CANNAtalk®

MAGAZINE FOR SERIOUS GROWERS

ISSUE 24 2014

PLANT NUTRITION and NUTRIENT DEFICIENCY

All the highlights

UP AND COMING SPORTS

Unusual sporting gems

CUCUMBER

'King of cool'

EXTRA DEFICIENCY GUIDE

And more:

HQTalk:

Everyone likes to party every now and then. And I'm not afraid to admit I actually prefer to party every now, instead of every then. So when I feel a bit tired for a couple of days, I accept the fact that it might have been too much partying. But just lately, it was more than a couple of days. At first I didn't worry about it too much. After all, it had been extremely busy and stressful at work too. But one morning I woke up with my head in a plate of oatmeal. I just fell asleep while eating breakfast! Time to see my doctor. It turned out I had an iron deficiency. Something I would never have guessed myself as I thought it was something that women usually suffer from.

I was afraid I might have to cut down on the partying, but my doctor reassured me that I could still have fun as long as I ate a healthy and varied diet. I realized that the work hard, play hard lifestyle had in fact meant that I had been skipping meals and the meals I did eat were low in vitamins and low in fiber.

Changing my eating habits really worked, but it took a while to totally recover.

It is true. Our bodies need the right kind and amounts of nutrients. And our bodies will protest if they don't get it. I realized it works the same with plants. If you use a well-balanced, quality fertilizer, you feed your plants correctly and the risk of a deficiency is minimized.

But just as my partying was not the main cause of my health issues, it probably did have an effect. Same goes for growing. Sometimes other factors have affect the development of a deficiency too. So a deficiency can happen to anyone.

In the case of plants with a nutrient deficiency, we growers have to be the doctors. We are the ones that have to recognize which deficiency we are dealing with and prevent as much damage as possible. The tough thing is, there are so many possible deficiencies that sometimes it is hard to diagnose the right one. That's why this issue of CANNAtalk is all about plant nutrition and deficiencies. There is a lot to say about it so our CANNA Research department has written an extensive article which you can find on page 4 and continuing on page 26. You will also like the Growers Tip on this subject on page 31.

And we are sure you will love our pull-out deficiency guide in the middle of the magazine. You can easily take it out and hang on your wall to help you recognize which deficiency you're dealing with. But in case you have more questions, don't hesitate to ask our experts for help through our website www.cannagardening.com.

Enjoy reading,
Jeroen

Contents

PART 1

PLANT NUTRITION AND NUTRIENT DEFICIENCY

MANY GROWERS HAVE SEEN PLANT SYMPTOMS THAT THEY CLASSIFIED AS A NUTRIENT DEFICIENCY, ANYTHING UNUSUAL FROM YELLOWING OF THE LEAVES TO BROWN NECROTIC SPOTS OR REDUCED GROWTH. SOME WILL HAVE EXPERIENCED THAT ADDING MORE NUTRIENTS IS OFTEN NOT A SOLUTION FOR THESE SYMPTOMS… By CANNA Research

Setting up a suitable cultivation strategy and a good nutrient balance is a prerequisite for a successful yield. But what determines a good nutrient balance? Which external factors play a key role here?
To better understand this, we will first highlight the different essential nutrients and how these behave in the soil or rhizosphere (the space where roots grow and nutrients are taken up by the plant) and how the plant can take up the different nutrients. Then we will focus on the function of the essential nutrients and how deficiency symptoms can be recognized.
The final part of this article will focus on how deficiency symptoms arise. As we will see, many problems are caused by soil or substrate imbalance. In this article we will discuss most of these aspects and how we can solve them.

Mineral plant nutrition

Plants need the right combination of nutrients for growth, and as an external supply for its internal metabolism. Plant nutrients or nutritional elements can be any mineral taken up by the plant. In 1972, Epstein defined two criteria for such an element to be essential for plant growth. The first criterion is; in its absence the plant is unable to complete a normal life cycle. And the second is that the element is part of some essential plant constituent or metabolite.

Plant nutrition is not only essential for plant growth and survival, but a balanced nutrient solution also aids for maximizing the yield, improving crop quality and the nutritional value of the plant itself (for example for human nutrition).

The importance of a nutrient depends on the crop species and crop variety. But as we will see, the abundance of other nutrients also plays a key role.

Classification of elements

Several classification methods have been proposed to sort the elements. Arnon and Stout proposed three criteria to consider if an element is essential for plants in the late 1930s. The first criterion is that a deficiency of the element should make it impossible for the plant to complete a normal life cycle. Secondly, the deficiency should be specific for the element in question. And finally, the element is directly involved in the nutrition of the plant, for example, as a constitute of an essential metabolite or required for the function of an enzyme system.
These criteria are described in further detail by Epstein (2005), who stated that an element should also be considered essential if the plant can be so severely deprived of the element that it exhibits abnormalities in its growth, development, or reproduction. That is, its 'performance' in comparison with plants not so deprived.

A completely different way of classifying the nutrients is by abundance in the plant (see figure 1) or by the amount the plants needs them. More than 93% of the plant biomass consists of carbon, hydrogen and oxygen. The remainder

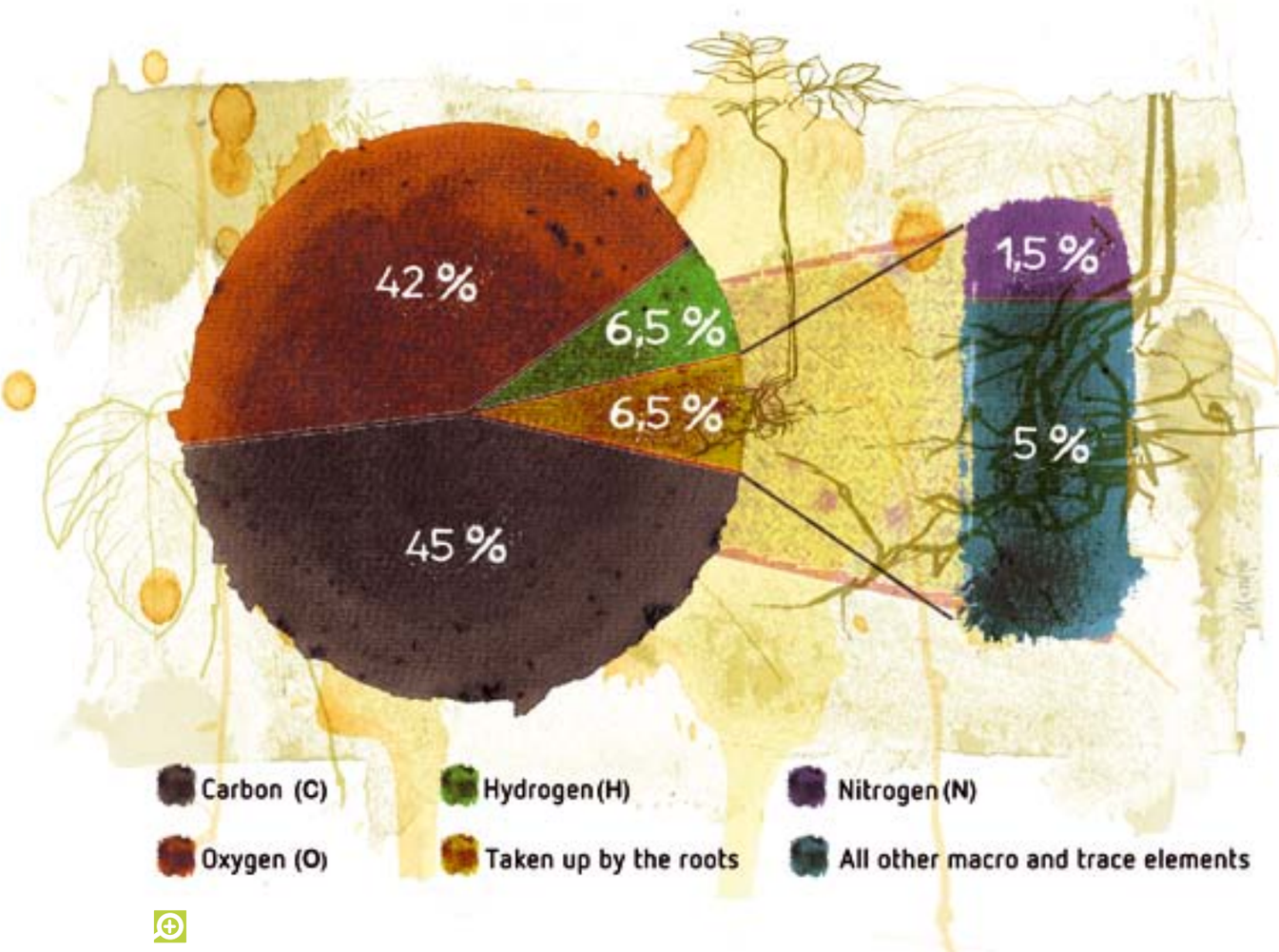


Figure 1: A German scientist, Knop, has estimated that if all the species of the plant kingdom were fused into one mass, the ultimate composition of the dry matter of this mixture would be as represented in this pie chart. Most of the plant biomass consists of carbohydrates, with carbon (C), oxygen (O) and hydrogen (H), making up as much as 93.5%. These elements are taken up by the plant mainly in the form of carbon dioxide gas, oxygen gas and water. The energy needed to produce carbohydrates (or any organic compound) usually comes from photosynthesis, the process by which light energy is 'fixed' in specialist plant organs called chloroplasts. Only 6.5% of the elements in the plant are taken up by the roots, of which nitrogen (1.5%) is the most abundant. The remaining 5% consists of all the other macro elements and trace elements.

PLANT NUTRITION AND NUTRIENT DEFICIENCY

PART 1

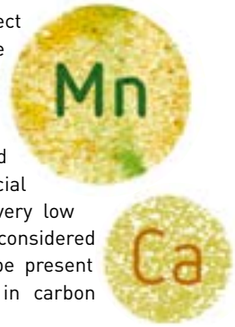
includes all other nutrients, which can be divided into two groups. Elements required in large quantities are called macronutrients or macro elements. These include nitrogen, potassium, phosphorus, calcium, magnesium and sulphur. Micronutrients or trace elements are the elements which are required in very low quantities. Iron, copper, manganese, molybdenum, boron and zinc are examples of elements required in minimum amounts yet essential for plant growth and development.

Some elements are not essential for plant growth or reproduction but may certainly be beneficial for plant growth. Silicon is an example of such a non-essential element. Only members of the Equisetaceae family (scouring rushes, see figure 3) require silicon for completing their life cycle. In other words: it is essential for the survival or reproduction of the plant.

For other crops such as tomato, cucumber and strawberries it is known that silicon accumulates in substantial amounts in plant tissue enhancing growth and stability (Woolley, 1957; Miyake & Takahashi, 1985). For rice it has been demonstrated that extra silicate supply during the reproductive stage was most important for plant growth (Ma et al., 1989).

Cobalt has recently been established as an essential element for nitrogen fixing micro-organisms. And as such may be essential for plant survival under nitrogen limitation where the plants depend on these symbiotic interactions. Natural levels of cobalt exist in both mineral and organic fertilizers. CANNA nutrients contain enough cobalt which reduces the chance of a cobalt (nutrient) deficiency to a minimum.

Sodium and chloride are often considered unwanted or even toxic elements. Tap water is the usual suspect when it comes to excess or toxic sodium or chloride levels. Toxic by means that these two elements affect potassium and nitrate uptake respectively, which may result in potassium and nitrate deficiency symptoms as we will see in the next paragraph. Sodium and chloride, if essential to commercial crops, would be required in a very low concentration and therefore considered a trace element. It appears to be present in enzyme complexes involved in carbon fixation.



The role of essential elements in plant growth and development

Nitrogen

Nitrogen (N) is mainly absorbed as nitrate (NO_3^-) and ammonium (NH_4^+). Under little circumstances organic nitrogen compounds such as amino acids are taken up by the plant. Nitrogen is about 0.3-5.0% of the plants total dry matter. Relatively most nitrogen can be found in young tissue still under development such as meristems and young leaves, decreasing towards maturity. The least nitrogen is found in senescent tissue. Being an important component of many essential components such as nuclear acids, proteins, enzymes, lipids, chlorophyll, phytochromes, plant hormones and vitamins it is evident that nitrogen is essential for plant growth and survival.

Potassium

Potassium (K) in the plant only exist in the cation form (K^+) and concentrates in plant parts with higher metabolic activity. Potassium is about 1-5% of the plants dry weight. Potassium is used by the plant for regulation of the water balance (osmosis, stomata and transpiration), activation of enzymes (pyruvate kinase, glutationine synthesases, starch synthase etc), increasing resistance (pests and diseases), for synthesis of polysaccharose and proteins, for sugar transport (potassium as a counter ion of H+ participates in sugar loading) and for energy metabolism (oxidative phosphorylation and photophosphorylation).

Phosphorus

Phosphorus (P) is absorbed mainly as dihydrogen phosphate ($H_2PO_4^-$). About 0.1-0.5% of the plants dry matter is phosphorus. It is a component in nuclear acids, lipids, co-enzymes and it plays a key role in the energy metabolism (forms adenosine triphosphate, ATP). As such it is part of the metabolism and transportation of sugar, regulates enzyme activities and it participate in protein, fat and starch synthesis.

Calcium

Calcium is taken up in its ion form (Ca^{2+}) by passive absorption and represents roughly 0.2-3% of the plant dry matter. More calcium can be found in the older than in the younger plant parts. The function of calcium in the plants' physiology is cell wall stabilization, activation of some enzymes, stabilization of membranes and osmoregulation.

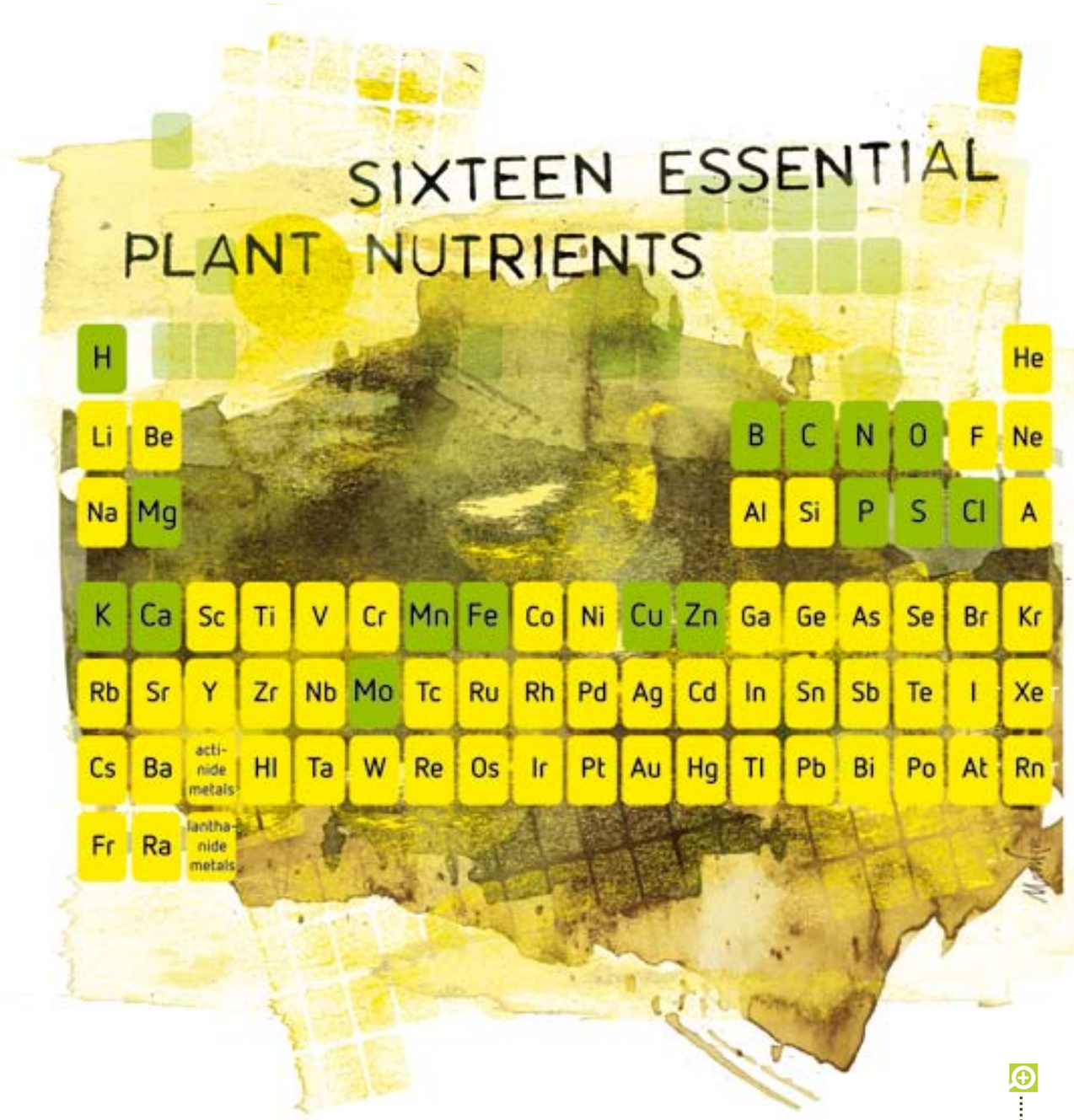


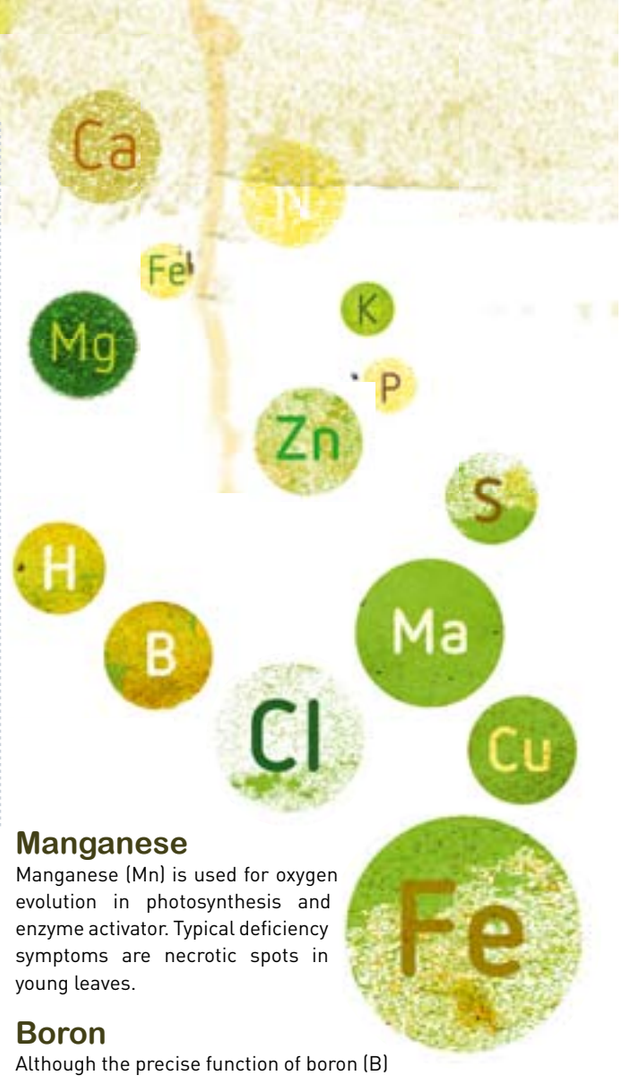
Figure 2: You are looking at a schematic overview of the sixteen essential plant nutrients. According to scientists Arnon and Stout, there are three criteria by which we can judge whether an element is essential for plants. 1. A deficiency of the element makes it impossible for the plant to complete a normal life cycle. 2. The deficiency should be specific for the element in question. 3. The element is directly involved in the nutrition of the plant.

Magnesium

Magnesium (Mg^{2+}) is about 0.03-0.7% of the total plant dry matter. Magnesium is relatively most abundant in the younger leaves. Although less abundant than the above mentioned nutrients, magnesium is essential for photosynthesis as part of the chlorophyllide molecules, which are the molecules responsible for capturing the light, and as an activator for Rubisco, the enzyme that transports carbon dioxide during sugar synthesis.

PLANT NUTRITION AND NUTRIENT DEFICIENCY

PART I



Sulfur

Sulfur is taken up as sulfate (SO_4^{2-}) and is about 0.01-0.5% of the plants total dry matter. There is more sulfur in the older leaves than in the younger leaves. Sulfur is a component of proteins and bio membranes.

Iron

Iron (Fe) is a co-factor for some enzymes, involved in photosynthesis and nitrogen fixation.

Figure 3: A typical scouring rush, the only plant family that needs silicon for survival.

Manganese

Manganese (Mn) is used for oxygen evolution in photosynthesis and enzyme activator. Typical deficiency symptoms are necrotic spots in young leaves.

Boron

Although the precise function of boron (B) in plant metabolism is unclear, evidence suggests that it plays roles in cell elongation, it enhances germination and tuber elongation, it is a component of cell wall and it promotes sugar transport.

Zinc

Many enzymes require zinc (Zn) ions for their activity. It is an activator or component of enzymes and is often involved in enzyme synthesis.

Copper

The function of copper (Cu) is comparable to iron. Being a component of or closely related to enzymes and other proteins it is also involved in electron transport.

Molybdenum

Molybdenum (Mo) enhances plants resistance against viral infections and it is a component of some transport proteins involved in nitrogen fixation.

Go to page 26 to read part two of 'PLANT NUTRITION AND NUTRIENT DEFICIENCY'

GrowIT YOURSELF

COOL AS A CUCUMBER

EATEN AND ENJOYED ALL AROUND THE WORLD, THE CUCUMBER CAN PROBABLY LAY CLAIM TO THE TITLE OF 'KING OF COOL'. THE STEVE MCQUEEN OF THE SALAD WORLD. BUT AS SLENDER AND SUCCULENT AS THE CUCUMBER MIGHT BE, IT HAS NEVER QUITE BEEN ABLE TO SHAKE OFF THE ASSOCIATIONS OF ITS – FRANKLY – PHALLIC FORM. IT'S PROBABLY AN ASSOCIATION THE CUCUMBER CAN LIVE WITH, THOUGH. NOTHING IS A PROBLEM WHEN YOU'RE AS COOL AS A CUCUMBER. By Marco Barneveld, www.braindrain.nu

In ancient Rome, wives, who wished for children, wore cucumbers around their waist. Maybe the idea was that the sight of the vegetable might inspire their spouse to achieve great things in the bedroom. The cucumber has been one of mankind's edible companions since the beginning of time, it seems. Originating in India, it spread quickly all over the world. Cucumbers are mentioned in the legend of Gilgamesh – an Uruk king who lived around the year 2,500 BC in what is now Iraq and Kuwait. And approximately 3,300 years later, cucumber cultivation spread to parts of Europe. In 900 AD the existence of this vegetable (which is actually fruit) was first recorded in France, where Charlemagne grew it in his garden. It was not until the time of the European colonists that cucumbers finally appeared in North America in the 1,500s.

The melon family

The most well-known cucumber is the long, dark green, smooth-skinned variety, Cucumis sativus, which we find in most grocery stores. But cucumbers actually come in a wide variety of colors, sizes, shapes and textures. You can find white, yellow, and even orange-colored cucumbers

CUCUMBER

Figure 4: **The world produces approximately 93 billion lbs of cucumbers every year.**

and they can also be short, slightly oval, or even spherical in shape. Their skin can be smooth and thin, or thick and rough. But all these shapes and sizes of cucumber belong to the botanical plant family called Curcubitaceae, a large family that includes melons and squashes.

Crunchy pickled cucumbers

While there are literally hundreds of different varieties of Cucumis sativus, virtually all of them can be divided into two basic types: those for slicing and those for pickling. Slicing cucumbers include all the varieties that are cultivated for immediate consumption while they are still fresh. These varieties tend to be fairly large, with thicker skin. Their size makes them easier to slice, and their thick skin means they can be transported easily.

Pickling cucumbers, on the other hand, are not cultivated for immediate consumption, but – as the name suggests – for pickling.

There are two basic types of pickles: fermented and non-fermented. Fermentation is the process of allowing the fresh cucumbers to soak in a solution – typically brine, water that has a very high salt content. In fact, the word 'pickle' actually comes from the Dutch word 'pekel', meaning brine. As well as salt, pickling brines often contain other ingredients, including vinegar, dill seed, garlic, or lime.

Non-fermented pickles rely on the addition of vinegar or some other acidic solution to prevent spoilage. 'Quick pickling', using just vinegar, can be accomplished in a matter of days. Pickling by fermentation usually takes a minimum of a few weeks.

Popular veggie

After tomatoes, cabbages and onions, cucumbers are the fourth most widely cultivated vegetable in the world. They are enjoyed on every continent and you will find them used in all types of cuisine. The world produces approximately 93 billion lbs of cucumbers every year.

Health benefits

Maybe cucumbers have not received as much press as other vegetables in terms of their health benefits, but this widely cultivated vegetable does in fact provide us with a unique combination of nutrients. Cucumbers have valuable antioxidant, anti-inflammatory, and anti-cancer benefits. They are a valuable source of conventional antioxidant nutrients including vitamin C, beta-carotene, and manganese. In addition, cucumbers contain numerous flavonoid antioxidants, including quercetin, apigenin, luteolin, and kaempferol.

Cucumbers are also an excellent source of anti-inflammatory vitamin K and the enzyme-cofactor molybdenum. They contain plenty of free radical-scavenging vitamin C, and potassium and magnesium which are essential for cardiac health. They give you bone-building manganese, energy-producing vitamin B5 and the silicon which is vital for the health of your nails.

Grow it yourself

Cucumber plants naturally thrive in both temperate and tropical environments, and generally require temperatures between 59 and 91°F. This means they are native to many regions of the world.

How to plant cucumbers

For the best-tasting fruit and optimum yields, grow plants in a sunny spot and in warm, fertile, and well-drained soil that is rich in organic matter. Raised beds are ideal. Cucumbers require a soil pH between 6.0 and 7.0. Seeds should be sown or transplants set out only when all risk of frost has passed and the soil has warmed to at least 59°F. An unexpected frost will kill your plants, and the vines will grow slowly and suffer from more stress in cooler conditions. You can start seeds indoors three to four weeks before your anticipated planting date outside. Be careful not to disturb the roots when transplanting.

Fertilize

Cucumbers thrive in light, friable soil. Several inches of organic matter worked into the soil prior to planting will help achieve that goal. The cucumber plants are heavy feeders, so be sure to feed the soil with rich compost or aged manure. After the vines have developed runners and the first flowers have appeared, follow up with a side dressing of compost, aged manure, or organic fertilizer. If the leaves become yellowish, the plants need more nitrogen. Make plenty of room. Giving your plants the space they need is also essential if you want them to thrive. Grow trellised plants 6 to 7 inches apart. Hills with one or two seedlings should be spaced about 3 feet apart, with the rows 4 to 5 feet apart.

Cucumbers are thirsty

Keep your plants well watered, especially around the time the plant is flowering and fruiting. Any water stress during this period of rapid growth will cause an increase in the amount of bitter-tasting compounds in your fruit. Cucumbers are vigorous growers and therefore need a lot of water per week, depending on the weather and the characteristics of your soil. The key is to keep the soil slightly moist at all times. You should water deeply about once or twice a week, or more often if you're gardening in sandy soil.

Mulchy mulch

You can further reduce water stress by mulching plants with an organic mulch. Mulch helps to conserve and moderate moisture levels and also blocks out weeds. Plastic mulches can be applied at planting time, but wait until summer or after the soil has warmed to above 70°F before applying organic mulches, such as straw.

Self-regulating moral

Cucumber vines will self-regulate the number of fruits they carry at a time. To maximize production, harvest fruits as soon as they reach picking size. Pick them daily, because under ideal conditions, cucumber fruits can actually double in size in just one day. Use scissors or small shears to snip off fruits with a short stub of stem attached. Lightly scrub, pat dry and refrigerate harvested cucumbers right away.

Tips:

- Use a trellis, such as a wire tomato cage, to increase the leaf-to-fruit ratio of your cucumbers. This will increase your yield of flawless, flavorful fruits and make them easier to pick.
- To further increase your yields, mulch beneath the cucumbers with organic material.
- Make two plantings a month apart to extend your harvesting season, and try to plant different varieties. If you experience super-hot summers, grow a second crop in early fall, using row covers.
- If you're planning crop rotations, note that cucumbers often do well following cabbage-family crops. •

RECIPE

FIVE-MINUTE **COLD CUCUMBER SALAD**

Stay cool with this easy-to-prepare salad. One serving provides 246% of your daily recommended intake of vitamin C and 52% for vitamin A.

INGREDIENTS:

- **1/2 medium red onion**
- **1 medium clove garlic**
- **1 medium cucumber**
- **1 medium tomato**
- **1 medium red bell pepper**
- **Some feta cheese**
- **6 olives, cut into halves or quarters**
- **A squeeze of fresh lemon juice**
- **Sea salt and pepper to taste**
- **Fresh or dried dill (optional)**

DIRECTIONS:

Chop the garlic and slice the onions; let these sit for 5 minutes. Combine the remaining ingredients and serve.

With an article about the expected revolution in cultivating crops we now come to the fifth part of our series. In previous CANNAtalk editions we have introduced you to the rules of Mendel, explained to you what phenotypes and genotypes are, brought you an article about photoperiodism and one about how to protect your plants genes.

THE CROPS WE GROW THESE DAYS NEED HIGHER INPUTS THAN EVER BEFORE. THE FUNDAMENTAL REASON FOR THIS IS THE FACT THAT MANY OF OUR CULTIVATIONS TAKE PLACE IN A RELATIVELY SHORT PERIOD AND THE TIME TO ACHIEVE ECOLOGICAL EQUILIBRIUM IS NOT THERE. By CANNA Research

EXPECTED: A REVOLUTION IN CULTIVATING CROPS

We are also now slowly realizing that this way of growing crops is not friendly and tears down the natural systems of our planet in different ways. Nevertheless we are dependent on these high outputs, why, because we are so many. Our demands for high inputs will only increase because there is little prospect of our numbers decreasing. We are not focused on the question of what will happen in the end, or how we can avoid it. We are only focused on the question how to squeeze out the last drops to prolong our existence. This article is about a very interesting way to decrease the inputs without losing too much of the output. Interestingly this way could benefits our planet, since it will change the way we grow our crops drastically.

After the discovery of making and using fire, agriculture is certainly man's greatest invention. Like fire, agriculture changed the way people live. Before agriculture, humanity had a nomadic way of living, collecting food and other materials derived from animals and plants, and with the introduction of agriculture, humans settled into a (more) permanent place to live *(figure 6, step 1 & 2)*. These first farmers selected the best plants or animals for propagation, so the concept of breeding is inextricably linked to concept of agriculture. Breeding energy -rich crops, like grains (i.e. rice, corn) or tuber crops (e.g. potatoes, yams) eventually made the existence possible of cities and complex civilizations. It was at this point that our history technically started, because we became able to write it down.

The work of a few thousands of years of generations of farmers made the crops possible we have today, especially the last few hundred years where much has changed. New species from other continents arrived *(figure 6, step 3)*. Monoculture was made possible by means of mechanization, chemical fertilizers and pesticides resulting in higher and higher yields. In the last fifty years, with soilless cultivation and control of climate by means of heated and lighted greenhouses, both inputs and yields have increased even more *(figure 6, step 4 & 5)*.

Figure 5: This is a genetically engineered plant that was grown in a petri dish in a protective environment. The aim of genetic engineering is to alter the plant's DNA and thus change the genetic code of the plant. This alters the plant's characteristics. The beneficial effects of this include better resistance to the cold, parasites and diseases, as well as ensuring that there is a better harvest. It can also make the crop more resistant to spoilage after it has been harvested.

Today, just like in the days at the dawn of agriculture, the ones who breed plants are looking for individuals that yield quickly. It is not only efficient to have crops with short cultivation cycles, breeding also is much faster with these individuals. With this in mind, it is quite logical that a lot of our current crops, and especially the energy -rich crops we depend on so much, are all crops with a short cultivation period. These crops have one or more life cycles per year, and are called annuals. The fact that supports this preference of annuals by man is the fact that most uncultivated plants are perennials.

Thirty years ago mankind took another great step: by transferring the characteristics from one organism into another, we became able to not only modify the genetic code of organisms (even with a code from other species), we also became able to read it. By being able to read a genetic code we in fact do not need endless generations to select the characteristics we want *(figure 6, step 6)*. If the genetic code for the desired characteristic is known, a breeder can screen the candidate plants. In this way he skips the time needed for the plants to express their characteristics. The breeder now only needs to raise a few plants instead of a few hundred. This gives him the opportunity to screen many more plants on their characteristics. In this way, a breeder can have results much faster, and therefore perennial crops have become more interesting to breed. Until recently, this remained theory because the methods of DNA –sequencing have been quite expensive. This has been changed and DNA –sequencing is now a standard tool affordable to breeding companies.

What are the benefits of growing perennial crops over annuals? Perennial crops do not need the high input of annual crops. There are a few reasons for this. One is that after the first year, the crop is established: this plant only needs energy from that point on to maintain itself and to regrow after a longer period of cold or drought. The farmer does not need to plough his land, and does not need to sow. In winter time the soil is covered preventing erosion and, because a perennial crop has a much better root system, it needs less water to be irrigated in summer time. The roots will also prevent things like nitrogen from leaking to the ground water. Of course there exist misunderstandings and prejudices about these future crops. They are compared with annuals under circumstances annuals are cultivated, but growing these perennial crops will also change the way we cultivate. For instance a common objection is that rotation of perennials is problematic and because they are in one place over more than one year, pests and diseases form a bigger problem. This is true if annuals are grown year after year on the same piece of land. Studies have shown that in the first years there will indeed be huge problems with diseases. However after about a decade, equilibrium is achieved in the soil. This means opportunist species like weeds and many pathogens are not able to invade the area anymore: the crop will be free from soil related problems Perennial cultivation is not giving chances to opportunists every year, and a state of equilibrium is achieved much faster. The idea of this new type of perennial cultivation is more comparable to that of permanent pastures in which disease problems are rare compared to the cultivation of annual grains.

Figure 6: The development of agriculture portrayed in a few steps.

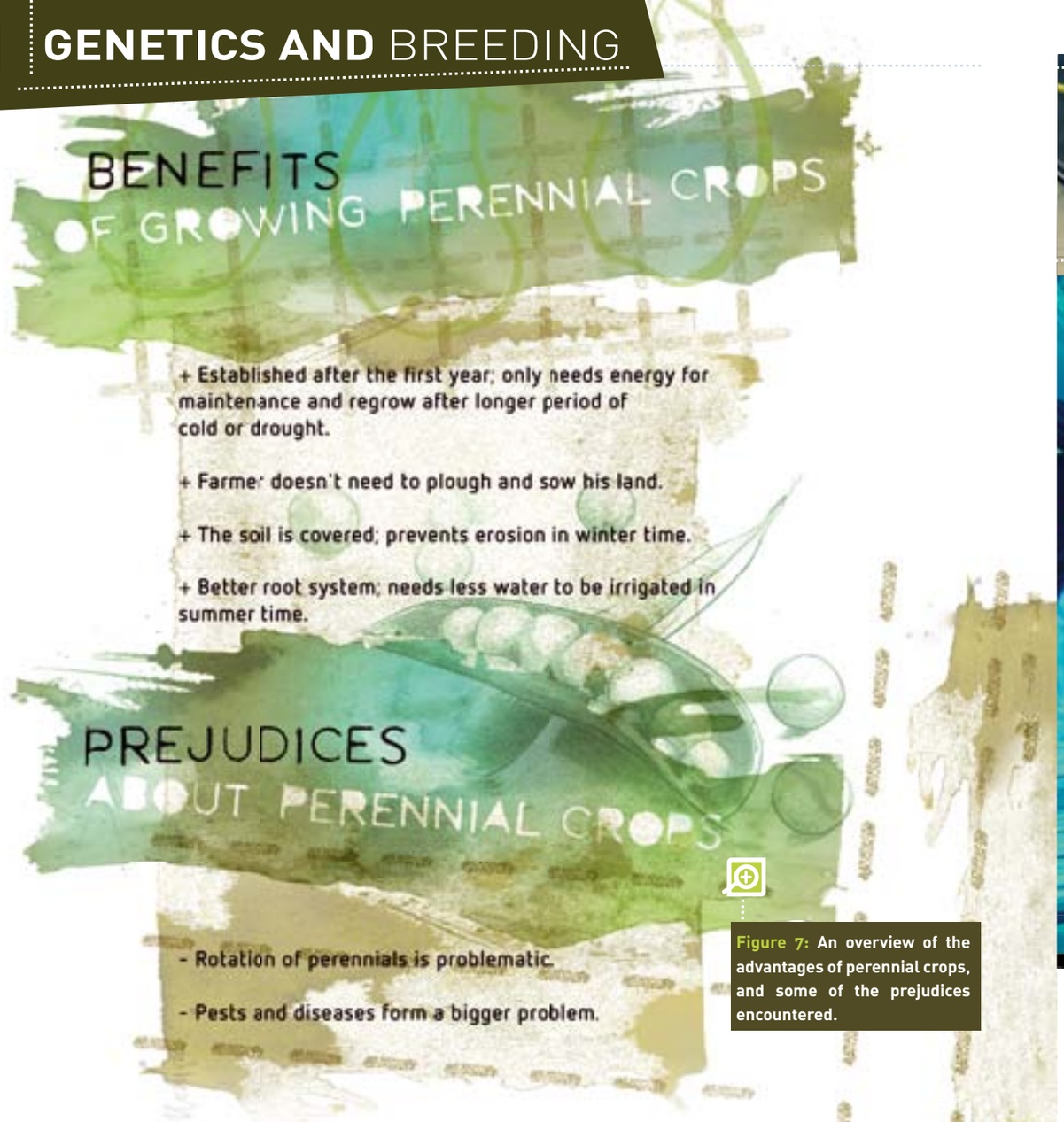


Figure 7: An overview of the advantages of perennial crops, and some of the prejudices encountered.

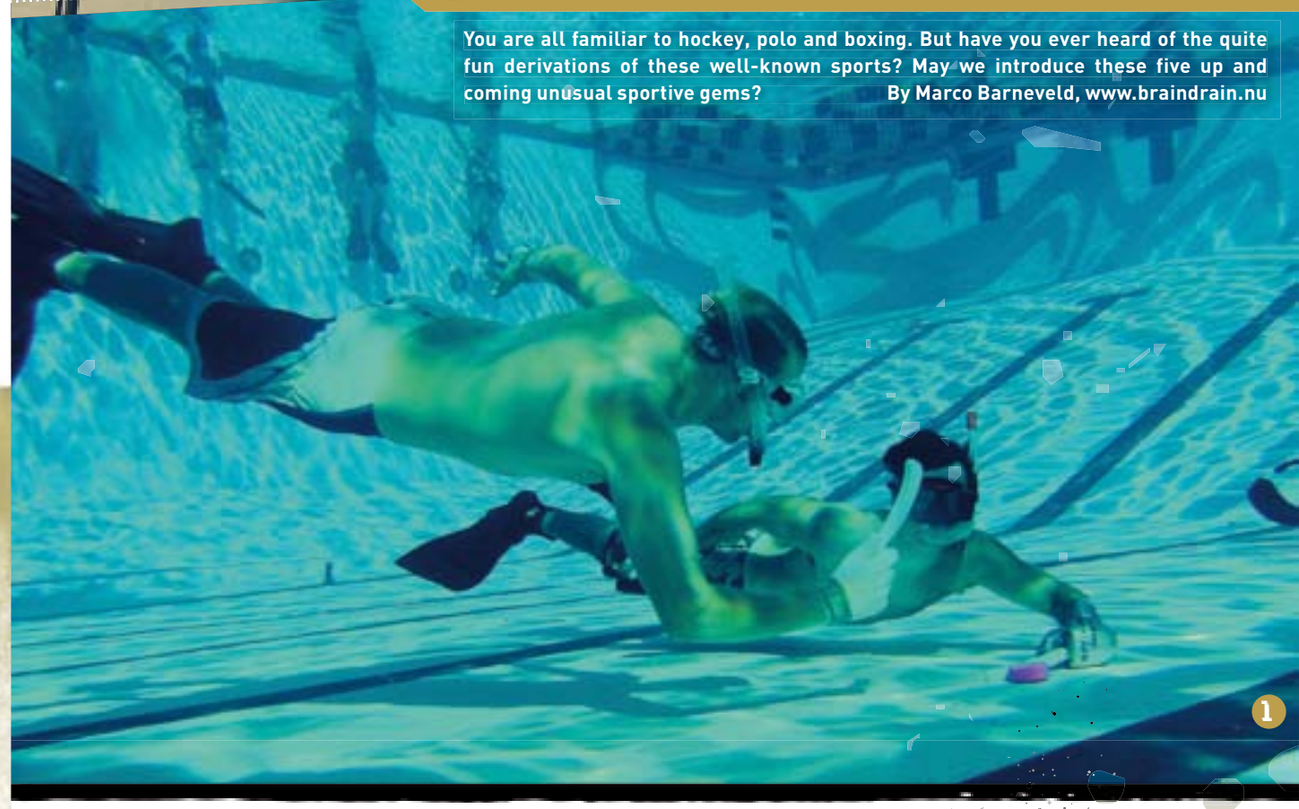
So if we were able to replace our important annual crops by perennials while maintaining the same yield, we could drastically save money and, at the same time, it could make agriculture less destructive to our planet. However knowing mankind, perennial crops are most probably also going to form a new treat. Perennials can grow better under suboptimal circumstances than annuals. In other words, they could grow in places farmers cannot currently grow their crop.

The idea of replacing annuals by perennials will not remain a dream. There still exist the perennial brothers and sisters of the first annuals selected to be the ancestors of our current crops. In fact the first breeding programs to replace annual wheat and rice by perennial alternatives has already been started. So, we are actually creating these crops, and by using new technologies we should be able to do thousands years of breeding within a single lifetime. If you doubt we can locate these perennial brothers and sisters in amounts that matter, there is more news. Some crops are grown as if they were annuals (or biennials), but in fact they are perennials. Examples include broccoli, chive, tomatoes, egg plants, bell peppers, and chili peppers.

From an economical perspective, not only food crops fall into this category, but also crops that have a high value non –food product could be interesting candidates.

We are so used to growing annuals that we have forgotten the benefits of perennial alternatives. To profit from these benefits we have to drastically change the way we grow our crops. Technically breeding new perennial crops or creating cultivation systems to grow crops we grow now in an annual way is not the challenge. Accepting the way we cultivate now has great drawbacks, especially where investments in time and money in coming up with new cultivation systems could result in a world in which we grow our crops radically different. •

What's HAPPENING



You are all familiar to hockey, polo and boxing. But have you ever heard of the quite fun derivations of these well-known sports? May we introduce these five up and coming unusual sportive gems? **By Marco Barneveld, www.braindrain.nu**

UP AND COMING SPORTS

1 Octopush: Hold-your-breath hockey

You take hockey and mix it with water polo. What do you get? You get a peculiar sport called octopush. Awesome sport played underwater in a pool. Created in 1954 by a diver called Alan Blake. The octo in octopush stands for eight because in it's original form each team consisted of eight players. Nowadays the game is played by two teams of up to ten players, with six players in the water at one time and the others substituting continuously during play. Basically octopush could be seen as under water hockey. The players submerge to the bottom of a pool wearing diving mask, fins and a snorkel. They have a stick called the pusher and try to shoot the puck, which is called a squid, into the goal, or gull as it is called in this game, of the other team.

At the start of each game the squid is placed in the middle of the pool and the teams start on opposite walls. On the referee's signal the game begins. As soon as the game begins the teams will swim to the puck, the forwards attempting to gain possession for their team. The team works together to try and score a goal while defending their own at the same time. Once a goal has been scored the squid is put back in the middle and the teams return to their respective starting points and play commences as before.

You think it is easy? Try holding your breath for minutes at a time while racing for a piece of lead and being kicked at on the bottom of a pool. This one is not for losers.

Chess **boxing**: Mind of fists or the other way round?

Not long ago the Dutch event artist Iepe Rubingh came up with the bright idea of combining chess and boxing, which became the hybrid sport of chess boxing.
The sport alternates between games of boxing and chess after each round – waiting for a checkmate or knockout to decide the match. A chess-boxing match between two individuals lasts up to eleven rounds, starting with a four-minute chess round and followed by two minutes of boxing. There is even a World Chess Boxing Organization, whose motto is: "Fighting is done in the ring and wars are waged on the board".
It must be hard to find someone with skills in both areas of boxing and chess. Chess players are known for their intelligence, and we would expect that they would be smart enough to know that getting into a ring with someone trying to hurt you is not a wise idea.

Photo courtesy of Neale A.

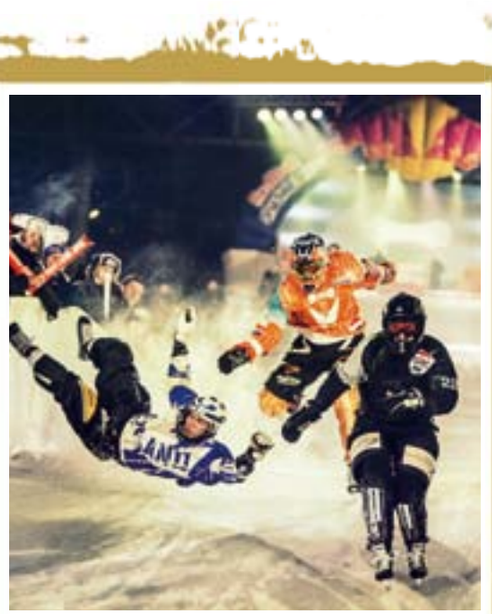
Hantis: Four-tabled Ping-Pong

Hantis is a simple game created by Jason Johns, spreading throughout schools in the US through PE teachers. The sport has some similarities to table tennis, but much more dynamic. Hantis can be played using the resources schools already have: four tables, one ball. Unlike the majority all other sports, this sport is free if using these existing materials. It can also be played in a small area and rightly so, because it was invented inside a small classroom.
It is the game play itself that makes Hantis so much fun for students: players are able to perform tricks within their first time playing, it isn't endurance based so students of any fitness level will enjoy it, and players will rotate teams every play which encourages a more playful competition instead of dominance.

Photo courtesy of Huron Bikes

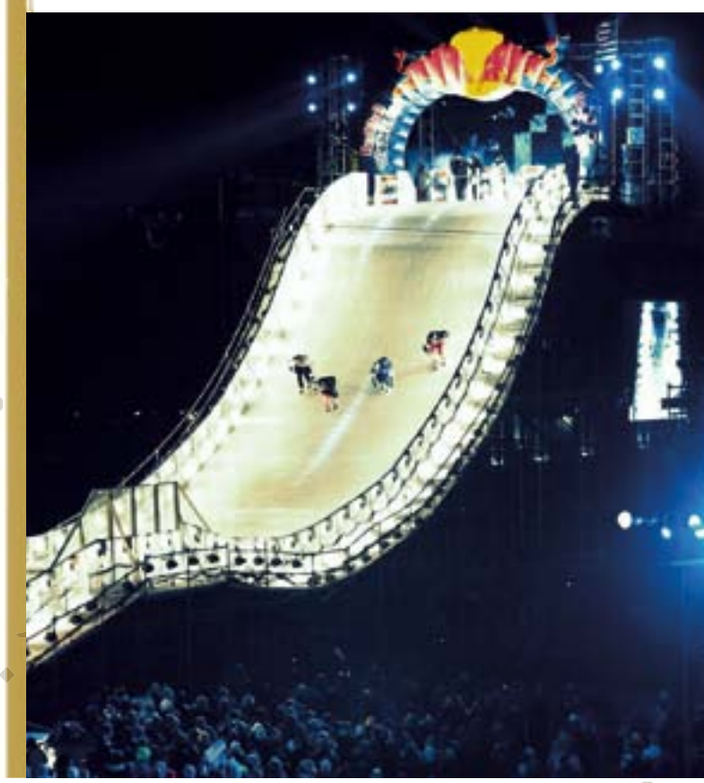
Urban **bike polo**: Not so posh polo

We all know polo. It's a great sport except you need to have a shitload of cash to buy and maintain all the horses' necessary. Bike polo or bicycle polo is an outdoor game similar to polo, except that bicycles are used instead of horses. Traditional bicycle polo is played on a large rectangular grass field, but the faster hard court version played by fewer players on a smaller court is getting popular. The hard court version is called urban bike polo, and is played by three players on a hard court surface such as for basketball tennis with a street hockey ball.
The rules vary slightly by city. Each team has three members, no substitutions, and all members are on the court at all times. In the case of a 'foot down' or 'dab' (touching the ground with one's foot) the player must 'tap out' by riding to mid-court and hitting a designated area with their mallet. There is usually a tap-out located on either side of the court. In order to score, the offensive player must hit the ball across the goal line using the narrow end of the mallet. The matches are played until one team scores five points.



Downhill **ice cross**: Slippery racing

Four guys dressed in hockey pads and helmets race each other down on skates on a winding 1771-feet course filled with twists, turns, jumps and bumps with a 197-feet vertical drop. It's all a blur, as skaters hit more than 44 mph. Welcome to the fantastic world of downhill ice cross. It is similar to ski cross and snowboard cross, except with ice skates on an ice track, instead of skis or snowboards on a snow track.
The sport is attracting a lot of attention thanks to the world tour event 'Crashed Ice'. Compared to snowboarding, skiing or even rollerblading, the sport of ice-skating doesn't have a reputation for being 'extreme'. But that might change thanks to Crashed Ice were competitors, having advanced from one of the try-outs in the prior months, race in heats of four skaters, with the top two advancing from each heat. It's an adrenaline filed sport that makes great TV. Don't try this at home kids. •



Deficiency Guide

Even when you use a high quality, consistent nutrient you could still run into deficiency problems. In this case, the deficiency is often caused by other factors than the nutrient (read more on page 26 of this CANNAtalk).
This deficiency guide helps you to first recognize the deficiency (what can you see?). And then it advices you what you can do in case you use a lower quality nutrient brand that might have been the cause of the deficiency. Followed by what you can do in case you use a high quality nutrient brand (such as CANNA) and the deficiency is caused by something else. We have produced this guide in collaboration with CANNA Research. We hope it is a useful tool to hang on your wall so you can check it easily although we hope you won't need it often.

Calcium

What can you see?
Yellow/brown spots, surrounded by a sharp brown outlined edge.

What can you do when you use a lower quality nutrient?
Add calcium by applying a liquid lime fertilizer such as a calcium nitrate solution.

What can you do when you use a high quality nutrient such as CANNA?
- Verify how you water (check Need-to-Know video 1, season 2 on CANNA website)
- Verify EC of the root medium
- Check if you used too much potassium additive (like CANNA PK13/14)
- Check if your medium temperature is too low (lower than 64°F)

Phosphorus

What can you see?
Small plant with purple/black necrotic leaf parts. Leafs become malformed and shrivelled.

What can you do when you use a lower quality nutrient?
Mix inorganic phosphate fertilizer thorougly through the potting mix or add extra liquid phosphate when growing in hydroponics.

What can you do when you use a high quality nutrient such as CANNA?
- Check if your medium temperature is too low (lower than 64°F)
- Check if your root medium EC is too low

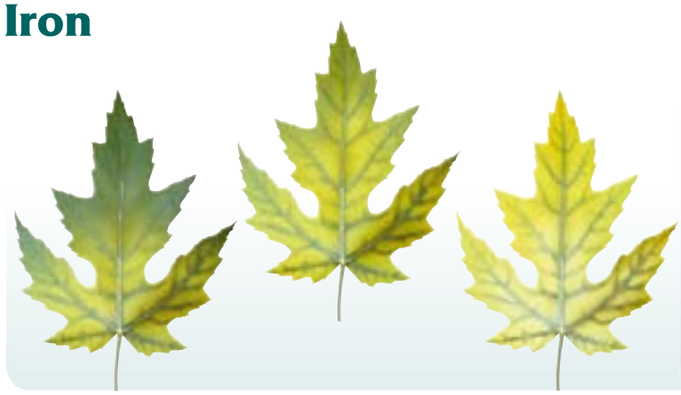
Magnesium

What can you see?
Rusty brown spots. Cloudy, vague yellow spots between the veins.

What can you do when you use a lower quality nutrient?
Spray with a 2% solution of Epsom salts every 4-5 days during about a week.

What can you do when you use a high quality nutrient such as CANNA?
- Verify how you water (Need-to-Know Video 1, season 2 on CANNA website)
- Verify EC of root medium
- Check if you used too much potassium additive (like CANNA PK13/14)
- Check if your medium temperature is too low (lower than 64°F)

Iron



What can you see?
Strong yellowing of especially the young leaves and growth shoots between the veins.

What can you do when you use a lower quality nutrient?
The best thing is to spray the plants with a chelated source of Iron.

What can you do when you use a high quality nutrient such as CANNA?
- Verify how you water (check Need-to-Know video 1, season 2 on CANNA website)
- Verify EC of root medium

Nitrogen

What can you see?
Purple stalks, yellowing leaves and leaves fall off.

What can you do when you use a lower quality nutrient?
Raise EC of the feeding or add extra nitrogen.

What can you do when you use a high quality nutrient such as CANNA?
- Verify how you water (Need-to-Know Video 1, season 2 on CANNA website)
- Verify EC of root medium
- Check if your medium temperature is too low (lower than 64°F)

Potassium

What can you see?
Dead edges on the leaves.

What can you do when you use a lower quality nutrient?
In case the EC in the substrate or potting mix is high, you can rinse it with clean water. Add potassium yourself.

What can you do when you use a high quality nutrient such as CANNA?
Verify EC of root medium (probably too low)

Manganese

What can you see?
Yellow stripes appear between the leaf's side veins.

What can you do when you use a lower quality nutrient?
Using products that contain trace elements (Tracemix).

What can you do when you use a high quality nutrient such as CANNA?
- Verify how you water (Need-to-Know Video 1, season 2 on CANNA website)
- Verify EC of root medium
- Check if your medium temperature is too low (lower than 64°F)

CANNA
Thé solution for growth and bloom

Pests & DISEASES

Fusarium is a large genus of soil fungi widely distributed in the world. Most species are harmless saprobes and are relatively abundant members of the soil microbial community. Nonetheless, some Fusarium species are economically important due to their devastating impact on crops.

By CANNA Research

Photo courtesy of UF IFAS-FLREC

FUSARIUM

Figure 8: The brown external petiole stripe corresponds with internal discoloration of the petiole. This is an example of fusarium foot rot, distinguished by a canker that shows a dark brown discoloration of the stem.

In the beginning there was confusion on its taxonomy with more than 1,000 species, varieties and races. People started to realize that Fusarium causes serious diseases and became relevant to make a precise classification system. Nowadays, scientists still debate the classification system from nine to about fifty species, zero to 29 varieties and zero to twelve forms.

Due to the confusion in identifying many Fusarium species, the classification is also based on the plant symptomatology. Therefore, most of the species have been divided in groups that are represented by the type of disease, like the Fusarium stem canker, the Fusarium foot rot and Fusarium wilt species groups.

Fusarium stem canker group is a soil fungus caused by six species (F. sulphureum, F. graminearum, F. lateritium, F. sambucinum, F. avenaceum and F. culmorum). **Fusarium foot rot and root rot group** is a soil fungus caused principally by F. solani. **Fusarium** wilt group is a vascular fungus caused by a xylem pathogen called F. oxysporum. In this group, F. oxysporum has several specialized forms – known as formae specialis (f.sp.) - that infect a variety of hosts causing various diseases.

F. oxysporum f.sp vasinfectum and F. oxysporum f.sp. apii cause damping-off and both are morphologically identical but the host changes, giving the name of the sub-specie. However, there is an ongoing debate on this classification system as many scientist suggest that F. oxysporum f.sp apii is from the same group of f.sp vasinfectum. Thus, the characterization of sub-specific groups is nowadays based on the generics of the fungus rather than on the host-pathogen interaction.

F. oxysporum f.sp.cubenses is a well defined sub-species that causes the Panama disease of Musa spp. This pathogen has caused the disappearance of the banana cultivar 'Gross Michael'. Afterwards, a new banana variety Cavendish was introduce due to its resistance to Fusarium. Like in banana, extensive breeding for resistance to Fusarium spp. is in progress in a wide range of crops, notably cereals, cotton, potato and tomato.

Disease damage and cycle

Fusarium colonies are usually pale or brightly colored (depending on the species) and may have a cottony aerial mycelium. Their color varies from whitish to yellow, brownish, pink or reddish. Species of Fusarium typically produce spores (called macro- and microconidias) for reproduction and dissemination.

Fusarium stem canker symptoms begin with an epidermal lesion, followed by chlorosis and necrosis. Close to the lesion, the trunk, branches or stems normally swell creating a canker that can split open. Leaves on affected stems wilt and necrose, without falling off the plant. This pathogen is also able to infect seedlings where it causes damping-off.

Base of host symptomatology, Fusarium foot rot may be confused with Fusarium stem canker as both of them cause canker. However, Fusarium stem canker leads to a reddish xylem discoloration while Fusarium foot rot is distinguished by soft, dark or black cankers that shows a dark brown discoloration of the stem.

Fusarium solani (root rot) is a saprophytic fungus, which means it can colonize dead or dying plant tissues. The fungus can invade stems at the nodes or at the soil line, taking advantage of wounds. Its spores germinate during prolonged periods of high humidity and temperature.

Fusarium oxysporum (wilt) is also saprophyte fungi that survive in the soil between crop cycles in infected plant debris. The fungus can survive either as mycelium, or as any of its three different spore types. The roots can be infected directly through the root tips or wounds. Once inside the plant, the mycelium grows through the root cortex until it reaches the xylem and later, through the whole plant's vascular tissue. This condition reduces water and nutrient uptake, the leaves wilt, and the plant eventually dies.

Management and control

Pathogenic Fusarium species are difficult to control due to their ability to survive in soil for long periods, with or without a host plant, besides their saprophyte condition. Thus, an integrated Fusarium management should include prevention, cultural practices, sanitation, biological and chemical control.

Reducing plant stress will reduce favorable conditions for the fungi to spread. Ensure to use clean and disease free seeds or plantlets. Avoid overwatering, deep planting, over fertilizing with nitrogen or phosphorus, and injuring plants when planting. Cultivating, harvesting, or sorting, are some of the practices to prevent Fusarium dissemination.

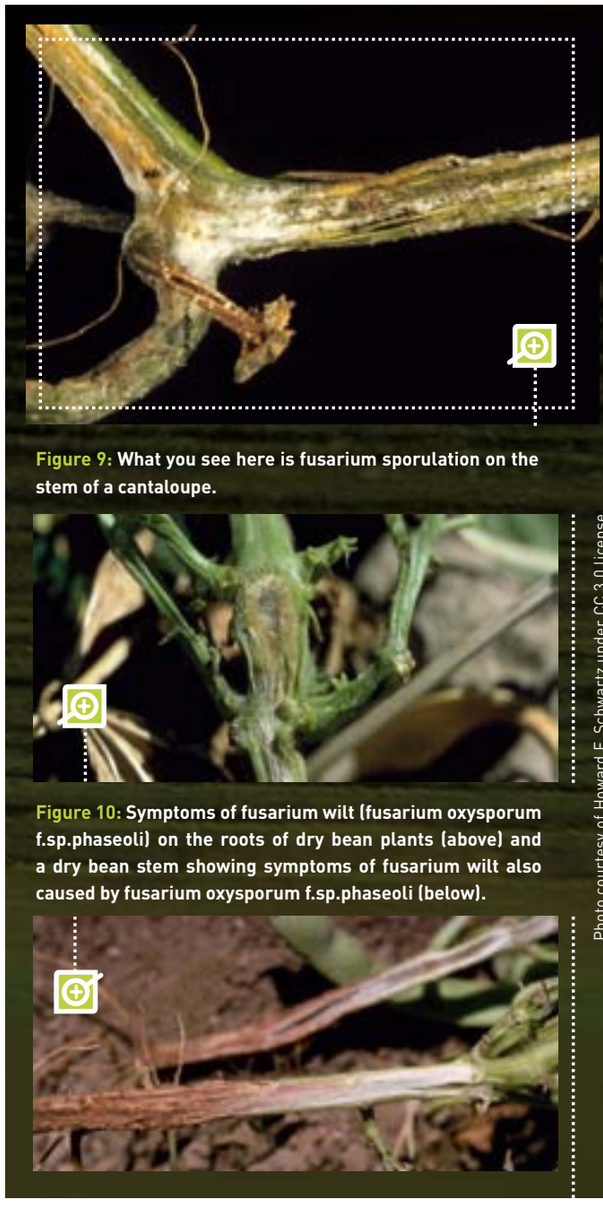


Photo courtesy of Gerard Holmes under CC 3.0 license.

Figure 9: What you see here is fusarium sporulation on the stem of a cantaloupe.

Photo courtesy of Howard F. Schwartz under CC 3.0 license

Figure 10: Symptoms of fusarium wilt (fusarium oxysporum f.sp.phaseoli) on the roots of dry bean plants (above) and a dry bean stem showing symptoms of fusarium wilt also caused by fusarium oxysporum f.sp.phaseoli (below).

Learning the symptoms of the disease in the early stage is the most effective practice to prevent Fusarium spread. Furthermore, disinfestations of the soil and use of fungicidal chemicals, crop rotation, or by using resistant cultivars, are the cultural, biological and chemical practices to manage Fusarium diseases. •

Questions & Answers

We receive a lot of questions about growing. Of course, our researchers are more than happy to answer them! Just go to the contact page on our website, www.canna-hydroponics.com, to submit your question.

Photo courtesy of Seattle FoodShed

Question

I grow organic cucumbers in a small greenhouse. I use your BIOCANNA BioFlores nutrient on a soil mix made of peat moss, sand and kitchen-scrap compost from last year. The seeds start out fine, but as growth accelerates, the leaves turn a lighter green and gradually yellow from the bottom up. What should I do?

Answer

Many things could be wrong. Your plants probably need more nutrients (mainly nitrogen). Kitchen-scrap compost is usually better as a soil conditioner than as a source of nutrients. Also you make no mention of liming your soil mix. If the pH is off, the mineralization of the compost can be very slow. Try using a complete and balanced organic potting mix to rule out potential potting mix imbalances.
The soil temperature could be too low (over 64°F is best). Proper organic soil mix is a must, especially when growing cucumbers because these plants are heavy feeders. They require more nitrogen, in particular. Hope this helps!

Question

My tomato plants (bush type) are wilting slightly, even though the soil is not dry. This only happens once they have reached full size. Sometimes, I even lose a plant or two. I have also noticed some leaves burn from the edges inwards and most of the fruits do not mature properly. Can you help me? I am at a loss to understand this.

Answer

We believe you are consistently over-fertilizing your plants. This would definitely result in rapid and luscious growth. But once the soil salinity exceeds a certain level (at full height) the high salts in the soil will actually begin to draw back the water from inside the plant (this is called reverse osmosis). Do an EC test on your soil to confirm this and change your fertilization technique accordingly. To save your existing plants, water with a low nutrient strength solution (EC=0.8 max) through your soil until the soil EC diminishes to an EC below 4 (TDS: 2000ppm). Good luck and lay off the sauce!

Question

I'm using 85% perlite and 15% coco to grow in. What nutrients should I use?

Answer

If you recirculate the solution, you can use CANNA Aqua (Vega and Flores), but only if your water quality is soft (lower as 0.3). In either case, especially if you drain to waste the solution after passing it through the root system, you can use Substra Vega and Flores. Make sure you have the right Flores for your type of water (Substra Soft or Substra Hard).

Question

I'm about to start growing in CANNA Coco slabs and the CANNA Coco A + B products. I was wondering, how well does a closed water system work with coco?

Answer

We don't recommend Coco substrate in a recirculating system. Although Coco is a very nice product, it also has some disadvantages. Coco releases potassium and sodium (even after being washed properly). These elements cannot leave your closed system, so they will accumulate in there. This increases the chance of burned leaves.

Question

I have been using CANNA Substra A + B to feed my soil-grown plants but I have noticed the CANNA Terra is specifically for soil-grown plants. Does this mean I've been using the wrong ones? Or can you use CANNA Substra A + B and Terra at the same time?

Answer

CANNA Substra A + B is a general run-to-waste fertilizer. It is high in calcium and nitrogen. For peat-based and soil mediums that lack a decent fertility balance and correct pH controls, Substra works the best. So we recommend using CANNA Terra Vega and Flores with a quality medium like CANNA Terra Professional Plus, to get the best possible results.

Question

I've been using CANNA COCO medium for years, but recently I'm having major problems. I have always had a pH of 5.8, I've never used water to run off and I've never had any problems, now that I'm doing it to run off... but I still get dark leaves and purple stems. I have read the website and it says that it has to do with nitrogen. But how is that possible if my leaves are dark and small, purple stripes starts on the main stalk and then spread to every branch petiole everywhere?

Answer

Dark leaves and purple stems are often related to your climate. Plants stay smaller if they are too cold, and they get darker and have purple stems. Plants take up their nutrients in another way when they are cold. The pH in the substrate goes up and this means that a plant has problems taking up the nutrients. This can also happen due to mistakes made by the grower, like giving a higher pH, giving a different nutrient (brand or type), not giving enough nutrients (lower EC) or water. Our recommendation is to check your temperature at night, check your fans and change your method of watering. Start with a pH of 5.5 the next time, add more nutrients in the beginning (more ml/L. = higher EC +10%) or increase the frequency of applying your solution if the plant is too dry.

Question

I'm using your Coco and CANNA Coco nutrients. My reverse osmosis water is about 0.2 EC so will I need to add a calcium/magnesium + additive to make my water harder, or will I get better results with tap water? I'd really appreciate any info you can give me to get the best out of my coco nutrients.

Answer

In general, reverse osmosis water should have an EC of 0.0. So either your filter has a leak, or you have mixed reverse osmosis water with tap water. Anyhow, an EC of 0.2 is fine.
As long as you add enough Coco A/B to that water, you will not get Ca and Mg deficiencies (check our grow guide and go for normal or heavy dose). Coco A/B contains a lot of calcium and magnesium. If you go for the low dose you'll often have to add extra calcium and magnesium to your water.

Question

I've got a 100-litre aquaponics system and my plants have a deficiency of magnesium and potassium. What product would you recommend to help my plants that are also safe for my fish?

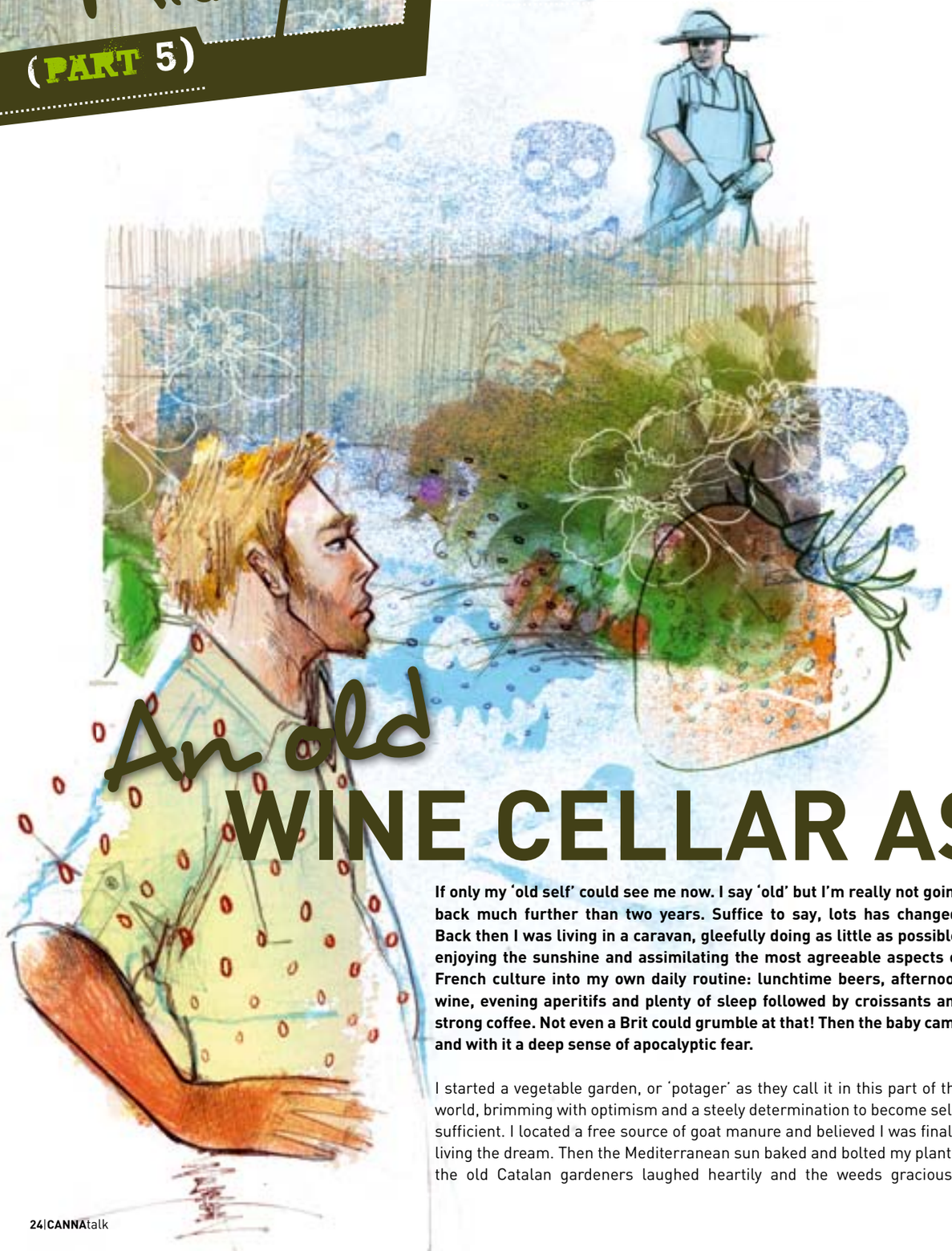
Answer

Try the CANNA Substra line, and be sure to match it to your water as hard or soft. It might be possible to correct this issue by adding CalMag to 60 ppm if you are not using a CANNA base nutrient, or CANNA COGr Buffer Agent to about 100 ppm. Good luck!

Don & Nicky

(PART 5)

Don and Nicky have moved back from Canada to their home country, the UK. Their search for the good life led them to France and they are now doing exactly what they wanted to do with their lives: growing. Don shares his experiences and will tell you everything about the good life in French Catalonia in this, and forthcoming editions.



An old WINE CELLAR AS AN INDOOR GARDEN

If only my 'old self' could see me now. I say 'old' but I'm really not going back much further than two years. Suffice to say, lots has changed. Back then I was living in a caravan, gleefully doing as little as possible, enjoying the sunshine and assimilating the most agreeable aspects of French culture into my own daily routine: lunchtime beers, afternoon wine, evening aperitifs and plenty of sleep followed by croissants and strong coffee. Not even a Brit could grumble at that! Then the baby came and with it a deep sense of apocalyptic fear.

I started a vegetable garden, or 'potager' as they call it in this part of the world, brimming with optimism and a steely determination to become self-sufficient. I located a free source of goat manure and believed I was finally living the dream. Then the Mediterranean sun baked and bolted my plants, the old Catalan gardeners laughed heartily and the weeds graciously conspired to camouflage my failure, speedily reclaiming the small territory only momentarily lost to my field of folly. The final straw came when I smelled the distinct aroma of herbicide wafting over from my neighbor's garden. The dear old chap was spraying some adjacent land he'd left lying fallow and a gentle westerly wind ensured that my meager array of harvestable veg received a complimentary coating of chemicals too. Au revoir home-grown, organic baby food, bonjour glyphosate-laced strawberries. If you tuned in last time you already know that my one decent subterranean crop—some fine Rosabelle potatoes—was subsequently stolen. That did it for me. Dummy well and truly thrown out of pram. I couldn't bring myself to visit the garden for two months after that.

1 Me planting a peach tree in the vegetable garden.

2 My wonderful and much-prized Rosabelle potatoes before they were stolen.

Now it's time to bring you up to date and hopefully cheer this miserable tale up a bit. Somehow my desire to produce something edible for my family has persisted. Last time I mentioned my successful outdoor sweet pepper hydroponics experiment. Believe it or not but I was still harvesting by the end of November! The plants were huge and opulent, but eventually became a little tired and windswept. One thing's for sure—hydroponics rocks (literally—I'm growing in twelve modular flood and drain buckets filled with expanded clay)! No dirt. No manure. No weeds. Automatic irrigation. Perhaps I've found my true niche?

It gets better. We've bought a house! Yeah, yeah, the dirty caravan-dwelling hippy finally defected. It's in the middle of a small village with no garden. "No garden!" I hear you shriek as if you cared – what was I thinking? Well, bear with me. It also has a huge wine cellar and that's what tipped it for me – it's built into a mountainous rock and tucked well away. Now, storing wine is far too civilized and disciplined for me so I'm turning this space into my very own indoor hydroponics garden! It's naturally insulated and there's room for up to eight HID grow lights. I've begged, borrowed and bought some equipment and soon year-round basil will be a reality. (It disappears from the supermarkets in October here.)

I plan to focus on culinary herbs and leafy greens at first and then maybe progress to some determinate tomato varieties (I figured the bush variety would be more suited to indoor cultivation). I hope to build on my earlier success with sweet peppers too.

I plan to focus on culinary herbs and leafy greens at first and then maybe progress to some determinate tomato varieties (I figured the bush variety would be more suited to indoor cultivation). I hope to build on my earlier success with sweet peppers too.

I remain convinced that, from now on, it's hydroponics all the way. I just feel a lot more in control, mixing up my nutrients, checking the EC and pH, topping up the tanks and dialing in my irrigation cycles. Sure – it's not organic – and don't my crusty friends love to remind me of that! Equally I enjoy countering that I use around 80 – 90 percent less fresh water than they do and, if this year's peppers are anything to go by, the produce tastes every bit as good.

Meanwhile, with horticultural enthusiasm restored, I've converted the forsaken outdoor patch to a long-term permaculture project (my chosen euphemism for a lazy man's garden). We've strimmed back the savannah, planted two peach trees (early and late variety) and a nectarine too. We've also left space for a large asparagus bed that I plan to get going this spring. Now if that doesn't say we're putting down roots I don't know what does!

Hopefully my old self would be proud of me but, if he's shaking his head in disgust, I'll simply tell him to get on with the weeding. •

PART 2

PLANT NUTRITION AND NUTRIENT DEFICIENCY

IN THE PREVIOUS RESEARCH ARTICLE (ON PAGE 4) WE MAINLY DISCUSSED THE DIFFERENT ESSENTIAL NUTRIENTS AND THEIR ROLE IN PLANT GROWTH AND DEVELOPMENT. IN THIS PART WE WILL I.A. FOCUS ON HOW THE PLANT CAN TAKE UP THE DIFFERENT NUTRIENTS AND HOW DEFICIENCY SYMPTOMS (CAUSED BY SUBSTRATE IMBALANCE) CAN BE RECOGNIZED AND SOLVED.

By CANNA Research

Nutrient uptake and transport

Nutrients are usually taken up by the root system. This process involves the following steps. The first requirement is mobility of the nutrients through the soil or any substrate in the rhizosphere to the roots. Then the nutrients need to pass several 'root barriers'; the cell wall, followed by the cell membrane. The crucial steps inside the plant are the migration of the nutrients to vascular tissue (called the xylem), followed by cell to cell transport.

The shifting of nutrients through the soil depends on the several soil characteristics; pH, structure, moisture content and microbial activity. Some micro-organisms affect the rhizosphere (especially mycorrhizal fungi, which interact directly with plant roots), but most soil borne micro-organisms do not or hardly affect the rhizosphere. Micro-organisms can be beneficial (e.g. improving nutrient availability) or harmful (e.g. in competition for soil nutrients or causing root diseases). The dissolved nutrients are transported with the convective flow of water from the soil to the plant roots. This flow depends highly on the water consumption of the plant and the average nutrient concentration in the water. As we will see later in this article, water uptake by the plant and nutrient content in the substrate can be controlled easily by the grower.

A small percentage (less than 1%) of the nutrients is taken up by interception through the root tip. This interception is based on direct ion exchange, where positively or negatively charged elements are swapped (e.g. a proton (H+) from the root for a potassium ion (K+) from the substrate or nutrient solution).

Now how are the nutrients 'in the flow' taken up by a plant *(figure 11)*? The biggest barrier is usually the cell membrane which is highly selective. The basic structure of a cell membrane is the phospholipid bilayer, which has very low permeability for most nutrients. Carbon dioxide, oxygen, water and some neutral molecules like urea are the only products that can easily pass the membrane directly through the lipid layer by diffusion.

All other essential mineral nutrients are absorbed as ions (except boron). Therefore all nutrients (except boron) need membrane transporters. To facilitate the uptake of these nutrients, the cell membrane contains so-called transport proteins embedded in the cell membrane, controlling the intracellular environment (=the space in the plant cell).
Two main mechanisms of cross-membrane movement can be identified; passive and active. Passive movement is the easy way, via carrier proteins and transport through

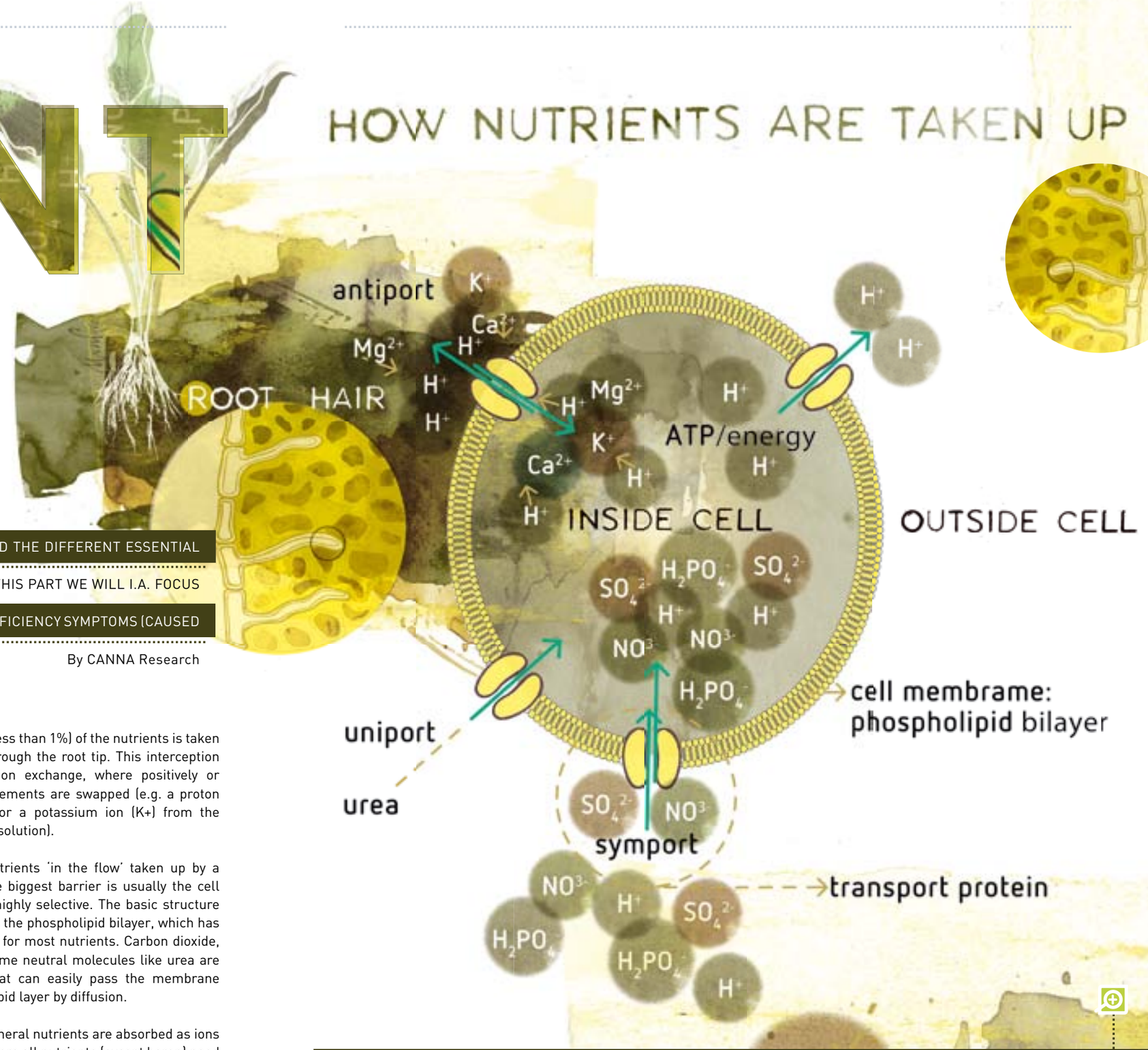
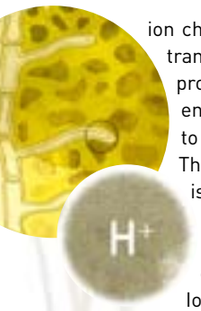


Figure 11: **Schematic overview of a root (hair) cell membrane. The portals incorporated into the cell membrane are transport proteins. These transport proteins function because all essential mineral nutrients are absorbed as positively or negatively charged ions (boron being the only exception here). A 'symport' transports the desired nutrients and protons in the same direction. These are usually negatively charged ions such as nitrates (NO3-), phosphates (H2PO4-) and sulphates ($SO4^{2-}$). The 'antiport' transports positively charged ions in exchange for protons (H+). For instance, excess potassium ions (K+) can be moved outside the cell. As can be seen in the picture, a proton (H+) is required in both cases to facilitate the transportation process. A 'uniport' transports compounds, molecules or ions without known coupling to the transport of any other compound, molecule or ion. Energy (ATP) is needed to re-transport the proton outside the cell.**

PART 2 PLANT NUTRITION AND NUTRIENT DEFICIENCY



ion channels. The active method is by ATP-ases or co-transport (Knox, Ladiges & Evans). ATP-ases are proteins that carry the 'energy molecule' ATP. The energy that is released by breaking down ATP is used to open or close specific transportation ports.

The driving force for passive movement is diffusion. It is selective for single nutrient molecules, requires no input of energy and has a non-linear dependence on concentration. Molecules will diffuse until the concentration is the same everywhere.

Ion channel transport can be controlled by voltage or ion concentration, even by light or hormones. Active transport requires input of energy, but nutrients can be transported against their concentration gradient.

Long distance transport

Several pathways of nutrient transport have been described in the plant. The most common one is the nutrient uptake by the root, followed by 'long distance transport' via the xylem vessels to the leaves and flowers (or any other plant organ). For the long distance transport two driving forces play a key role; the water potential gradient and the root pressure. Root pressure arises when osmosis drives water from the soil into the roots. Effectively because plants accumulate the nutrients taken up in the xylem tissue.

Factors that influence nutrient uptake

There are intrinsic and environmental factors which affect the nutrient uptake. Charge and ion diameter are intrinsic factors. Environmental factors are light, temperature, water, O2, pH, concentration and interaction between nutrients. The uptake often increases in the following order; uncharged molecules are taken up better than monovalent cations and anions, followed by bivalent cations and anions (Marschner, 2011).

The nutrient uptake is pH dependent, but not every nutrient is equally affected. In most cases there is an optimum and too high and too low pH levels decrease the nutrient uptake. The root zone pH influences the charge of the root surface which is slightly negative. Most nutrients are plant available in the pH range 5.5-6.5. Light is a source of driving forces, therefore there are diurnal fluctuations in nutrient uptake. Like pH also temperature has an optimum level, too high and too low temperatures decreases nutrient uptake. Temperature is a driving force for evaporation of plants, opening stomata and the root zone temperature depend the nutrient uptake. Water is important, because, except for interception, nutrients are transferring through mass flow and diffusion, all of which are dissolved in the soil solution. It is important to maintain a suitable soil water content (60-80% field water holding capacity) for optimal growth of plants. Oxygen will limit plant growth in poorly aerated substrates (Hopkins, 1950). The higher the nutrient concentration the higher the uptake rate, the increase slows down at very high concentrations. Interaction between ions can be antagonism (competition) or synergism. In the first case one ion inhibits the absorption of another ion. And in the second case one ion enhances the absorption of another ion. Competition can be between cation versus cation, anion versus anion, the same charge and different charge. A single salt resulting in plant poisoning is called toxicity of a single salt (KCl, CaCl). Ion antagonism is referred as the interaction among ions can limit the toxicity of a single salt (NaCl+KCl+CaCl2 or NaCl+CaCl2). Synergism is that anions promote cation uptake and divalent cations promote mono-charged cations (Ca2+ promotes the uptake of K- and Cl-).

Fertilization of crops

The uptake of nutrients is facilitated by cell membrane bound protein transporters membrane transporters. Synthesis of transporters responds to nutrient deficiency and toxicity. Nutrient transporters behave like enzymes. Transport can be driven by concentration and electrical gradient (passive transport) and metabolic energy (active transport).

The quality of the crop, or the fertilization success of crops depend on a phenomenon, which can be shortly explained by the following theory. The barrel theory (or the law of minimum) is about the crop yield which is limited by the most deficient nutrient, and the limited nutrient is changeable. This concept was originally applied to plant or crop growth, where it was found that increasing the amount of plentiful nutrients did not increase plant growth. Only by increasing the amount of the limiting nutrient (the one most scarce in relation to 'need') was the growth of a plant or crop improved *(see figure 12)*.

There is also absorption of mineral nutrients by the leaves. Foliar nutrition is a method in which the fertilizer is applied to plant shoot, usually to leaves. The advantage of foliar nutrition is that the supply and uptake of nutrients is effective and fast, because the usual lag period between root uptake and vessel transportation towards the plant organs is cut out. Furthermore, the nutrients applied have a higher utilization rate. Leaf fertilizers are usually a supplement way to compensate macronutrient deficiency such as nitrogen and magnesium, but also effective against micronutrient deficiencies such as iron.

The concentration which can be applied is not too high. The nutrients need to remain on the leaf surface, preferably in a thin film. Therefore, the mixture of nutrients should be applied together with a surfactant.

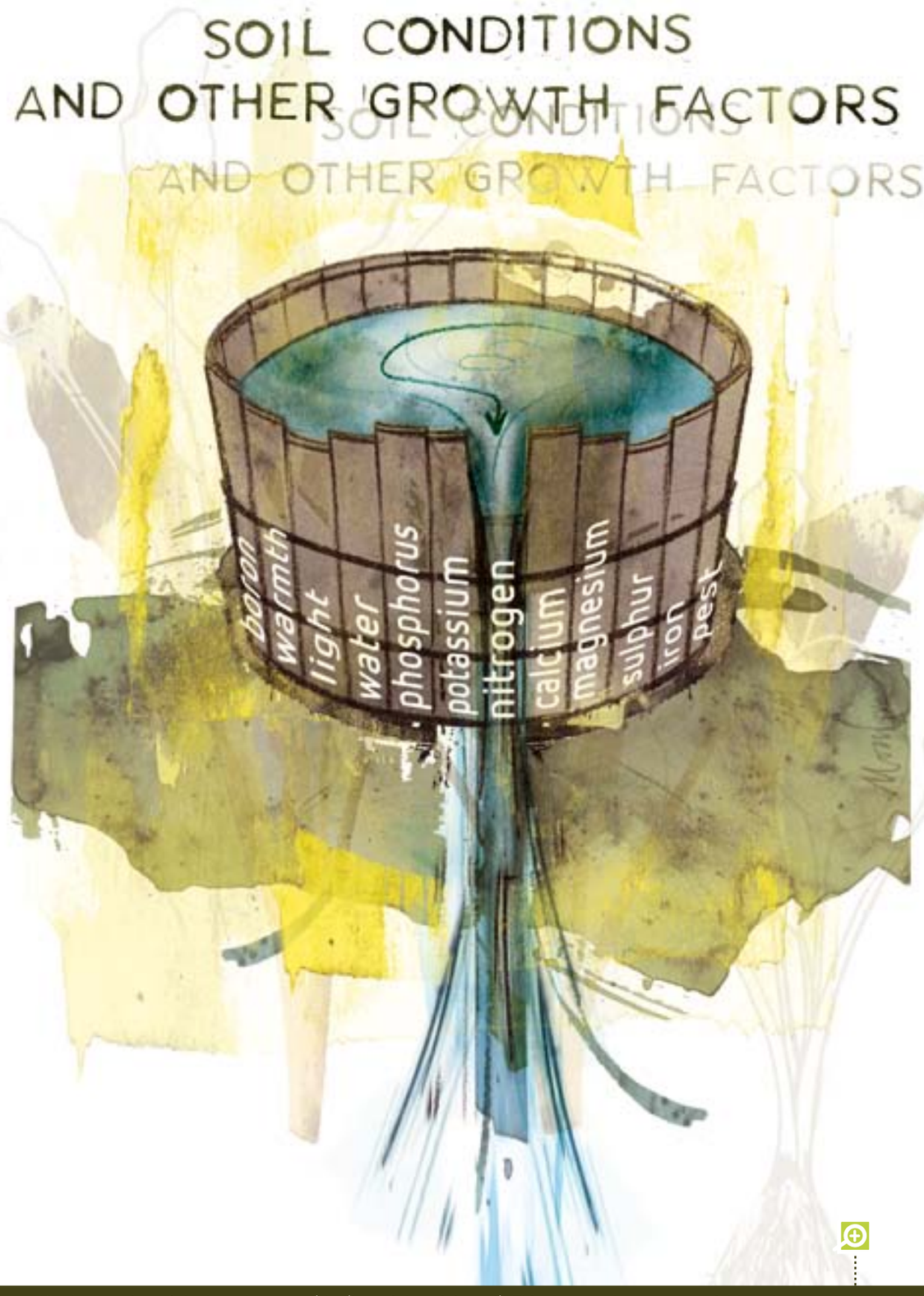


Figure 12: An overview of the barrel concept (the 'law of the minimum'). This theory relates to crop yield, and states that the yield is limited by the nutrient which is the most deficient; this could be any one of the nutrients shown. According to this image, the growth of a plant or crop can only be improved by increasing the amount of this 'limiting' nutrient.

PART 2 PLANT NUTRITION AND NUTRIENT DEFICIENCY

Spraying is recommended only in the evening or on a cloudy day to prevent burn marks.

Deficiency symptoms caused by substrate imbalance

We have seen the driving forces behind the nutrient uptake. Plants can be very selective, but they can never run away in search of food. Despite the tricks that plants developed during evolution, they surely need the growers' help.
For a grower it may sound very easy to identify individual deficiency symptoms. We observe our plants and try to answer as many of the following questions as possible. Do we see necrotic spots? Do we see yellowing of the leaves? Where do these symptoms occur? In the older plant parts, or just in the younger? Important questions to exclude elements and shorten the list of suspects.

Unfortunately, deficiency symptoms are often caused by external factors, not the amount of fertilizer we supply to our plants. A very common issue here may be **over watering** *(figure 13)*. The substrate is too wet, leaving less room for air. Now plant roots definitely need oxygen which they take up from these air spaces. In case of oxygen stress, roots will die – a process that occurs faster than you may think. Root tips die off and nitrogen and potassium are amongst the first nutrients whose uptake are reduced. If the substrate remains too wet, the plant growth is lagged and symptoms much like nitrogen deficiency arise.
To prevent over watering, check your substrate regularly. In case of a wet substrate, check drainage and reduce the amount of water given per turn. In case of over watering, skip one or a few turns. Allow the substrate to dry a little. This will stimulate the plant to form new roots to replace the ones that died before.

As we have seen in the previous paragraphs, the plant itself influences the soil pH. Aiming a neutral ion charge inside and outside the plant, nutrients like ammonium (NH4+) are taken up in exchange of a proton (H+). This may lead to acidification of the substrate. Nutrients like phosphorus, potassium, sulfur, calcium, magnesium and molybdenum (although abundant in the rhizosphere) will become less available for the plant.
The risk of acidification of your substrate is reduced considerably if you choose the right substrate. Do not use improper peat mixes, check the soil pH before use; at pH values lower than 5.5 the risk of acidification is increased considerably. Also, keep in mind that peat based substrates that you want to re-use may have used up the chalk buffer during a previous cultivation cycle. A chalk buffer can be 'repaired' by mixing some additional dolomitic prior to planting and will reduce the chance of deficiency symptoms caused by low pH values.

On poorly buffered substrates or inert substrates like rock wool, we always advise to set the pH value of your nutrient solution to values ranging from 5.2-6.2 on rock wool to 5.8-6.2 on peat mix. Rock wool, or any other inert substrate does not have a nutrient or pH buffer. If the nutrient solution is not applied at the right pH range, nutrient deficiencies caused by a high pH may occur. Deficiency symptoms that can be seen include deficiencies of trace elements like iron, copper, zinc and manganese.
In case of high soil pH values, one could choose to decrease the pH value of the nutrient solution. During crop cultivation, the addition of some extra ammonium may help. This nitrogen source helps to lower the pH around the roots, which increases the plant availability of most trace elements. •

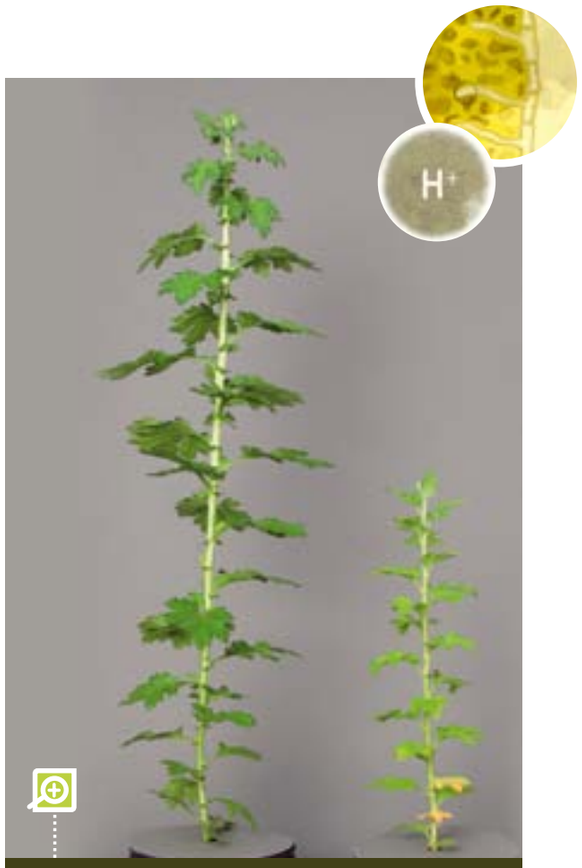


Figure 13: The golden daisy on the left is a healthy one, the one on the right is not. This is a typical example of a plant that is suffering from overwatering; the substrate has been kept too wet for too long and plant growth has lagged behind. To prevent overwatering it is advisable to check your substrate regularly.

Grower's TIP #24

By F.F.

NUTRIENTS A SEEMINGLY COMPLICATED ISSUE!

Troubleshooting plant nutrition issues can be extremely complex. For the purpose of this article, which is to provide you with a simplified troubleshooting key, we will assume that you are sticking to one brand of nutrient and additives and not mixing up your own witch's brew.

Using nutrients and additives from many different companies in your feeding reservoir means that the various ratios between the major and/or minor nutrients could become skewed, giving rise to serious plant nutrition issues. In our experience, most cases of inadequate plant nutrition are caused by abiotic conditions (linked to soil and air environment).

The first step is to sample your medium and perform an EC and pH test (1:1.5 ratio, check CANNAtalk #5, available on the CANNA website). If values are too low or too high, correcting them (with a corrective nutrient solution and ample run-off) should solve the problem within 3 to 5 days. You should also verify that the potting mix temperature is between 64 and 75°F.
If the root medium is fine, take a look at your root profile (see Need To Know video 4, season 2, 'Healthy root system' on canna-hydroponics.com) to rule out over or under-watering issues. Either of watering issues can create a myriad of nutrient deficiencies and/or toxicities.
Finally, the following climate-related situations can impose metabolic stress on plants and aggravate nutrition issues:

- Lights are too close and generate excessive radiant heat. This would cause the most symptoms in the upper part of the plant, with the worst on the topmost leaves.
- Climate is too dry and/or too hot promoting excess transpiration which complicates nutrient uptake over time. Intense horizontal air flow can also create conditions similar to high heat and low relative humidity (RH).
- The climate is too moist, slowing down the flow of water through the plant and possibly limiting the delivery of nutrients from the roots to the leaves and growing shoots. Overdosing oil-based foliar sprays (such as neem oil) can limit water flow through the plant by blocking the stomas. Insufficient horizontal air flow can also limit nutrient delivery.
- Low lighting intensity, such as occurs deep under the leaf canopy (the lowest plant leaves) can deactivate photosynthesis. The plant responds by draining the leaves of its movable nutrients and initiating abscission (leaf detachment off stem). The plant population may be too high.

Keep in mind that 95% of the final weight of your plants is made up of carbon, hydrogen and oxygen which are not listed as classic nutrients. The nutrients taken up via roots can be compared to the oil in your car engine. Too much of it will cause the gaskets to leak. Too little and your engine might wear and tear faster or worse still, seize up entirely! Fertilize wisely and we hope you enjoy great results! •

Puzzle&WIN

Because of the great success of our old time favourite: 'sudoku' in the previous CANNAtalk we have decided to once again put you up for the test. Never done a sudoku before? Here's what to do: each row, column and 3 x 3 grid must contain the each of the numbers one to nine once.

WIN A 1 L BOTTLE OF CANNA START

1	9			6		8		
	3						7	
6	2	7		1	5			
		9				2	3	4
				9				
4	1	2				5		
			6	3		4	8	7
	7						2	
		6		2			1	9

PRIZES

So get your brains working out those numbers, and don't forget to let us know what your solution is (sending the middle part of the puzzle to editor@cannatalk.com is enough to check) and maybe **YOU** will be the lucky one who wins a 1 L bottle of CANNA Start!

Winner **Puzzle#22**

We picked a random winner from all the correct entries we received, and we would like to congratulate

Mr. Brodsky

Congratulations on your 1 L bottle of CANNA Coco A and a 1 L bottle of CANNA Coco B. We will contact you as soon as possible to organize the dispatch of your prize.

NO WEEPING WILLOW

Most plant crops are not really suitable for use in making bio-fuels because they contain too much lignin. Lignin is what makes plants rigid and the more of it that a plant contains, the more woody and rigid the plant is. Belgian and British biotechnologists have now developed a crop that is much less woody than normal, and is thus much more suitable for use in bio-fuels. The technologists discovered that the enzyme caffeoyl shikimate esterase plays a crucial role in the formation of lignin in plants. Using genetic modification techniques, they were able to 'switch off' the production of this enzyme, reducing the amount of lignin by 36% compared to the model plant (in **Arabidopsis thaliana**). The new variants were less sturdy, but they were not so limp that they fell over. When they were dried and processed, (without heating, which is necessary for normal plants) they produced four times as much glucose – the basis for bio-fuel.

The next step will be to go through the same process of genetic modification in the woody crops that are suitable for use in bio-fuels, paper and bio-plastics (**Arabidopsis thaliana** is used mainly for laboratory purposes).

GOLDEN **OLDIES**

According to researchers from the University of Wageningen in the magazine Nature Climate Change, European woods are less capable of absorbing carbon dioxide from the atmosphere and thereby countering the effects of global warming. This is because the woods are getting old. Many were planted following the Second World War and after sixty or seventy years, and the trees have stopped growing as fast as previously.

The researchers saw a number of different indications that the capacity of European woods for absorbing carbon dioxide has reached its limit; trees are growing less thick and are being affected by fires, storms and pests more frequently. More woodland is also being used for other purposes these days. For every hectare of woodland that disappears, an average of 65 tonnes of carbon is unlocked.

Facts

It is still not clear whether it would be possible to cultivate plants on Mars – like a vegetable garden for example. Researchers from the University of Montreal have discovered that plant reproduction would be difficult because of the different gravity on Mars.

VEGETABLE GARDEN ON MARS?

Scientists made this discovery when they attempted to grow pollen tubes from a Japanese rose in a centrifuge (a device that can recreate conditions of increased or reduced gravity compared to what we normally experience here on earth) at the European Space Agency in Noordwijk, the Netherlands. They chose pollen tubes because these are the fastest-growing cells in the whole plant kingdom. In fact, a pollen tube can grow from male pollen grains within a few seconds of coming into contact with a stamen.

The experiment in the centrifuge showed that the pollen tubes grow much more slowly under reduced gravity. The diameter of the tubes declined by up to eight percent. When the pull of gravity was stronger, the thickness of the pollen tubes increased. The changes in gravity disrupted the transport of substances that enable the male reproductive organs to grow and function.

WHAT'S NEXT

CANNAtalk 25 is all about light and the light spectrum. Of course you know that light is crucial for your lovely plants, because they need it to produce their own fuel and building materials through photosynthesis. In this issue we will give you a little more background information; our researchers will explain the effects of the light spectrum on plants and will give you a lot of practical information about LEDs in the second research article.

Furthermore Don will share his experiences of growing in his indoor wine cellar-garden in a new episode Don & Nicky, and we have a Grow it Yourself about how to grow tomatoes and potatoes as one (the TomTato or Potato Tom). Read all about this, and a lot more, in the next edition of CANNAtalk. Don't miss it!

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Email: editor@cannatalk.com
Co-editor: Marleen van Merode
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Contributors issue 24:
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