

# Plant Sap Analysis

## Increase Plant Vigor with a Closer Look at Nutrients

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Since the 1950s plant sap analysis has been used as a tool to manage crop fertilization strategies and nutritional content. To produce a well-developed crop, a balanced uptake of macro- and micronutrients is required. When plants are able to take up all essential nutrients in the needed amount and in the right equilibrium they develop optimally and, as a result, are stronger and more productive. By analyzing plant sap from the leaves, these plant nutrients can be monitored. This gives growers a tool and the ability to manage their plants' nutritional status and to improve plant vitality.

### PLANT SAP VERSUS TISSUE TEST

Conventional tissue testing analyzes the total amount of present nutrients in the dry matter of a leaf. These are the nutrients a plant has taken up until that moment. These nutrients are mainly complexed in the cell walls, etc. These complexed nutrients are not totally available for plant development at that moment. A plant sap test gives a view of the nutrients which are available for the plant, at that time, for growth or development. A plant sap test is similar to a blood test.

### NUTRIENT UPTAKE

When taking a closer look at nutrient uptake, there are several key factors that influence this process. Environmental factors such as temperature, light and soil conditions have a significant effect on the uptake of nutrients.

### TEMPERATURE

It is well-known that a lot of crops have difficulty taking up phosphorus when soil temperatures are low. Temperatures below 63°F can cause reduced mobility of phosphorus in the plant. Within a few days plants will show the first deficiency symptoms with older leaves showing purple discoloration. Nitrogen and magnesium deficiencies can easily occur during cold weather conditions in early spring when soil temperatures are low and plant

activity is increasing. Even when there is enough nitrogen or magnesium available in the soil, the low temperature can inhibit these compounds from being available for root uptake.

### LIGHT

Poor light conditions, caused by dark weather, can cause nitrate accumulation in leaves. As a result, necrotic or chlorotic spots can occur on leaves and plants start to take up too much water. The high water uptake is caused by the osmotic effect that is stimulated by nitrate. Quickly changing weather conditions such as increased irradiation combined with a rise in temperature can cause tip-burn in a lot of crops. When crops suddenly have to start evaporating and the calcium uptake cannot keep up, new cells will contain low calcium. If then a moisture deficit occurs in periods with more dark weather conditions these cells are too weak to handle the increasing cell pressure; cell walls collapse, caused by a calcium deficiency. Leaf tips turn brown and will necrose, which has a negative effect on the total photosynthesis capacity. Plants will be less disease resistant and the shelf life of fruits decline.

### SOIL PH

Soil conditions, such as pH, can strongly influence the nutrient uptake of a crop. Changes in soil pH directly result in differences in nutrient uptake. High pH results in alkaline soils where elements like iron, manganese, copper and zinc are less available for root uptake. In acidic soils plants will have difficulty taking up nitrogen, phosphorus, potassium, sulfur, calcium, magnesium and molybdenum. Between several elements there can be, depending on which elements are

involved, an interaction in root uptake. For example, potassium and calcium are strongly related as they are directly competing in root uptake; one of the reasons is because both are cations. High potassium concentrations will result in lower calcium uptake and the other way around (Figure 1).

### PLANT GROWTH STAGE

Another factor influencing nutrient uptake is the growth stage of the crop. In a vegetative stage plants need more nitrogen, phosphorus, calcium and magnesium. When the cultivation progresses and plants are starting to bear fruit, the need for potassium increases. In practice, growers often apply potassium to their crops too early, which results in a competition in nutrient uptake between potassium, calcium and magnesium. This leads to reduced growth due to magnesium deficiency and lower product quality because of calcium deficiency. Growers who regularly analyze their crops are postponing potassium applications until plants are fully in their reproductive growth stage which can lead to improved yields, both quantitative and qualitative.

Besides these growth stages the root system also has an effect on nutrient uptake. When developed well, crops will take up nutrients quite easily when levels in the soil are low. Poorly developed root systems are low in uptake, even when nutrient concentrations in the soil are high. Plant sap analysis can provide information that cannot be provided by a soil or substrate analysis. For each element it becomes directly clear if the crop suffers from a deficiency or an excess.

**Nitrogen uptake needs to be sufficient to guarantee active plant growth, but too high nitrate-nitrogen levels in the plant sap will cause more susceptibility.**

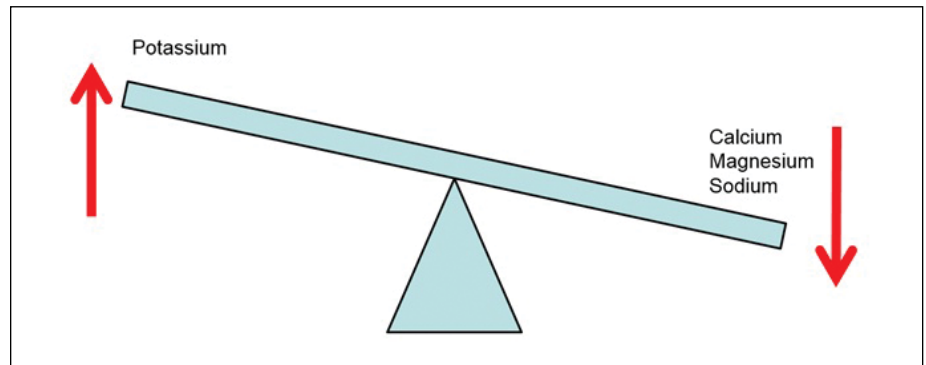
## PLAGUE & DISEASE

When a crop is vital and healthy the risk of infection by plagues and diseases will be lower. Perfect growing conditions, such as the optimal climate, water supply, rooting and a balanced fertilization will result in vital plant growth. To create these optimal growing conditions and strive for a less susceptible crop it is important to optimize plant nutrition. Improving the crop's fertilization by managing specific nutrients will result in an increase of the plant's natural resistance.

### CALCIUM & BLOSSOM END ROT

An example of an important relationship between fertilization and prevention of diseases is the infection of blossom end rot in tomato and bell pepper (See Figure 2 and Figure 3). This disease is caused by insufficient calcium transport to fruits and young plant parts. A cause can be found in the climate conditions. In situations where greenhouse or tunnel climates are inactive the mobility of calcium is inhibited because the uptake of this element is dependent on plant evaporation. Another cause can be the presence of sodium in the soil or irrigation water. Calcium and sodium are highly competitive during nutrient uptake. An underrated, contributory cause can be a recent or continuous over-application of potassium allowing potassium to directly suppress calcium from being taken up. There should be a balanced supply of these elements. It is strongly recommended to regularly check sodium and potassium levels in the soil or in irrigation and drain water. When levels are becom-

Figure 1



Competition in uptake between potassium and calcium, magnesium and sodium.

ing too high, growers should take serious action to lower these levels or increase calcium uptake.

### SILICON & POWDERY MILDEW

The susceptibility to powdery mildew is variety dependent. In some cases this can be traced to the nutrient uptake of varieties. The strawberry varieties Darselect and Sonata, as shown in Figures 4 and 5, grown on the same plot and receiving the same fertilization, water amount and crop protection, differ in powdery mildew infection. Sonata shows no powdery mildew symptoms, while Darselect is clearly showing a severe infection. Plant sap analysis showed that the silicon uptake of Darselect was 40 percent less. During this infection most of all other elements were about 5 percent less present in Darselect. In strawberry plant propagation silicon fertilization is applied as an effective instrument to improve the firmness of leaves. Although, in production fields

growers should monitor silicon levels to avoid problems with fruit quality caused by high silicon concentrations.

### NITRATE-NITROGEN & APHID SUSCEPTIBILITY

Nitrogen uptake needs to be sufficient to guarantee active plant growth, but too high nitrate-nitrogen levels in the plant sap will cause more susceptibility. Plants take up most of their nitrogen as nitrate and convert this into proteins. This is a rapid process and results in a vegetative height growth with long internodes. Nitrate, as a salt, will put another mechanism into effect. High nitrate-nitrogen levels result in too high moisture uptake by the plant, cells elongate more and cell walls are weaker. This makes it easier for aphids and other leaf cuticle-penetrating insects or fungi to suck out nutritional plant sap from plant leaves. High nitrate-nitrogen levels in the plant sap will also result in a low sugar content. Plants with

Figures 2 & 3



Blossom end rot in tomato and peppers. This disease is caused by insufficient calcium transport to fruits and young plant parts.

## Figures 4 & 5



*Powdery mildew susceptibility in Darselect and powdery mildew resistance in Sonata.*

low sugar levels will be more susceptible to diseases. Aphids will not be attracted by a plant which has high sugar levels because when an aphid consumes high amounts of sugars it dies.

An excess in nitrate-nitrogen can also be determined by plant sap analysis when the ratio between the nitrogen that has been taken up and the total converted nitrogen is no longer optimal. A high total nitrogen level combined with a low nitrate-nitrogen concentration is ideal. The higher the share of nitrate-nitrogen

in the total converted nitrogen, the higher the amount of nitrogen that is unnecessarily stored in the leaves. To prevent a crop from getting infected by aphids, it is important to get the nitrate in the plant and make sure it is converted to amino acids and proteins. This will reduce nitrate accumulation. The nitrate-nitrogen levels should be compared with the total nitrogen concentration.

### INTERACTIONS BETWEEN ELEMENTS

Some plant nutrition problems cannot be directly related to problems with pH, low soil concentrations or environmental conditions. In such cases often an interaction between different elements is having an impact on the uptake of an element on its own.

### MAGNESIUM & MOLYBDENUM

Nitrogen uptake needs to be limited to just the necessary amount needed. Also the conversion to protein compounds out of this nitrate-nitrogen needs to be stimulated. The key to this can be found in magnesium and molybdenum. Molybdenum plays an important role in the production of the enzyme nitrate reductase. The function of this enzyme is the conversion of nitrate into amino acids and proteins; it prevents nitrate accumulation in the leaf. This is why molybdenum deficiency directly causes nitrate accumulation, causing weak cells. Besides molybdenum, magnesium also has an influence on the efficiency of the nitrogen conversion. In addition to nitrogen, magnesium is a key important compound of chlorophyll. Chlorophyll

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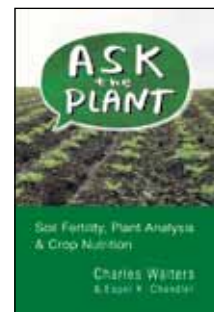
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### Ask the Plant on Petiole Testing

The plant root feeds and drinks every day, just like a growing youngster. This observation calls into question the practice of feeding the plant once a year. With the expectation of a maximum yield a few months later, by checking the plant daily or weekly — crop-logging — the flow of its bloodstream, so to speak, telegraphs its future growth for 7-21 days. When a suitable inventory in the soil fails for any reason, the sap test enables a saving action on time and in compliance with production objectives. “I can’t stress it too much,” Chandler always reminds us. “The leaf test defines the past. It is valuable, but not really as valuable as petiole testing for the future.”

Source: *Ask the Plant* by Charles Walters & Esper K. Chandler, Acres U.S.A.





plays an important role in the process of photosynthesis and so on in plant development. Chlorophyll mainly consists of carbon, hydrogen, oxygen, nitrogen and magnesium. Each magnesium molecule is surrounded by four molecules of nitrogen. The nitrogen/magnesium ratio is important for the right chlorophyll composition. Knowing this, we can conclude that an accumulation of nitrogen in leaves can also be caused by a magnesium deficiency. A lot of growers are applying extra nitrogen when their crop is not growing optimally, but most of time an extra magnesium and/or molybdenum application would be more effective.

### TRACE ELEMENT UPTAKE

When deficiency symptoms of trace elements appear, often the first reaction is to start applying higher concentrations. In most cases this does not have any beneficial effect on nutrient uptake, simply because the pH level in the soil is not optimal. A pH of 6.0 or higher will cause problems in uptake of manganese, iron and zinc more available in soils, but then calcium, magnesium and potassium will be less available. Lower calcium concentrations can result in improved boron uptake. To improve the uptake of other trace elements such as copper, lowering the pH only is not always sufficient. After a pH adjustment it is still possible that high phosphorus soil concentrations can block pathways regulating trace element root uptake. In that case, lowering the phosphorus application is needed to create the possibility to activate these pathways. In general, phosphorus leaf concentrations should not exceed 750 ppm. Differences in optimal phosphorus concentrations per crop exist, as the preference of trace element uptake differs from crop to crop or variety to variety.

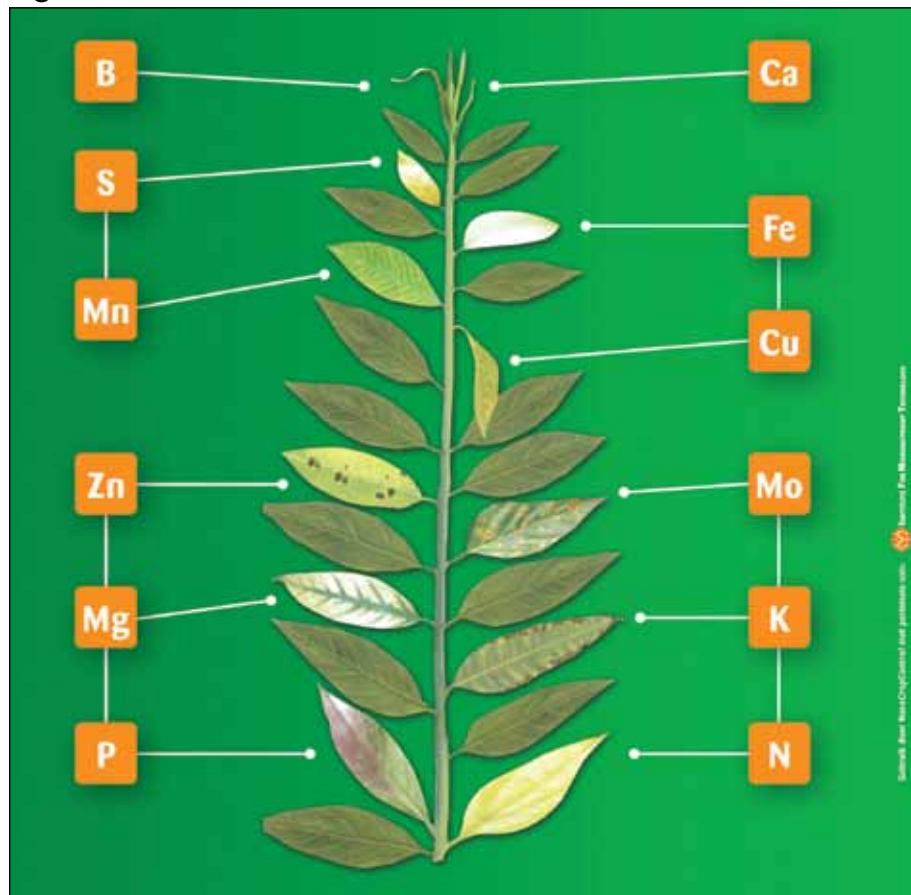
### SAMPLING CROPS

Deficiencies in micronutrients are often accepted. They occur in periods of rapid growth; symptoms are often indicated as 'growth spots.' By analyzing plant sap it becomes clear which nutrients are insufficiently present in the plant, before the deficiency symptoms will be visible. Direct action can be taken when analysis shows an approaching deficiency.

### MOBILITY OF ELEMENTS

Plant sap analysis also provides information about the reserves of different elements in the plant. Mobile elements such

Figure 6



Mobile elements such as potassium, magnesium and nitrogen are stored in older leaves.

as potassium, magnesium and nitrogen are stored in the older leaves. When plants are taking up too little of these elements, the young leaves are relying on the older leaves for their potassium, magnesium or nitrogen supply. High concentrations in young leaves and lower concentrations in old leaves indicate that plants suffer from a lack in uptake of the specific element (See Figure 6). Growers then can increase their nutrient supply specifically for that element.

NovaCropControl, based in The Netherlands, is a laboratory specializing in plant sap testing. With experience in a wide range of horticultural and agricultural crops, NovaCropControl provides insight in the plants' nutritional status, quickly and accurate. The NovaCropControl laboratory has been using the plant sap analysis for 10 years and have been offering the complete range of macro- and micronutrient analysis in more than 100 different crops for the past five years.

Growers who manage their crop fertilization based on plant sap testing gain several advantages. Firstly, plants are healthier and less susceptible for plagues

and disease; growers notice this because the requirement to spray crops with fungicides and pesticides is decreasing. Secondly, fertilization applications based on the plant's demand can result in savings on fertilizers. Thirdly, nutrient deficiencies can be avoided before they start to cause severe visible damage to crops. This will increase the potential of plants which results in higher yields, both qualitatively and quantitatively. Last, growers can specify their fertilization program on the different varieties being cultivated, as plant sap testing will give an indication of the varietal differences in nutrient uptake. Depending on the growing period of the crop, it is best to analyze plant sap weekly for short cultivations or bi-weekly for longer cultivations. Growers then can follow the long-term progress of the nutritional status in plants precisely. In 2013 John Kempf and other consultants from Advancing Eco Agriculture used NovaCropControl plant sap analysis to monitor nutrient uptake in some trials.

For more information about NovaCropControl visit [www.novacrocontrol.nl/en](http://www.novacrocontrol.nl/en).