35
Normal	62
Above normal	0
Excessive	0

Symptoms of deficiency

- Younger leaves chlorotic
- Reduced growth
- Stems thin and brittle

Magnesium

Normal leaf level: 0.31–0.60% dry weight

Leaf symptoms

Magnesium (Mg) is essential to chlorophyll structure and many energy-related processes. Magnesium deficiencies are rare, and they're generally associated with low soil pH. Deficiencies most often occur in light, acid soils, or in sandy soils high in potassium.

Symptoms look similar to K deficiency, or virus yellowing. Interveinal necrosis (tissue death) sometimes occurs.

Chlorosis begins in the older leaves, then moves to the younger leaves. Leaves may be stiff and brittle. A leaf analysis can be very helpful for diagnosis.

Above-normal Mg levels in themselves aren't a cause for concern, but they suggest that you should evaluate low K levels more carefully.

High Mg levels interfere with K nutrition.

Magnesium: % of PNW red raspberries that are:

Deficient	1
Below normal	3
Normal	84
Above normal	13
Excessive	0

Symptoms of deficiency

- Chlorosis beginning in the older leaves
- Brittle, scorched leaves

Copper

Normal leaf level:
6–15 ppm

Leaf symptoms

Copper (Cu) plays an important part in plant photosynthesis and may form part of chlorophyll and other plant pigments. Deficiency symptoms may include interveinal chlorosis (yellowing between the veins in a leaf, with the vein itself remaining green), reduced growth, and abnormal fruit development. See figure 4.

Responses to Cu sprays in other crops has been reported; considering the low cost of such sprays, they may be advisable for below-normal or deficient plants. However, research hasn't demonstrated Cu responses in the Pacific Northwest.

Copper: % of PNW red raspberries that are:

Deficient	1
Below normal	10
Normal	87
Above normal	2
Excessive	1

Symptoms of deficiency

- Interveinal chlorosis
- Reduced growth
- Poorly developed fruit

Figure 4.—Cu deficiency. Copper deficiencies often result in interveinal chlorosis (as shown here) and dieback of the young canes.

Manganese

Normal leaf level: 51–300 ppm

Leaf symptoms

Manganese (Mn) is related to energy-producing processes and photosynthesis. Manganese deficiencies haven't been documented in the Pacific Northwest.

As we stated earlier (page 1), the acid soils commonly found in the Pacific Northwest make Mn more available, and they can cause Mn toxicity. Toxicity is characterized by brown spots on the leaves, especially older leaves. A leaf analysis and a soil pH test can help diagnose a Mn toxicity.

Manganese: % of PNW red raspberries that are:

Deficient	0
Below normal	0
Normal	79
Above normal	18
Excessive	2

Symptoms of deficiency

- Brown spots on leaves, especially older leaves

Boron

Normal leaf level: 31–70 ppm

Leaf symptoms

Although the specific role of boron (B) isn't well understood, B is very important to protein synthesis, shoot growth, sugar transport, and fruit set. Plants may exhibit retarded growth, misshapen leaves, poor fruit set, and delayed ripening. See figure 5.

Research has shown that B can increase yield, berry size, and vitamin C content of raspberries.

Most recent research has focused on local deficiencies within a plant. It's quite common for buds to be low in B even though leaf values are high and the entire plant shows no deficiency. Annual foliar sprays have been recommended to supply B to developing buds even when leaf values are normal.

Figure 5.—B toxicity. Boron toxicities don't occur naturally, but they're common with overapplication of boron-containing fertilizer.

If you do make annual applications of B, it's wise to monitor leaf levels and skip a year if B levels rise above normal. Grower experience indicates that it's unlikely that annual applications (using recommended rates of foliar B) will produce toxic levels in the leaf.

However, in view of the losses excessive B can cause, monitor leaf B closely! Plants with toxic levels of B may exhibit a scorched appearance on the leaf surface or margin. These leaves may fall prematurely.

Leaf symptoms of a boron deficiency are rare in the field and difficult to experimentally produce. Boron symptoms appear in reproductive tissues (bud death, poor fruit set or shape) and in the leaf.

Boron: % of PNW red raspberries that are:

Deficient	11
Below normal	11
Normal	59
Above normal	12
Excessive	8

Symptoms of deficiency

- Retarded growth
- Dead shoot tips
- Abnormal leaf shape and color
- Poor fruit set
- Late ripening

Symptoms of toxicity

- Scorched leaf surface or margin
- Early leaf fall

Figure 6.—Zn deficiency. Zinc deficiencies are commonly seen as interveinal chlorosis, leaves with a dark green margin, or contorted leaves, first appearing on the newest growth. However, in many cases Zn deficiencies result from adverse environmental conditions. Later in the season, new growth may be unaffected. This raspberry appears to be recovering from an initial severe Zn deficiency, and it mimics what is commonly seen in the field.

Zinc

Normal leaf level: 16–50 ppm

Leaf symptoms

Zinc (Zn) is essential to N metabolism and enzyme function, and it may play a role in other aspects of plant metabolism. Plants deficient in Zn show interveinal chlorosis in the leaves. Leaves may have a dark green margin, and may be small or misshapen. See figure 6.

Zinc applications may increase the dry weight of raspberry fruit, but they haven't been shown to increase yield.

In view of the low cost of Zn applications, and numerous studies in other crops that suggest the likelihood of a response, consider Zn applications if either Zn deficiency symptoms or below-normal plant analysis levels occur.

By avoiding Zn applications when leaf levels are above normal or excessive, you can avoid toxicity.

Zinc: % of PNW red raspberries that are:

Deficient	1
Below normal	5
Normal	90
Above normal	4
Excessive	1

Symptoms of deficiency

- Interveinal chlorosis
- Dark green margin on leaves
- Leaves contorted

Using soil tests and plant analysis

Leaf and soil analyses have been useful tools for many years. It's important for growers to understand and use these resources. Either a leaf or soil analysis alone can indicate nutrient problems, diagnose deficiencies or toxicities, or help design a management program. However, the two analyses together are far more useful.

Don't make your management decisions on the basis of an analysis alone. It's wiser to consider other factors such as age of the planting, previous fertilizer practices, and the general performance of the crop.

Some plant analysis labs will give you long-term averages for the industry. You may interpret a low leaf concentration differently if all values in a given year are low.

With that information, you may determine whether an abnormal analysis value should be corrected, or whether it has causes not connected to fertilizer practices. Optimum soil and leaf nutrient levels have been established for most regions of the Pacific Northwest.

Leaf mineral levels can vary throughout the season, and you need to take samples at the proper time and in the correct manner to ensure an accurate interpretation.

Soil samples are less variable with time, but proper sampling is still essential. Because each lab has a different sampling technique, we recommend that you contact your county Extension agent on how, when, and where to sample.

Look at plant and soil analysis as a tool rather than the last word in fertilizer management. You have a "feel" for how your raspberries are doing, and one analysis can't override years of experience.

Even though we know much about the factors that affect element concentrations, it's difficult to recognize the complex set of interactions that take place in the field.

Low nutrient levels may be caused by factors other than underfertilization. Soil pH, rainfall, disease, pests, and many other factors can affect nutrient uptake. An analysis can often indicate a problem without revealing its source.

Recommended reading

Check with your county Extension agent for current Extension publications on red raspberry production.

Chaplin, Michael H., and Lloyd W. Martin. 1980. "The effect of nitrogen and boron fertilizer applications on leaf levels, yield and fruit size of the red raspberry." *Communications in Soil Science and Plant Analysis* 11(6): 547-556.

Mengel, K., and E.A. Kirby. 1982. *Principles of Plant Nutrition.* 3rd edition. International Potash Institute.

Righetti, Timothy L., Kris L. Wilder, and George A. Cummings. 1991. "Plant analysis as an aid in fertilizing orchards." In: *Soil Testing and Plant Analysis,* 3rd edition, R.L. Westerman, ed., Soil Science Society of America, Madison, WI.

Here's help!

For information on raspberry culture, including fertilization and leaf and soil analysis, you'll find agents and researchers who can provide it at these Extension Service and Experiment Station offices in Oregon, Washington, and Idaho. You'll find addresses and phone numbers under "County Government" in the local phone book.

Oregon State University Extension Service
Benton County, Corvallis
Lane County, Eugene
North Willamette Research and Extension Center, Aurora
Washington County, Hillsboro

Washington State University Cooperative Extension
Clark County, Vancouver
Pierce County, Tacoma
Skagit County, Mt. Vernon
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University of Idaho Extension System
Idaho Research and Extension Center, Sandpoint

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