NUTRITIONAL DEFICIENCIES: WHAT THEY LOOK LIKE

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One of the most useful skills to have when wandering a greenhouse is the ability to visually detect nutritional deficiencies in plants. If skilled at this, a grower can correct nutritional problems during production without a major loss of plant yield and quality.

I believe the best way to develop this skill is to cause the problems, on a small scale of course, on a few plants and watch as the symptoms develop over time. Only then can one see patterns, feel the leaves and roots, and learn when and how to correct the problem. Each species, and occasionally, different cultivars, can behave differently in the absence of specific nutrients. But who has time to grow each variety in controlled conditions to learn what each plant "says" when it is low in nutrients?

To begin learning the symptoms, I think it is helpful to learn all the nutrients and, briefly, what each nutrient does for the plant. It can be helpful also to learn how nutrients move in the plant and, at times, how they get into the plant. With this information in hand, you can begin to learn patterns that are common to all plants for specific nutrients. This will also give us direction on how to correct problems when they do show up. For example, if we see an iron deficiency, is it best to apply foliar spray, apply Fe to the root zone, or just water differently? While a nutrient deficiency may be an obvious visual symptom, knowing what other stresses cause these symptoms may allow us to fix a problem rather than just treat its symptoms. This way, a tomato grower knows the symptoms for not only tomatoes, but for bedding plants, nursery plants, and native species. It is so much easier learning a handful of characteristics than memorizing specifics on each plant species.

This paper is meant to supplement the visuals of the seminar. When you leave today, I also want you to take a list of other reference materials that can describe in much better detail what we discuss and watch (See lists below). To be certain of a visual diagnosis, it is often helpful to follow up with a plant tissue, water, and/or soil analysis. I have included a brief section on how to take a sample as well as how to interpret (and not over-interpret) the data.

WEBSITES:

http://www.back-to-basics.net/nds/# includes alfalfa, apples, canola, citrus, coastal bermudagrass, corn, cotton, forages, peanuts, potatoes, rice, small grains, soybeans, sweet corn, tobacco, tomatoes, tree fruit, vegetables, wheat
http://www.ces.ncsu.edu/depts/hort/floriculture/def/ for floriculture crops
http://extension.agron.iastate.edu/soilfertility/nutrienttopics/deficiencies.html corn and soybean
www.unce.unr.edu/publications/FS02/FS0265.pdf this is a pdf file, so you need Adobe Acrobat Reader
http://muextension.missouri.edu/explore/agguides/hort/index.htm extensive information
Lots of other sites with excellent text descriptions

BOOKS:

Epstein, E. and A.J. Bloom. 2005. Mineral nutrition of plants: principles and perspectives. 2nd edition Sinauer Associates, Inc. Sunderland, Mass.
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ESSENTIAL ELEMENTS

Essential elements have been defined as any element that a plant needs in order to complete its life cycle under controlled conditions (Arnon and Stout, 1939). Recently, a slightly new definition has been introduced and that is either the nutrient is contained as part of a molecule in a plant or growth of the plant without that nutrient is abnormal compared to plants not deprived of that nutrient (Epstein, 2005). In this talk, I will use this second definition of essentiality and as a result, the list of nutrients we discuss today is slightly different from what some of you may know. In Table 1, I have listed the essential elements, a brief description of what each is used for, and a general pH range in which, ideally, the nutrient is available.

Table 1. Essential elements, their use in the plant, and pH range of ideal availability

Nutrient[1]	Use[2]	ideal pH range[3]
N	Proteins, genetic information	6.0 – 8.0
P	Proteins, genetic information, energy	6.5 – 7.5 & >8.75
K	Water relations	>6.0
Ca	Cell wall, cell signaling	>7.0
Mg	Photosynthesis	6.8 – 8.5
S	Proteins, Photosynthesis, respiration	
Fe	Photosynthesis, respiration, detoxifying free radicals	<6.0
Mn	Photosynthesis, detoxifying free radicals	5.0 – 6.5
Cu	Photosynthesis, respiration	5.0 – 7.0
Mo	Nitrogen use	>6.0
Zn	Proteins, processing genetic information	5.0 – 7.0
B	Cell wall development	4.5 - 6.5 & >8.5
Cl	Photosynthesis, Water relations	>6.0
Si	Disease resistance, leaf and canopy structure	<7.0
Na	Regenerating photosynthesis products in C4 species	>8.0

[1] List of essential nutrients from Epstein and Bloom (2005). Ni is also essential, but sufficient supply of Ni comes from contamination of fertilizers or water.

[2] Use as described from Marschner (1995) and Epstein and Bloom (2005).

[3] Ideal pH range from Lucas and Davis (1961) and Lambers et al. (1998). This range only describes when most of the nutrient should be available in solution; it does not describe an acceptable or optimal pH range for plant growth.

Table 2. Mobility within the plant (from Marschner, 1995)

Good re-mobilization	Partial to limited re-mobilization
K, N, Cl, S, Na, P, Mg	Fe, Zn, Cu, Mo, B, Ca, Si, Mn

I have found that Table 1 and Table 2, together, can help predict where symptoms may occur for any plant species, and greatly assist in predicting how quickly and thoroughly recovery can be for plant yield and quality. There are generally one or two tricks for each nutrient that can push the visual diagnosis from a "maybe" to a "probably". Table 3 holds those keys.

Table 3. Simple key for diagnosing nutrient deficiencies

Nutrient	Key
N	Chlorosis of older leaves before young leaves
P	Usually marginal "purple" discoloration on middle to old leaves
K	Sudden, necrotic spots from leaf margin – no discoloration prior to lesions
Ca	New growth, necrotic spots, eventual growing point death, root browning to blackening, fruit end and inside "rot"
Mg	Patchy discoloration (yellow, orange, red) on maturing leaves
S	Uniform chlorosis on all leaves
Fe	Interveinal leaf chlorosis on young leaves
Mn	Spotty "stippling" chlorosis on maturing leaves
Cu	Chlorosis and necrosis from petiole out to leaf margins
Mo	Rare, "stingray" leaf shape on new and developing leaves
Zn	Super enlargement of leaves, interveinal chlorosis on developing leaves.
B	New growth, necrotic spots, eventual growing point death, glossy, malformed leaves, wide veins, root tip death, lots of branching
Cl	Unknown symptoms, similar to K?
Si	Susceptibility to powdery mildews and chewing insect pests.
Na	Unknown symptoms, similar to K?

It is extremely important to know your crops. Confucius is credited with say that "the footsteps of the farmer are the best fertilizer." This basically means that you can help the plants grow well by seeing them regularly. Certain crops have propensities for certain nutrient deficiencies. For example, tomato and Ca (blossom end rot) seem to go hand in hand as does lettuce with Ca/B deficiencies (tip burn). Looking at Table 1 and understanding how each of these nutrients is used in the plant provides insights into why these deficiencies occur where they do. We might try to push growth as fast as we can to maximize the number of turns for a space and have conditions that allow more B and Ca (not mobile in the plant) to follow water streams in the plant rather than high growth activity

NUTRIENT ANALYSIS

Finding a good plant, soils, and water analysis lab can be as important as finding a reliable media supplier. Speed, accuracy, and price are important considerations when attempting to find an analysis lab, but, in spite of the "easy to read" reports and printed guidelines, the interpretation of analyses is largely up to you. Before reaching that stage, it is important to send the lab the right samples. I will limit the discussion in this report to plant tissue.

Most recommendations are developed based on results from surveys, using many varieties, at various stages of development, and are on recently matured leaves. This is important to know because, if you send in tissue from a young, developing leaf or root, the report you get back will be in relation to these survey results or "accepted values". The survey results should serve only as loose guidelines. In other words, compare similar tissues and realize that the guidelines you receive may not be of a similar tissue. What do the wide ranges mean? At times it may mean that there is a wide range of acceptable values, but more likely, it means that we just don't know what an acceptable amount is. As an example, we analyzed 104 varieties of geranium and found a range of 3x in the macronutrients (i.e., P) and a range of about 10x for the micronutrients (i.e., Mn) (Figure 1). So based on this survey, what is acceptable for a particular variety of geranium? I couldn't conclude, definitively, a particular value for a given geranium.

Even within a plant, values for nutrients vary, and should, be based on the tissue's needs. For example, it is not uncommon to have B concentrations in mature leaf tissues of 100 ppm (mg kg-1) and only about 15 to 20 ppm in flower tissue. Both are healthy and both are correct. Ironically, deficient in both tissues may be a value of 10 to 15 ppm, which suggests there is little room for error in some tissue types for some nutrients.

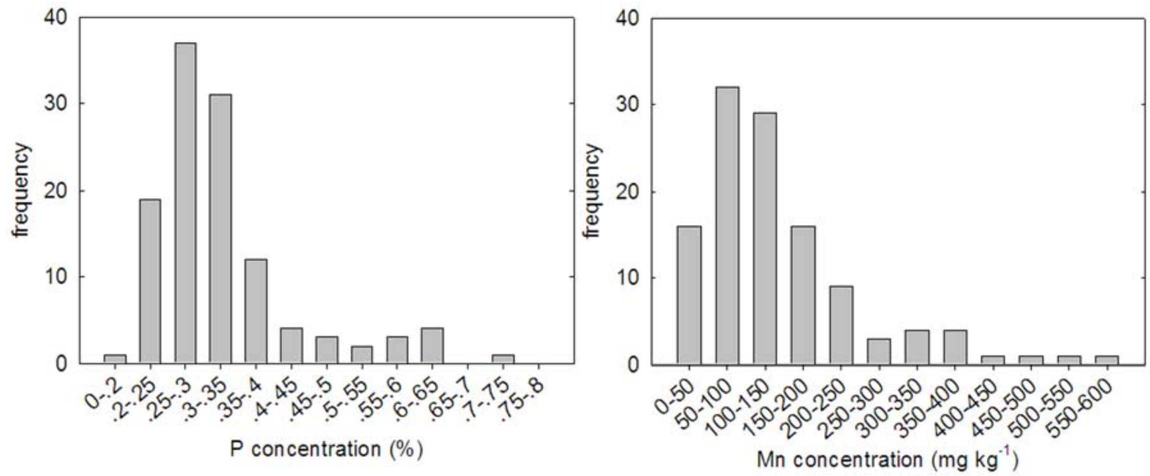

Figure 1. Range of P and Mn mature leaf tissue concentration in found 104 varieties of Pelargonium (Geranium) grown in the same environment with the same fertilizer. Macronutrients ranged 2 to 4 fold while micronutrients ranged about 10 fold.

Prior to sending tissue to a lab, rinse the tissue with the cleanest water available to remove fertilizer deposits on the leaf surface, dirt, and dust. This will enable you to have faith that the numbers you receive in the analysis are truly of what is in the plant rather than what happened to be on the tissue surface. If you are fortunate enough to have some healthy (symptom-less) appearing plants with unhealthy plants, send the same tissue type of both healthy and unhealthy tissue. This will show differences and potential problems much better than comparing "sick" tissue to a random book value.

OTHER PROBLEMS

Many other things can manifest themselves as nutrient deficiencies and can potentially confuse some diagnoses. For example, various root pathogens can result in a plant appearing as though it is experiencing Ca or B deficiencies in the roots and Fe deficiencies in the shoot. Lack of oxygen in the rootzone caused by heavy media, over watering, or a broken water pump can lead to Fe and K deficiency symptoms. High EC can result in Ca deficiency, air pollution can cause Mn, S, and P symptoms, while growth regulators can cause unusual chlorotic patterns akin to many nutrient deficiencies. pH problems can cause both deficiency and toxicity problems. High light can cause photobleaching that appears like S, Mg, Zn, and other deficiencies, and viral infections can seem, at times, like Mn deficiency. So while visual diagnosis can be helpful, it is not a cure all and only tells us part of the story; seek more information such as foliar environment conditions, media and watering patterns, spray history, pest history, and varietal information to make a complete diagnosis.

DISCLAIMER

Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of other products or vendors that also may be suitable.

REFERENCES

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