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:

- Don & Nicky
- Questions & Answers
- Pests & Diseases
- Grower's Tip
- Genetics & Breeding
- Puzzle & Win

HQTalk:

Oh dear we are already a few months into 2014... how time flies! I still remember New Year's Eve 1999 and the fear of all the world's computers crashing. They predicted that after midnight there would be a catastrophe but guess what, here we are, 14 years on! There were no problems at all in the end. Speaking of problems, many growers face problems while growing their crops, so we have dedicated this issue to nutrient deficiencies. Many growers think a deficiency occurs because they are providing the wrong nutrition – either too much or too little. However many deficiencies originate with a mistake in the climate control and have nothing to do with the amount of nutrition being provided. In this issue of the CANNAtalk we tell you all about plant nutrition and nutrient deficiencies. As a bonus we have included the very famous CANNA deficiency guide in the middle of the magazine. So why not pull out this small poster and hang it in your grow room so that you can take action immediately when a deficiency occurs.

As well as the research articles and the pull-out guide we have the very last article in the genetics and breeding section. There is a pest and diseases article about Fusarium and of course Don tells you all about his adventure in France as progress is being made!

If you have any questions, comments, feedback, information or anything else, please feel free to contact us via the website www.cannatalk.com or via the answering card in the back of the magazine.

Regards,

Karin

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PART 1

PLANT NUTRITION AND NUTRIENT DEFICIENCY

MANY GROWERS HAVE SEEN THEIR PLANTS EXHIBIT SYMPTOMS THAT THEY HAVE IDENTIFIED AS A NUTRIENT DEFICIENCY. THESE SYMPTOMS CAN BE ANYTHING, FROM YELLOWING OF THE LEAVES TO BROWN NECROTIC SPOTS OR REDUCED GROWTH. SOME GROWERS WILL ALSO HAVE LEARNED THAT SIMPLY ADDING MORE NUTRIENTS IS OFTEN NOT A SOLUTION TO THESE SYMPTOMS...

By CANNA Research

An appropriate cultivation strategy and a good balance of nutrients are two factors that are vital to a successful yield. But what actually determines the right balance of nutrients? Which external factors play a key role here?

To understand this better, we will first highlight the various essential nutrients and how these behave in the soil or rhizosphere (the space where the roots grow and nutrients are taken up by the plant), and how the plant can take up these various nutrients. Then we will focus on the function of these essential nutrients and how symptoms of a deficiency can be recognised.
Finally, we will focus on how nutrient deficiency can arise. As we will see, many problems are caused by soil or substrate imbalances. In this article, we will discuss most of these aspects and how we can solve them.

Mineral nutrition

Plants need the right combination of nutrients for growth as well as an external supply for its internal metabolism. Plant nutrients or nutritional elements can be any mineral that is taken up by the plant. In 1972, Epstein identified two criteria for such an element to be considered essential for plant growth. The first criterion is that the plant is unable to complete a normal life cycle in its absence. The second is that the element is part of some essential plant constituent or metabolite.
But plant nutrition is not only essential for plants to survive and grow; a balanced nutrient solution will also help maximise the yield, improve crop quality and enhance the nutritional value of the plant itself (if it to be consumed by humans, for example).
The importance of a particular nutrient will depend on the crop species and crop variety. But as we will see, the availability of other nutrients also plays a key role.

Classification of elements

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

A completely different way of classifying the nutrients is according to their abundance in the plant (see figure 1) or

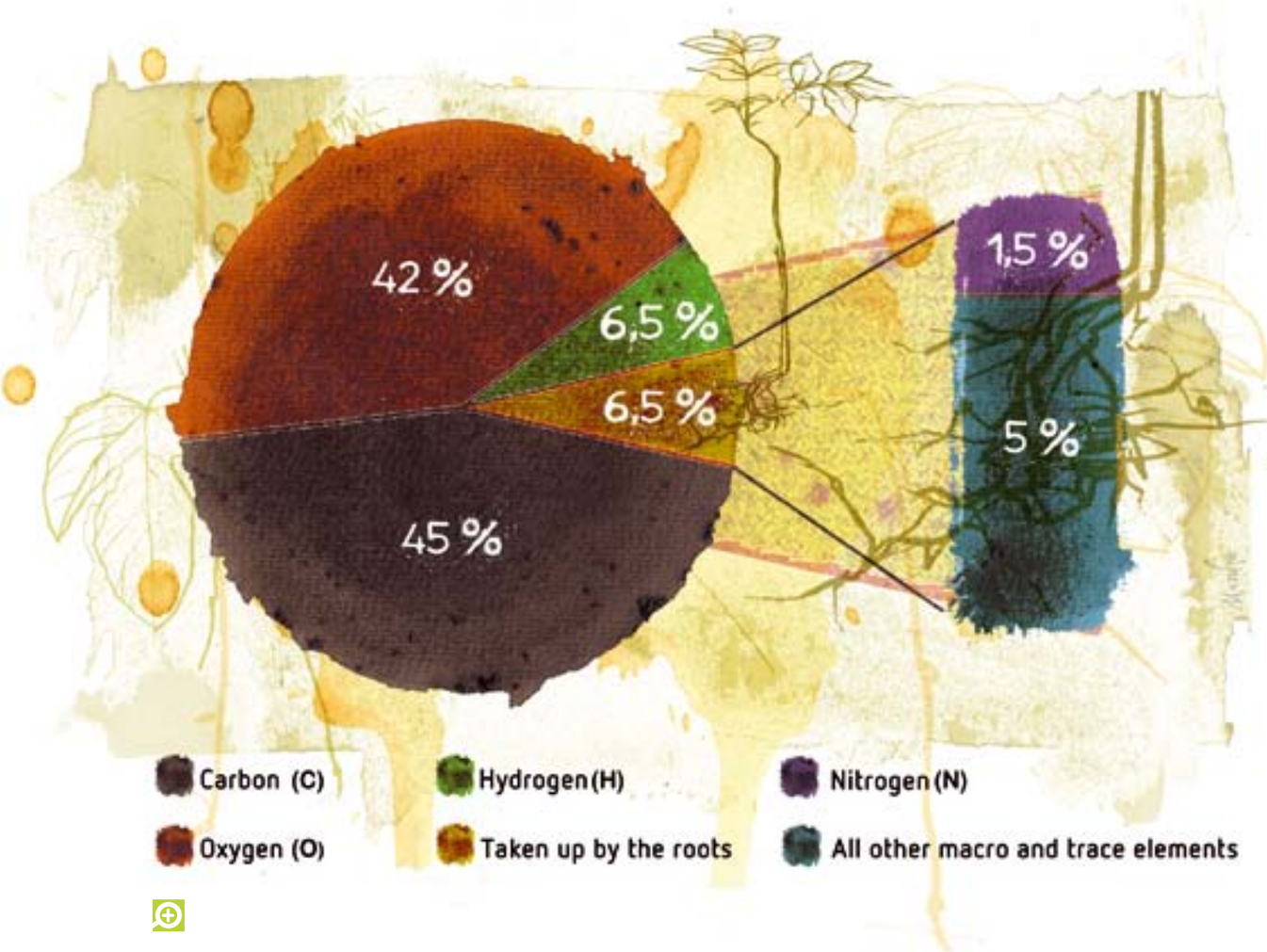


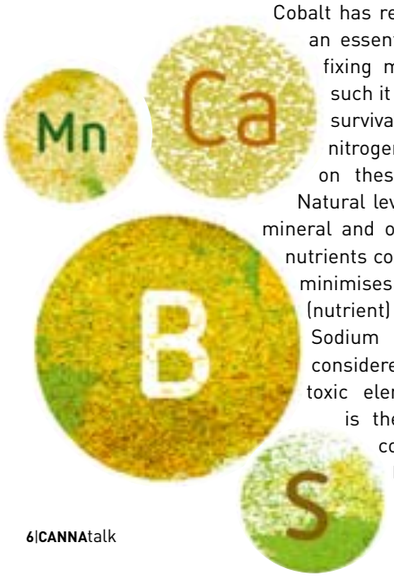
Figure 1: A German scientist, Knop, has estimated that if all the species of the plant kingdom were fused into one mass, the ultimate composition of the dry matter of this mixture would be as represented in this pie chart. Most of the plant biomass consists of carbohydrates, with carbon (C), oxygen (O) 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 I

by how much the plant needs them. More than 93% of the plants' biomass consists of carbon, hydrogen and oxygen. The remaining 7% includes all the other nutrients, which can be divided into two groups. The elements required in large quantities are called macronutrients or macro elements. These include nitrogen, potassium, phosphorus, calcium, magnesium and sulphur. Then there are the micronutrients or trace elements, which are required in very small quantities. Iron, copper, manganese, molybdenum, boron and zinc are examples of elements that are required in very small amounts yet area essential to the plant growth and development of plants.

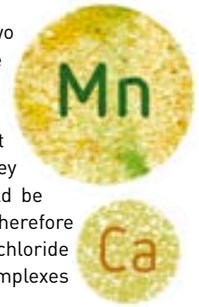
Some elements are not essential for plant growth or reproduction but may certainly be beneficial for plant growth. Silicon is an example of such a non-essential element. Only members of the Equisetaceae family (scouring rushes, see figure 3) actually require silicon to complete their life cycle. In other 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 and enhances growth and stability (Woolley, 1957; Miyake & Takahashi, 1985). For rice it has been demonstrated that an extra supply of silicate during the reproductive stage was very important for plant growth (Ma et al., 1989).



Cobalt has recently been confirmed as an essential element for nitrogen-fixing micro-organisms, and as such it may be essential for plant survival when there is limited nitrogen and the plants depend on these symbiotic interactions. Natural levels of cobalt exist in both mineral and organic fertilisers. CANNA nutrients contain enough cobalt which minimises the chance of a cobalt (nutrient) deficiency.

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



The role of essential elements in plant growth and development

Nitrogen

Nitrogen (N) is absorbed mainly in the form of nitrate (NO3-) and ammonium (NH4+). Under a few circumstances, organic nitrogen compounds such as amino acids are taken up by the plant. Nitrogen makes up about 0.3 - 5.0% of the plant's total dry matter. In relative terms, the most nitrogen can be found in young tissue still under development such as meristems and young leaves, and there is less in more mature tissue. The least nitrogen is found in senescent tissue. Nitrogen is an important component of many essential components such as nuclear acids, proteins, enzymes, lipids, chlorophyll, phytochromes, plant hormones and vitamins and as such it is obviously essential for the growth and survival of plants.

Potassium

Potassium (K) in the plant only exists in the cation form (K^+), and it is concentrated in those parts of the plant with the highest rates of metabolic activity. Potassium is about 1 - 5% of the plant's dry weight and is used by the plant to regulate water balance (osmosis, stomata and transpiration), activate enzymes (pyruvate kinase, glutationine synthesases, starch synthase etc.), enhance resistance (pests and diseases), synthesise polysaccharose and proteins, transport sugar (potassium as a counter ion of H^+ participates in sugar loading) and in the energy metabolism (oxidative phosphorylation and photophosphorylation).

Phosphorus

Phosphorus (P) is absorbed mainly in the form of dihydrogen phosphate ($H_2PO_4^-$). About 0.1-0.5% of the plant's dry matter is made up of phosphorus. It is an essential component in nuclear acids, lipids, co-enzymes and plays a key role in the plant's energy metabolism (it forms adenosine triphosphate, ATP).

As such it is part of the metabolism and transportation of sugar, regulates enzyme activities and plays a role in the synthesis of protein, fat and starch.

Calcium

Calcium is taken up in its ion form (Ca^{2+}) by passive absorption and represents roughly 0.2-3% of the plant's dry matter. More calcium can be found in the older parts of the plant than in the younger parts.

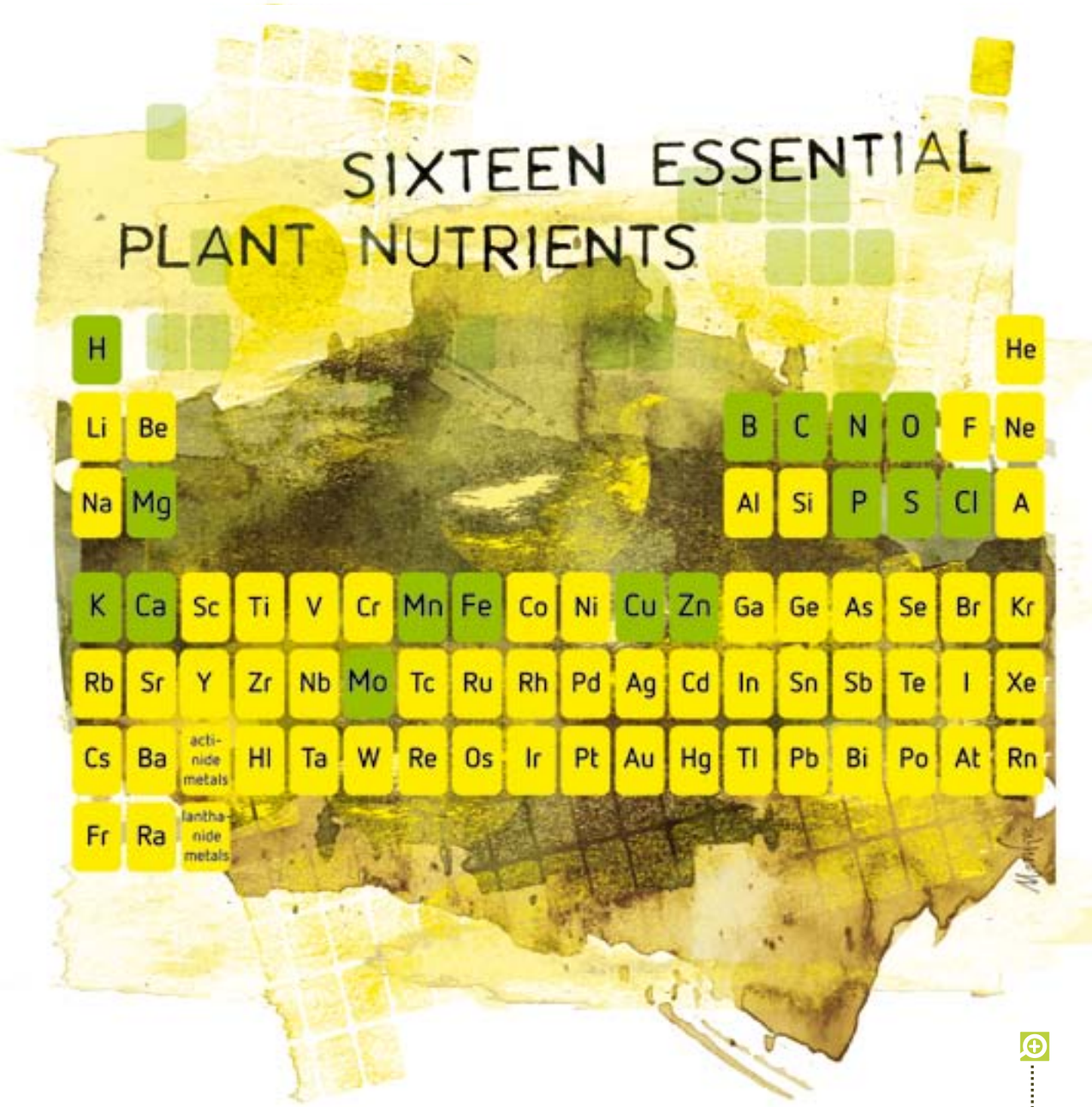


Figure 2: You are looking at a schematic overview of the sixteen essential plant nutrients. According to scientists Arnon and Stout, there are three criteria by which we can judge whether an element is essential for plants. 1. A deficiency of the element makes it impossible for the plant to complete 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.

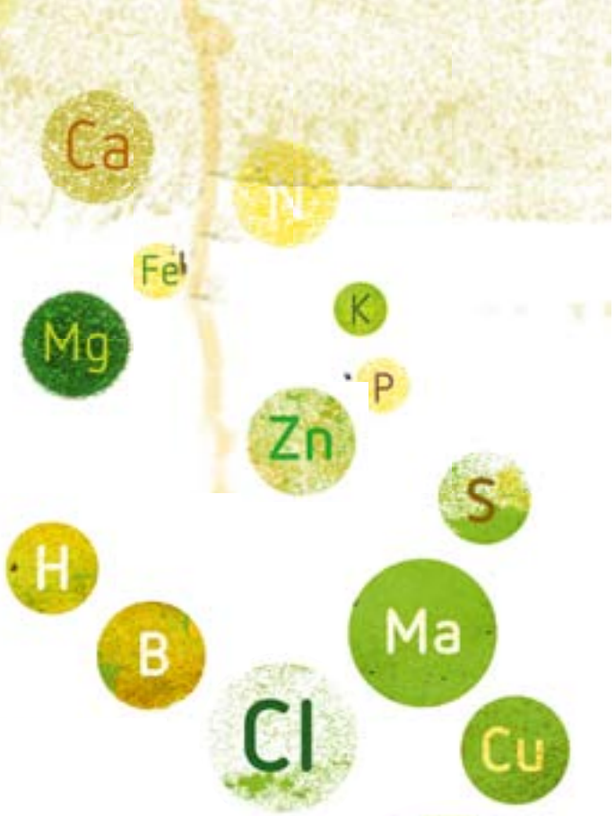
The function of calcium in the plants' physiology is to stabilise the cell walls, activate some enzymes, stabilise membranes and regulate osmosis.

Magnesium

Magnesium (Mg^{2+}) represents about 0.03-0.7% of the plant's total dry matter and is relatively most abundant in the younger leaves. Although less abundant than the nutrients mentioned above, 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 1



Sulphur

Sulphur is taken up in the form of sulphate (SO_4^{2-}) and represents about 0.01-0.5% of the plant's total dry matter. There is more sulphur in the older leaves than in the younger leaves. Sulphur is a component of proteins and bio membranes.

Iron

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

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 as an enzyme activator. Typical symptoms of a deficiency are necrotic spots in young leaves.

Boron

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

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 that of iron. Being a component of or closely related to enzymes and other proteins, it is also involved in electron transport.

Molybdenum

Molybdenum (Mo) enhances the plant's 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'

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 colours, sizes, shapes and textures. You can find white, yellow, and even orange-coloured cucumbers

CUCUMBER

Figure 4: **The world produces approximately 42 billion kilogrammes 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 42 billion kilogrammes 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 15 and 33°C. 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 15°C. 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.

Fertilise

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 fertiliser. 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 21°C 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 maximise 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, flavourful 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 DEMAND THE INPUT OF MORE RESOURCES THAN EVER BEFORE – IN TERMS OF IRRIGATION WATER, FERTILISERS AND PLANT PROTECTION PRODUCTS. THE FUNDAMENTAL REASON FOR THIS IS THE FACT THAT MUCH OF OUR CULTIVATION IS CONCENTRATED INTO RELATIVELY SHORT BURSTS AND THIS DOES NOT LEAVE TIME FOR THE CROPS TO ACHIEVE ECOLOGICAL EQUILIBRIUM. By CANNA Research

EXPECTED: A REVOLUTION IN CULTIVATING CROPS

Today, we are also slowly realising that this way of growing crops is not environmentally friendly and is undermining the natural systems of our planet in many different ways. Nevertheless, we have grown dependent on these high input, high output crops. And why is this? Because there are now so many of us to feed. Global demand for food will only increase because there is little prospect of the human population declining. But here we are not concerned with the fate of humankind, or how we can avoid a catastrophe. We will simply discuss a way to prolong our existence. This article is about a very interesting way to decrease the resources that crops need without losing too much of the output in terms of yield. Interestingly, this method could also benefit our planet, since it would drastically change the way we grow our crops. Agriculture is certainly man's greatest invention since he learned to create and use fire. And just like fire, agriculture changed the way people live beyond recognition. Before agriculture, humans were nomadic, collecting food and other materials derived from animals and plants; with the introduction of agriculture, humans settled in (more) permanent places to live *(figure 6, step 1 & 2)*. The first farmers selected the best plants or animals for propagation, so the concept of breeding is inextricably linked to the concept of agriculture. Breeding energy-rich crops, like grains (e.g. rice, corn) or tuber crops (e.g. potatoes, yams), eventually enabled the growth of the huge cities and complex civilisations. It was at this point that 'history' really started, because we became able to write it down.

Over the millennia, generations of farmers developed the crops that we know today, and in the past few hundred years in particular, there have been a lot of changes. New species from other continents have arrived *(figure 6, step 3)*. Monoculture was made possible by means of mechanisation, chemical fertilisers and pesticides, which produce higher and higher yields. In the last fifty years, with soilless cultivation and the control of climate by means of heated and lighted greenhouses, both inputs and yields have increased even further *(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 as at the dawn of agriculture, those who breed plants are looking for individuals that can grow quickly and produce a high yield. Not only is it efficient to breed crops with a short cultivation cycle, but breeding is also much faster with these individuals. With this in mind, it is logical that many 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. However, in nature most plants are perennials – it is only in agriculture that the majority are annuals.

Thirty years ago, mankind took another great step forwards by managing to transfer genetic characteristics from one organism into another. Suddenly, we could not only modify the genetic code of an organism (even using a genetic code from other species), we could also read the code itself. Being able to read the genetic code meant that we no longer needed to cultivate endless generations and select the characteristics that we wanted *(figure 6, step 6)*. Now, if the genetic code for the desired characteristic is known, a breeder can screen candidate plants for that gene. In this way he can save a whole lot of time and only needs to grow a few plants instead of a few hundred. This gives him the opportunity to screen many more plants for their characteristics. Using these methods, breeders can achieve results much faster, and this has made perennial crops more practical for use in agriculture. Until recently, this was just a theory because DNA sequencing remained quite expensive. However, this is changing rapidly and DNA sequencing is now a standard tool that breeding companies can afford.

What are the benefits of growing perennial crops, rather than annuals? Perennial crops do not need the same high input as annual crops and there are a number of reasons for this. One is that after the first year, the crop is already established. From that point on, the established plants only need energy to sustain themselves and regrow after a period of cold or drought. The farmer does not need to plough his land and sow new seed. During the winter the soil remains covered, preventing erosion, and because a perennial crop has a much better root system, it needs less irrigation in the summer. The better roots also prevent substances like nitrogen from leaking into the ground water. Of course there are many misunderstandings and prejudices about these perennial crops of the future. The comparison is often made with annuals and the circumstances under which annuals are cultivated, but growing these perennial crops will also change the way we cultivate. For instance, a common objection is that crop rotation is problematic with perennials because they are in one place for more than one year, and that pests and diseases also pose a bigger threat for the same reason. This certainly applies when annual crops are grown year after year on the same piece of land. Studies have shown that in the first years there will indeed be problems with diseases. However, after about a decade, equilibrium is achieved in the soil. This means opportunist species such as weeds and many pathogens are no longer able to invade the area as easily: the crop will be free from soil-related problems. Perennial cultivation does not open the door to opportunists every year, and a state of equilibrium is achieved much faster. In fact, the idea of this new type

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

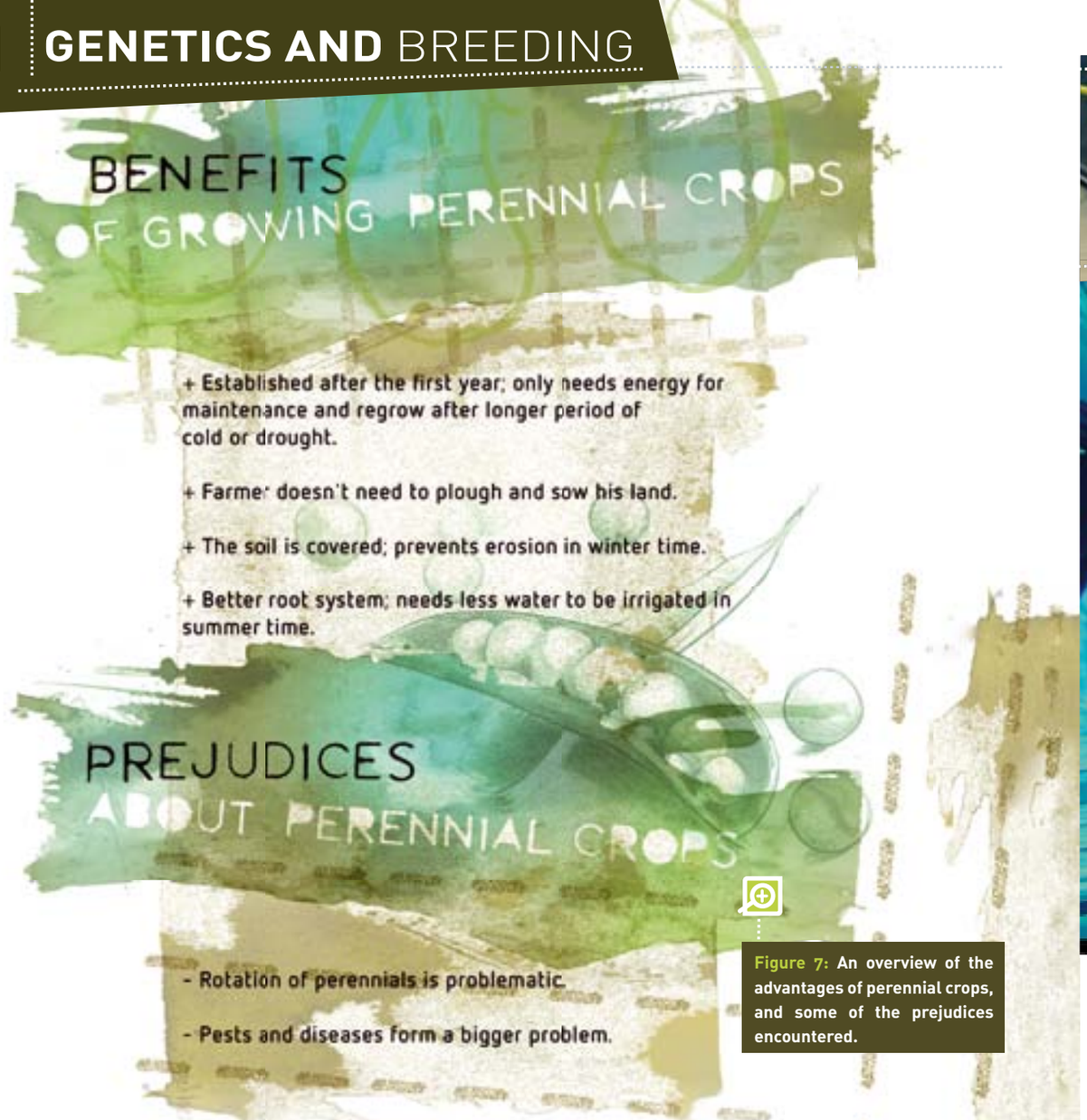


Figure 7: An overview of the advantages of perennial crops, and some of the prejudices encountered.

of perennial cultivation is quite similar to the concept of permanent pasture, where the problem of disease is rare compared to the cultivation of annual grains.

So if we were able to replace our major annual crops with perennials while maintaining the same yield, we could save a lot of money and, at the same time, make agriculture more environmentally friendly. However, human nature being what it is, perennial crops will undoubtedly also be used to make larger profits. Perennials also grow better under suboptimal circumstances than annual crops, which means that they can also grow in places where farmers cannot currently grow crops.

It seems that the idea of replacing annuals with perennials will rapidly become a reality. The perennial brothers and sisters of our well-known annual crops are still living in nature. In fact the first breeding programmes to replace annual wheat and rice with perennial alternatives has already begun. So, we are actually already in the process of creating these new crops, and new technology should enable us to do thousands of years of breeding within just a single lifetime. And if you are sceptical about whether we can locate these perennial brothers and sisters in numbers that matter, there is some more news. Some crops are grown as if they were annuals (or biennials), but they are in fact perennials. Examples of such crops include broccoli, chives, tomatoes, egg plants, bell peppers and chili peppers. And it is not only food crops that fall into this category, but also crops that have a high value as non-food products.

Humankind is so accustomed to growing annual crops that the benefits of the perennial alternatives are often not even considered. But to maximise these benefits we would also have to drastically change the way we grow our crops. Technically, breeding new perennial crops or creating new cultivation systems for perennials is not such a major challenge. But simply sitting back and continuing to grow crops in the same way will have significant drawbacks, especially when investing time and money in developing new ways of cultivating could yield such benefits and result in a world where we grow our crops in a radically different way. •

What's HAPPENING

You are all familiar with the sports of hockey, polo and boxing. But have you ever heard of some of the fun spin-offs from 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

Octopush:
Hold-your-breath hockey

Let's take field hockey and combine it with water polo... What do we get? We get an unusual game called octopush. It's a remarkable sport that is played mainly underwater in a swimming pool. It was devised in 1954 by a diver called Alan Blake. The 'octo' in octopush stands for eight because in originally 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 field hockey. The players dive down to the bottom of a pool wearing a diving mask, fins and a snorkel. They have a stick called a pusher and they try to shoot the puck, which is called a squid, into the other team's goal, or gull as it is called in this game.

At the start of each game the squid is placed in the middle of the pool and the teams begin on opposite walls of the pool. At the referee's signal the game begins and the teams dash towards the puck, the forwards attempting to gain possession for their team. The teams work together to try to score a goal while at the same time defending their own goal. When 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.

Sounds easy? Hmm... well try holding your breath for minutes at a time while swimming underwater towards a piece of lead at the bottom of a swimming pool. And then try doing it while your opponents kick you and push you away. This is not a game for wimps!

2 Chess **boxing**: Is it brain before brawn, 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 rounds of boxing and chess – waiting for a checkmate or a knockout to decide the match. A chess-boxing match between two individuals lasts up to eleven rounds, starting with a four-minute chess round 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".

But it must be hard to find someone who is good at both boxing and chess. Chess players are famously smart, so you might generally expect them to understand that entering a boxing ring to get punched in the head is not such a great idea.

Photo courtesy of Neale A.

3 **Hantis**: Four-tabled Ping-Pong

Hantis is a simple game created by Jason Johns, that is becoming more and more popular in schools in the US due to PE teachers. The sport has some similarities with table tennis, but it is much more dynamic. Hantis can be played using the resources that schools already have: four tables and one ball. Unlike the majority of other sports, this sport is free once you have these 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, and the game is not endurance-based so students of any fitness level will enjoy it. Players rotate teams for every game which encourages a more playful competition rather than dominance.

Photo courtesy of Huron Bikes

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

We all know polo. It's a great sport, but it helps to be a millionaire. Because buying, feeding and accommodating all those horses doesn't come cheap. Bicycle polo is an outdoor game similar to polo, except that you use bikes instead of horses. Traditional bicycle polo is played on a large rectangular grass field, but the faster hard court version is played by fewer players on a smaller court and is growing in popularity. The hard court version is called urban bike polo, and is played by three players on a hard court surface like that used in basketball. The ball used is a street hockey ball.

The rules vary slightly between cities. Each team has three members, there are no substitutions, and all team 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 each side of the court. In order to score, the attacking player must hit the ball across the goal line using the narrow end of the mallet. The matches are played until one of the teams scores five points.

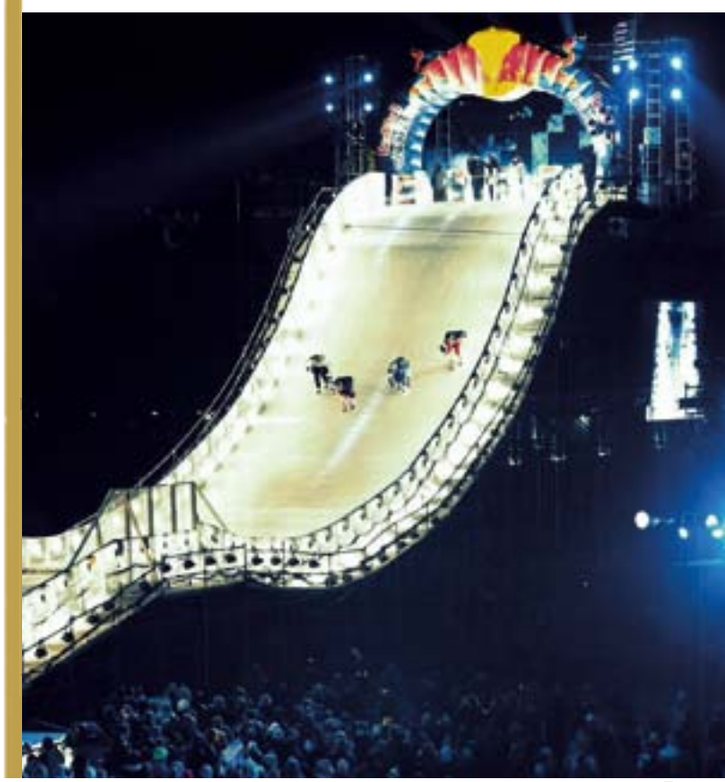
5 Downhill **ice cross**: Slippery racing

Four guys kitted out in ice hockey pads, ice skates and helmets race each other down a winding 1771-feet course of solid ice. The course has twists and turns, jumps and bumps, and also includes a 100-feet vertical drop. Everything's a blur as the skaters reach speeds of over 45 mph. Welcome to the fantastic world of downhill ice cross!

It is similar to ski cross and snowboard cross, except they wear ice skates and race down 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 all that could change as a result of Crashed Ice, where competitors, having advanced from one of the try-outs in the prior months, race in heats of four skaters, with just the top two skaters from each heat going forward. It's a sport for competitive adrenaline junkies and it makes great TV. But just 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 recognise the deficiency (what can you see? And secondly: what can you do?). 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?
Add calcium by applying a liquid lime fertiliser such as a calcium nitrate solution.

Phosphorus

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

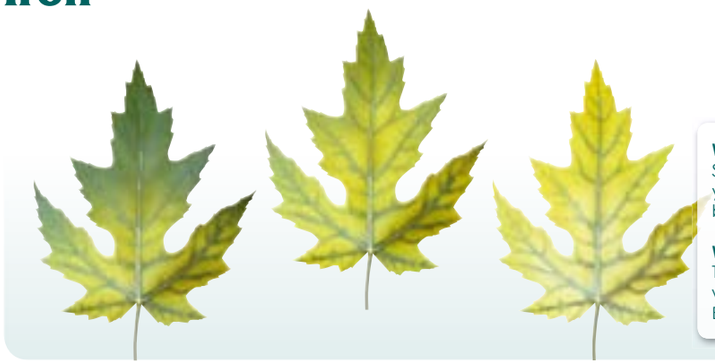
What can you do?
Mix inorganic phosphate fertiliser THOROUGHLY through the potting mix or add extra liquid phosphate when growing in hydroponics.

Magnesium

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

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

Iron



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

What can you do?
The best thing is to spray the plants with a watery solution of EDDHA or EDTA chelates.

Nitrogen

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

What can you do?
Raise EC of the feeding or add extra nitrogen.

Potassium

What can you see?
Dead edges on the leaves.

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

Manganese

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

What can you do?
Using products that contain trace elements (Tracemix).

CANNA
The solution for growth and bloom

Pests & DISEASES

Fusarium is a major genus of soil fungi that is found in many parts of the world. Most species are harmless saprobes and are relatively abundant members of the soil microbial community. Nonetheless, some Fusarium species are economically significant due to the devastating impact they can have on crops. By CANNA Research

Photo courtesy of UF IFAS-FLREC

FUSARIUM

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

In the beginning there was some confusion surrounding the taxonomy of Fusarium and its over 1,000 species, varieties and races. But as people started to understand that Fusarium causes serious disease, the need for a precise system of classification became more urgent. Nowadays, scientists still debate the system of classification that includes between nine and 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's symptomatology. This means that most of the species have been divided into groups according to the type of disease that they cause, such as the species groups for Fusarium stem canker, Fusarium foot rot and Fusarium wilt.

The **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. Within this group, F. oxysporum has several specialised forms – known as formae specialis (f.sp.) - that infect a variety of hosts to cause a range of 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 names of the sub-species. However, the debate on this classification system is far from over, since many scientists suggest that F. oxysporum f.sp apii is from the same group as f.sp vasinfectum. Because of this, the characterisation of sub-specific groups is now based on the generics of the fungus rather than on the host-pathogen interaction.

F. oxysporum f.sp.cubenses is a clearly defined sub-species that causes the Panama disease of Musa spp. It was this pathogen that caused the disappearance of the banana cultivar 'Gross Michael', after which a new banana variety, 'Cavendish', was introduced due to its resistance to Fusarium. As 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 can be pale or brightly coloured (depending on the species) and may have a cottony aerial mycelium. The colour varies from whitish to yellow, brownish, pink or reddish. Species of Fusarium typically produce spores (called macro- and microconidias) to reproduce and disseminate themselves.

Fusarium stem canker symptoms begin with an epidermal lesion, followed by chlorosis and necrosis. Close to the lesion, the trunk, branches or stems will 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, in which it causes damping-off.

Because of host symptomatology, Fusarium foot rot may easily be confused with Fusarium stem canker because both of them cause a canker. However, Fusarium stem canker leads to a reddish xylem discolouration while Fusarium foot rot is distinguished by soft, dark or black cankers that show up as dark brown discolouration on the stem.

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

Fusarium oxysporum (wilt) is also saprophyte fungi that can 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, throughout the vascular tissue of the whole plant. This condition progressively limits water and nutrient uptake, the leaves wilt, and the plant will eventually die.

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, as well as their saprophyte status. A thorough Fusarium management programme should include prevention, cultural practices, sanitation, biological and chemical control.

Reducing plant stress will limit the favourability of conditions for the fungi to spread. Ensure that you use clean and disease free seeds or plantlets. Avoid overwatering, deep planting, over fertilising with nitrogen or phosphorus, and injuring plants when planting. Cultivating, harvesting, and sorting are some of the practices that can help prevent the spread of Fusarium.

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 to spot the symptoms of the disease in the early stage is the most effective practice for preventing the spread of Fusarium. Furthermore, disinfestation of the soil and the use of fungicidal chemicals, crop rotation, or the use of resistant cultivars, are the best cultural, biological and chemical practices to control and limit 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-uk.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 mineralisation 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 18ºC 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-fertilising 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 fertilisation 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 use 85% perlite and 15% coco to grow in. Which nutrients should I use?

Answer

If you reuse your drain water, you can use CANNA Aqua (Vega and Flores), but only if your water quality is soft (lower than 0.3). In either case, especially if you drain the solution to waste after passing it through the root system, you can use CANNA Hydro Vega and Flores. Make sure you have the right Flores for your type of water (Hydro Soft or Hydro 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 Hydro A + B to feed my soil-grown plants but I have noticed the CANNA Terra Flores is specifically for soil-grown plants. Does this mean I've been using the wrong ones? Or can you use CANNA Hydro A + B and Terra Flores at the same time?

Answer

CANNA Hydro A + B is a general run-to-waste fertiliser. It is high in calcium and nitrogen. For peat-based and soil mediums that lack a decent fertility balance and correct pH controls, Hydro works the best, but not perfectly. 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?

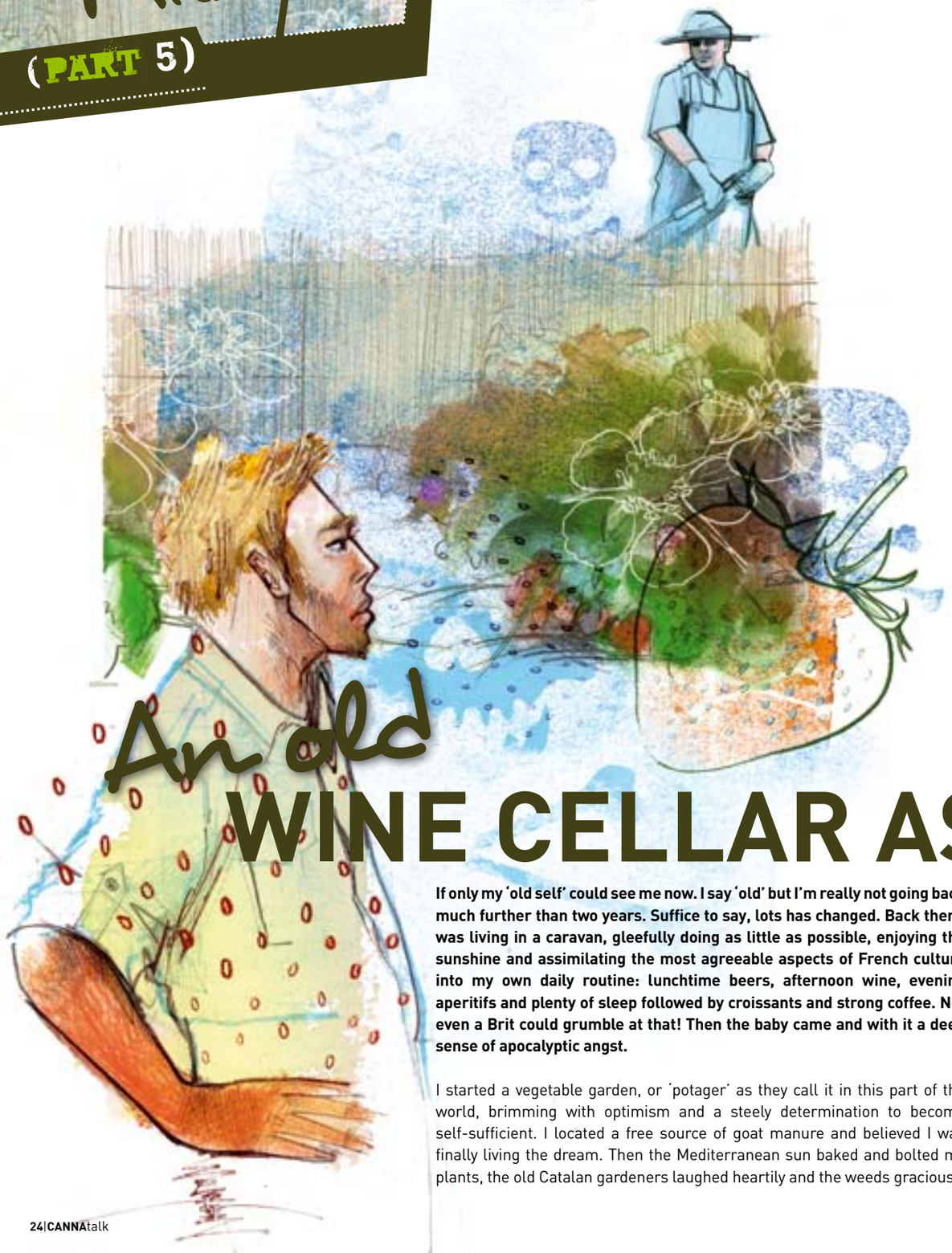
Answer

It is unlikely that you could have a magnesium and a potassium deficiency at the same time (because they are opposite elements, antagonism). It is a combination of calcium and magnesium, which often occurs when water is very soft (good quality) and has an EC value lower than 0.4. You can add the mononutrients; 3 ml/L CaO15% and 3 ml/L MgO7% or 6 ml/L COGr Bufferagent, which is a mixture of calcium and magnesium. 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 angst.

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 smelt the distinct aroma of herbicide wafting over from my neighbour's garden. The dear old chap was spraying some adjacent land he'd left lying fallow and a gentle westerly wind ensured that my meagre 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'll 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.

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 civilised 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 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 dialling 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. •

1 Me planting a peach tree in the vegetable garden.

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

PART 2

PLANT NUTRITION AND NUTRIENT DEFICIENCY

IN THE PREVIOUS PART OF THIS RESEARCH ARTICLE, WE DISCUSSED THE VARIOUS ESSENTIAL NUTRIENTS AND THEIR ROLE IN PLANT GROWTH AND DEVELOPMENT. IN THIS PART WE WILL FOCUS ON HOW PLANTS CAN TAKE UP THE VARIOUS NUTRIENTS AND HOW THE SYMPTOMS OF DEFICIENCY (CAUSED BY SUBSTRATE IMBALANCE) CAN BE RECOGNISED AND REMEDIED.

By CANNA Research

Nutrient uptake and transport

Nutrients are usually taken up via the root system. This process involves a number of steps. The first requirement is that the nutrients themselves are able to move through the soil or substrate in the rhizosphere so that they can find their way to the roots. Then the nutrients need to pass several 'root barriers' – namely the cell wall, and then the cell membrane. Once inside the plant, the nutrients must then be transported through the plant's vascular tissue (called the xylem), followed by cell to cell transport.

The movement of nutrients through the soil depends on the characteristics of the soil – its pH, structure, moisture content and microbial activity. Some micro-organisms affect the rhizosphere (especially mycorrhizal fungi, which interact directly with the plant's roots), but in fact most soil-borne micro-organisms hardly affect the rhizosphere. Micro-organisms can have a beneficial effect on the availability of nutrients, but equally some may be harmful (e.g. if they compete for soil nutrients or cause root diseases). The dissolved nutrients are transported with the convective flow of water from the soil to the plant roots. This flow depends on the water consumption of the plant and the average nutrient concentration in the water. As we will see later in this article, the rate at which the plant takes up water and the nutrient content of the substrate can both be controlled easily by the grower.

A small percentage of nutrients (less than 1%) are taken up by a process known as interception which occurs at the root tips. Interception is based on direct ion exchange, where positively or negatively charged elements are exchanged (e.g. a proton (H+) from the root for a potassium ion (K+) from the substrate or nutrient solution).

After this initial stage, how are the nutrients 'in the flow' then transported onwards by the plant *(see 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 pass easily through the lipid layer of the membrane by diffusion.

All other essential mineral nutrients are absorbed as ions (with the exception of boron). This means that all nutrients (except boron) need membrane transporters. These are transport proteins embedded in the cell membrane which control the intracellular environment (the spaces in the plant cell).

Two main mechanisms of cross-membrane movement can be identified; passive and active. Passive movement is the

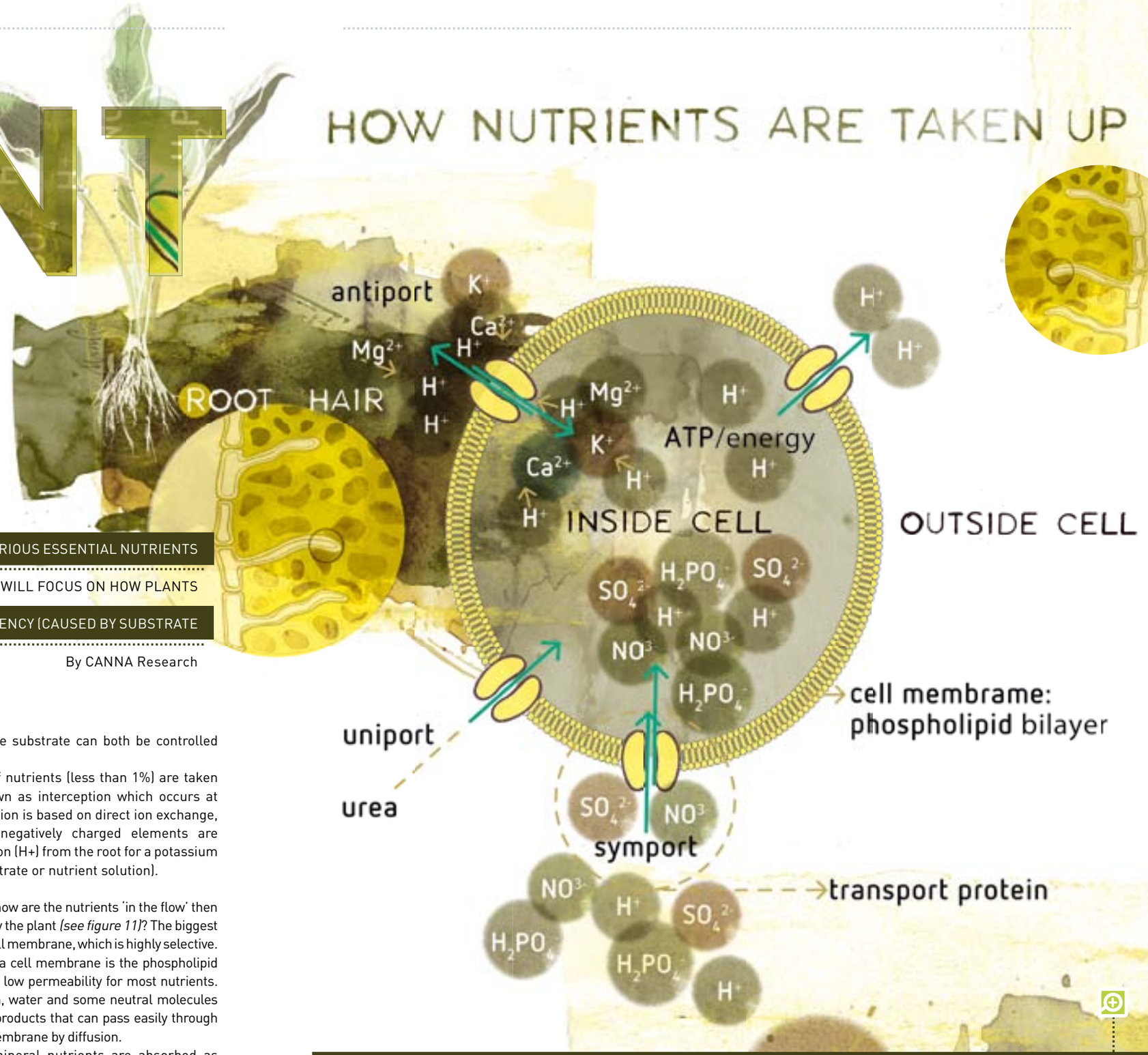


Figure 11: Schematic overview of a root (hair) cell membrane. The portals incorporated into the cell membrane are transport proteins. These transport proteins function because all essential mineral nutrients are absorbed as positively or negatively charged ions (boron being the only exception here). A 'symport' transports the desired nutrients and protons in the same direction. These are usually negatively charged ions such as nitrates (NO_3^-), phosphates ($H_2PO_4^-$) and sulphates (SO_4^{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.

PLANT PART 2

NUTRITION AND NUTRIENT DEFICIENCY

easier method, via carrier proteins and transport through ion channels. The active mechanism is via 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. This is selective for single nutrient molecules, requires no input of energy and has a non-linear dependence on concentration. Molecules will simply tend to diffuse until their concentration is the equal everywhere.

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

Long-distance transport

There are several pathways for nutrient transport within the plant. The most common route is nutrient uptake by the root, followed by 'long-distance transport' via the xylem vessels to the leaves and flowers (or any other plant organs). Two driving forces play a key role in this long-distance transport; the water potential gradient and the root pressure. Root pressure occurs when osmosis drives water from the soil into the roots. This is effectively because plants accumulate the nutrients taken up in the xylem tissue.

Factors that influence nutrient uptake

There are also intrinsic and environmental factors that affect the uptake of nutrients. Charge and ion diameter are intrinsic factors. Environmental factors include light, temperature, water, O_2, 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).

Nutrient uptake is affected by pH, but not every nutrient is affected equally. In most cases there is an optimum level, and a pH that is too high or too low will reduce nutrient uptake. The pH of the root zone pH will influence the charge of the root surface which is slightly negative. Most nutrients are plant available in the pH range of 5.5-6.5. Light is a source of energy that drives the transport of nutrients, so there will be diurnal fluctuations in nutrient uptake. Like pH, temperature also has an optimum level, and temperatures that are too high or too low will reduce nutrient uptake. Temperature is a driving force for evaporation in plants, because the stomata open when the temperature rises; the root zone temperature depends on nutrient uptake. Water is important because, except for interception, nutrients transfer 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 the optimal growth of the plants. Do not over water; excess watering will result in poorly aerated substrates which in turn lead to low oxygen levels. As the plant roots require oxygen for growth, low oxygen levels may limit plant growth in poorly aerated substrates (Hopkins, 1950). The higher the nutrient concentration, the higher the rate of nutrient uptake, although the rate of increase will slow at very high concentrations. Interaction between ions can be antagonistic (competition) or synergistic. In the case of antagonism, one ion inhibits the absorption of another ion, while in the case of synergy, one ion enhances the absorption of another ion. Competition can be between cation and cation, anion and anion, or between opposite charges. A single salt that causes plant poisoning is known as toxicity of a single salt (KCl, CaCl). Ion antagonism is the term used to describe interaction between ions that can limit the toxicity of a single salt ($NaCl+KCl+CaCl_2$ or $NaCl+CaCl_2$). Synergy is when anions promote cation uptake and divalent cations promote mono-charged cations (Ca^{2+} promotes the uptake of K^- and Cl^-).

Fertilising crops

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

The quality of the crop, or the fertilisation success of a crop, depends on a phenomenon which is best explained using the following metaphor: the barrel theory (or the 'law of minimum') encapsulates how crop yield is limited by the nutrient that is the most deficient, whichever nutrient that is. This concept was originally applied to plant or crop growth: it was found that simply increasing the amount of plentiful nutrients did not increase plant growth. It was only by increasing the amount of the limiting nutrient (the one that is the most scarce compared to 'need') that the growth of a plant or crop could be improved *(see figure 12).*

The absorption of mineral nutrients can also take place through the leaves. Foliar fertilisation refers to the method by which fertiliser is applied to plant shoots, usually to leaves. The advantage of foliar nutrition is that the supply and uptake of nutrients is fast and effective, because it cuts out the usual lag period between root uptake and vessel transportation towards the plant organs. Furthermore, the nutrients applied have a higher rate of utilisation. Leaf fertilisers are usually a supplementary way to compensate for macronutrient deficiency such as nitrogen and magnesium, but they are also effective against micronutrient deficiencies such as iron.

However, it is not possible to apply high concentrations of

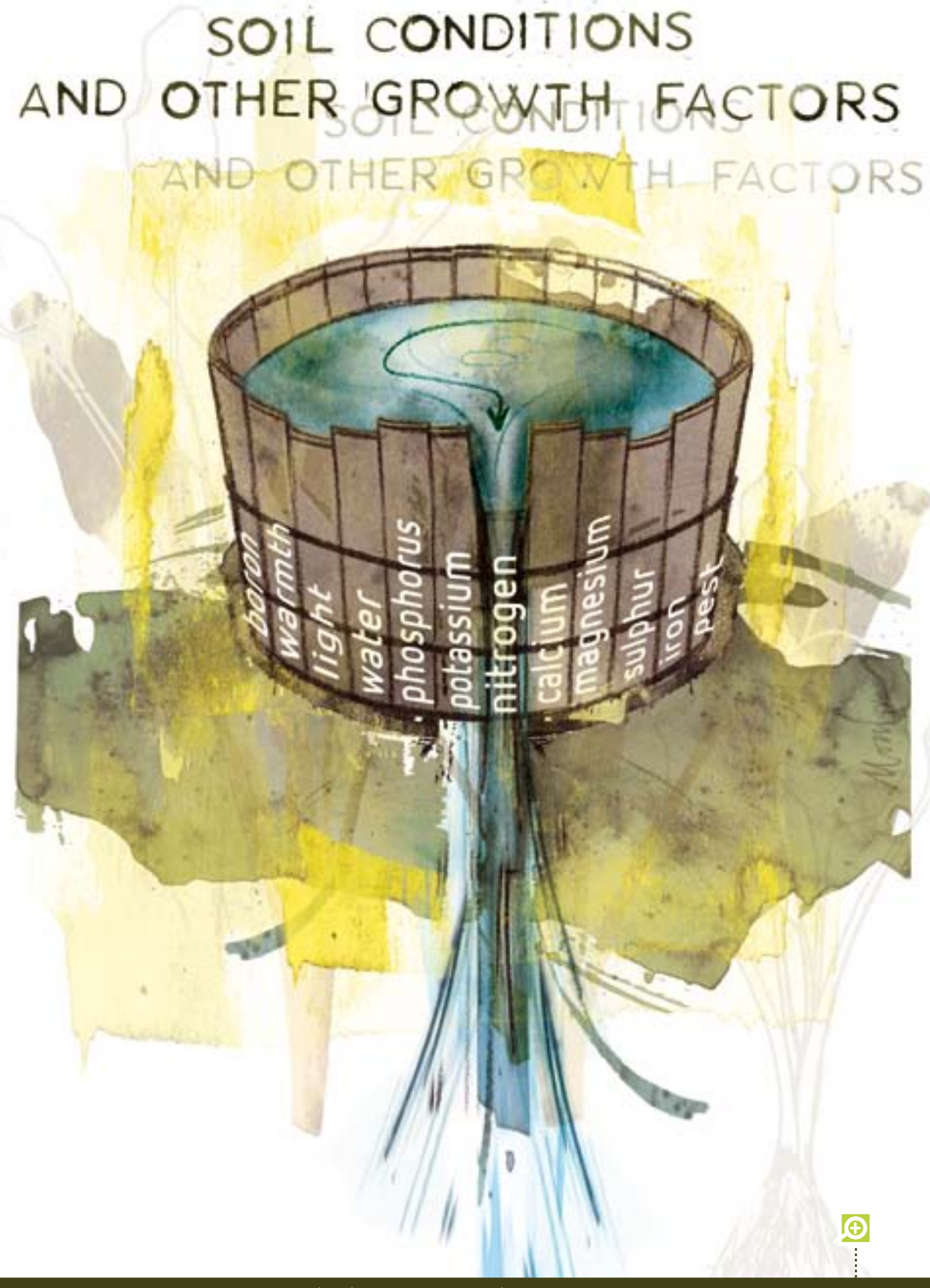


Figure 12: **An overview of the barrel concept (the 'law of the minimum'). This theory relates to crop yield, and states that the yield is limited by the nutrient which is the most deficient; this could be any one of the nutrients shown. According to this image, the growth of a plant or crop can only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

PLANT PART 2

NUTRITION AND NUTRIENT DEFICIENCY

nutrients in this way. 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.
Nutrient spraying is recommended only in the evening or on cloudy days, otherwise burn marks may occur.

Deficiency symptoms caused by substrate imbalance

So now we have seen the forces that drive the uptake of nutrients. And although plants can be very selective, they can never get up and walk away in search of food. Despite all the tricks that plants have developed during evolution, they certainly still need a lot of help from us growers.
For a grower it may sound very easy to identify the symptoms of individual nutrient deficiencies. We keep a close watch on our plants and try to look out for the tell-tale signs. Do we see necrotic spots? Is there any yellowing of the leaves? Where are these symptoms visible? In the older plant parts, or just in the younger ones? These are all important questions when trying to pinpoint which elements could be missing and shorten the list of suspects.
Unfortunately, deficiency symptoms can often also be caused by external factors, independent of the amount of fertiliser we are giving our plants. A very common issue here may be **overwatering** *(figure 13)*. If the substrate is too wet, there is less room for air. The plant roots need oxygen, however, which they take from these air spaces. In the case of oxygen stress, the roots will die – a process that occurs faster than you may think. The root tips die off and the uptake of nitrogen and potassium is reduced. If the substrate remains overwatered for longer periods, plant growth will decrease and symptoms much like nitrogen deficiency arise.
To prevent overwatering, check your substrate regularly. In case of a wet substrate, check the drainage and reduce the amount of water you are giving at each watering. If you find that overwatering has already occurred, skip one or a few waterings. Allow the substrate to dry a little. This will stimulate the plant to form new roots to replace the ones that have died.

As we have seen earlier in this article, the plant itself influences the soil pH. Aiming a neutral ion charge inside and outside the plant, nutrients such as ammonium (NH4+) are taken up in exchange for a proton (H+). This may lead to the **acidification** of the substrate. Nutrients like phosphorus, potassium, sulphur, calcium, magnesium and molybdenum (even though these may be abundant in the rhizosphere) will become less available for the plant.

You can reduce the risk of acidification considerably by choosing the right substrate. Do not use inappropriate peat mixes and check the soil pH before use; at pH values lower than 5.5, the risk of acidification increases considerably. Also, keep in mind that peat-based substrates that you want to re-use may have already depleted the chalk buffer during the previous cultivation cycle. The chalk buffer can be renewed by mixing some additional dolomitic prior to planting, thereby reducing the chance of deficiency symptoms caused by low pH values.
In poorly buffered substrates or inert substrates like rock wool, we always advise setting the pH value of your nutrient solution to values in the range of 5.2-6.2 on rock wool or 5.8-6.2 for peat mix. Rock wool – like any other inert substrate – has no nutrient or pH buffer. If the nutrient solution is not applied within the right pH range, **nutrient deficiencies caused by a high pH** may occur. Deficiency symptoms that can be seen will include deficiencies of trace elements such as iron, copper, zinc and manganese.
In the case of high soil pH values, you can 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 availability of most trace elements to the plant •

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). 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 18 and 24°C.
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-uk.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! Fertilise 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 SET OF CANNA MONONUTRIENTS

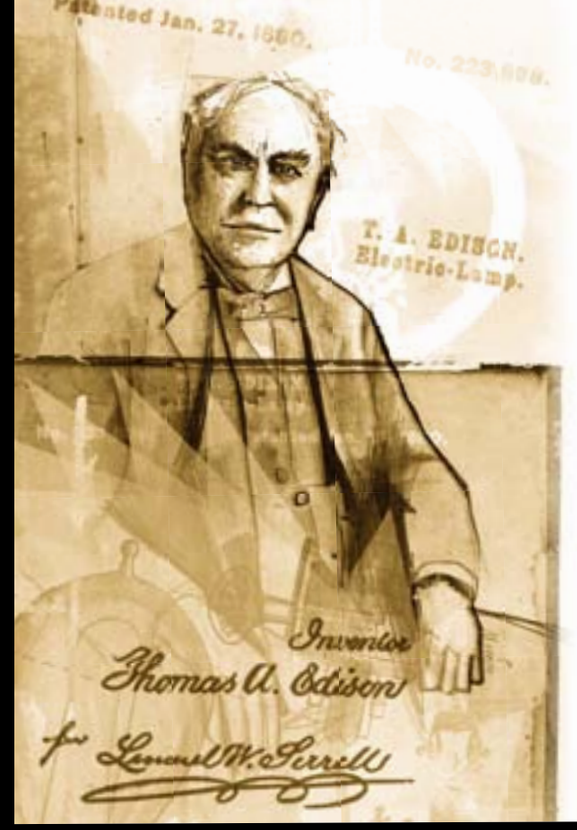
1	9			6		8		
	3						7	
6	2	7		1	5			
		9				2	3	4
				9				
4	1	2				5		
			6	3		4	8	7
	7						2	
		6		2			1	9

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 is enough to check) and maybe... **YOU will be the lucky one who wins a set of CANNA Mononutrients!**

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!



LIGHT

We enjoyed producing this magazine, and we hope you have enjoyed reading it! Maybe you want to thank us for this magazine, or you just have a question. Maybe you want to make a suggestion or comment on one of our articles. Whatever it is, we would like to hear from you. We love to read your comments and find out what issues our readers are facing. So don't hesitate to get in touch!

CANNAtalk is your magazine, YOUR VOTE COUNTS!

Write your answers to the puzzle, your comments, questions or suggestions on the answering card (we'll refund the postage). You can also visit our website or send us an e-mail at info@CANNAtalk.com.

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- ☐ List of shops in my area
- ☐ Send me a CANNA Calendar 2014. I've secretly enclosed 10 pounds in this envelope to pay for it.

Solution to the puzzle:

#24

CANNAtalk

SERIOUS GROWERS

CANNAtalk:

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