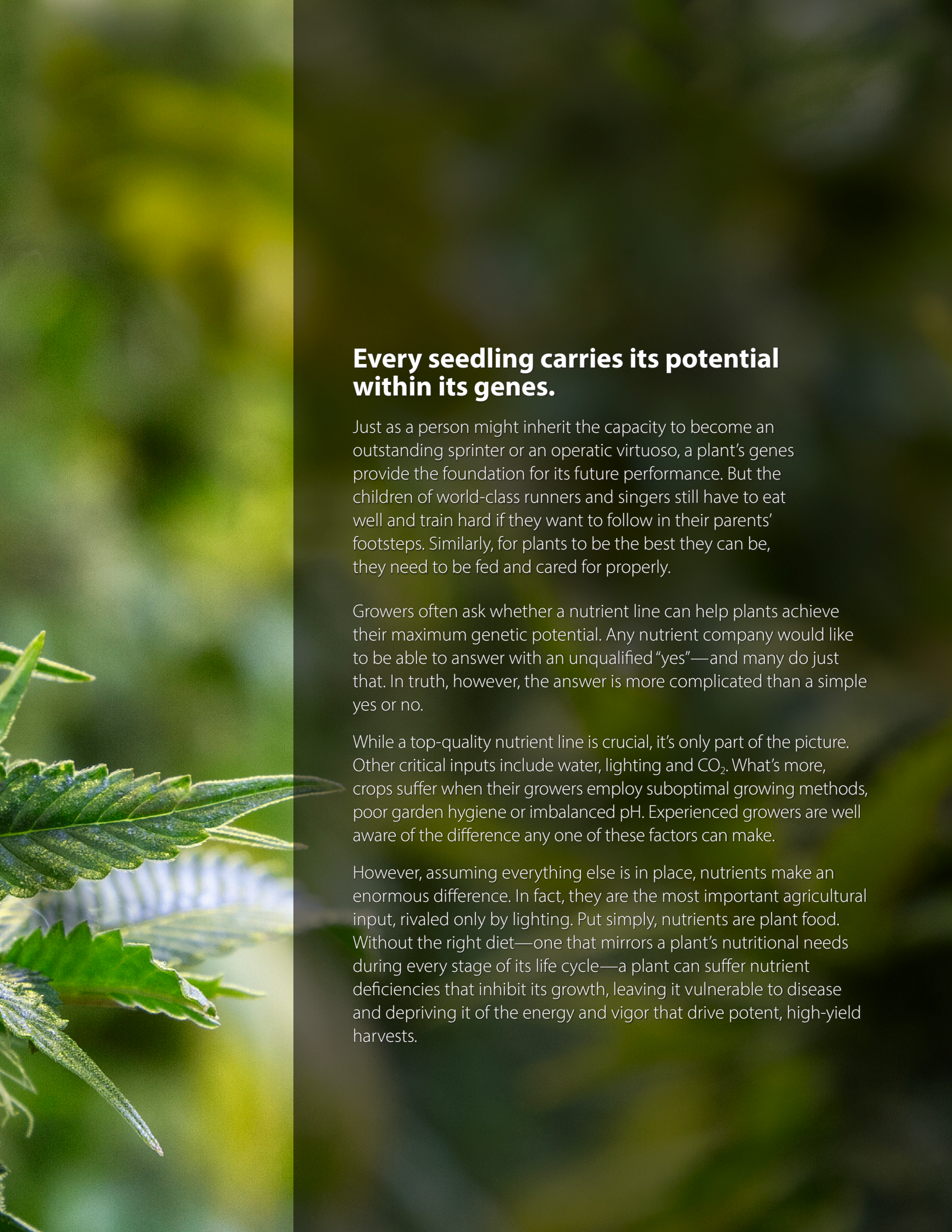
SUPERIOR NUTRIENTS, SUPERIOR PLANTS:

How the Right Nutrients Help Plants Reach Their Genetic Potential

EMERALD HARVEST®



Every seedling carries its potential within its genes.

Just as a person might inherit the capacity to become an outstanding sprinter or an operatic virtuoso, a plant's genes provide the foundation for its future performance. But the children of world-class runners and singers still have to eat well and train hard if they want to follow in their parents' footsteps. Similarly, for plants to be the best they can be, they need to be fed and cared for properly.

Growers often ask whether a nutrient line can help plants achieve their maximum genetic potential. Any nutrient company would like to be able to answer with an unqualified "yes"—and many do just that. In truth, however, the answer is more complicated than a simple yes or no.

While a top-quality nutrient line is crucial, it's only part of the picture. Other critical inputs include water, lighting and CO_2. What's more, crops suffer when their growers employ suboptimal growing methods, poor garden hygiene or imbalanced pH. Experienced growers are well aware of the difference any one of these factors can make.

However, assuming everything else is in place, nutrients make an enormous difference. In fact, they are the most important agricultural input, rivaled only by lighting. Put simply, nutrients are plant food. Without the right diet—one that mirrors a plant's nutritional needs during every stage of its life cycle—a plant can suffer nutrient deficiencies that inhibit its growth, leaving it vulnerable to disease and depriving it of the energy and vigor that drive potent, high-yield harvests.

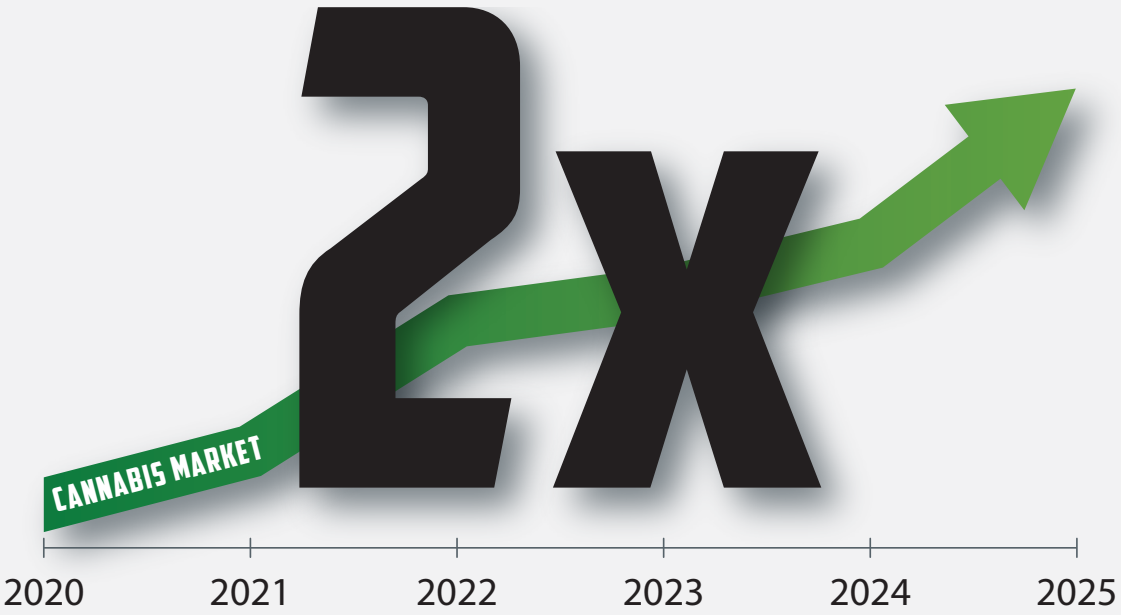
In this white paper, we first touch on the current market context: why maximizing plant genetic potential is more important than ever. We then survey the inputs and environmental factors that contribute to bigger yields, as well as the growing methods that set crops up for success, before diving into the role nutrients play in maximizing crop productivity and potency. We examine what nutrients are and how their concentrations and ratios should mirror plants' nutritional needs at every stage of their growth, and we look at the beneficial extras that fill in the gaps in a superior nutrient line to take plants to the next level. Finally, we offer pointers on how to select a first-rate nutrient line—one that helps maximize the genetic potential of high-value crops.

GET AN EDGE ON THE COMPETITION

Potency and yields have always been important, but never as important as today. With widespread cannabis legalization, consumer choice is greater than ever, and growers face heightened competition and pressure to stand out.

Cannabis is still a winning business despite the crowded market. In Canada, where post-legalization sales figures failed to meet

The global cannabis market will double over the next 5 years



stakeholders' expectations, 2020 revenues are nonetheless expected to balloon to CAD 3.16 billion, nearly double those of 2019.[1] Federal restrictions stifled profits in 2019, but the legalization of new products—including edibles, extracts and topicals—has paved the way for new growth. In the US, New Frontier Data forecasts that as more states legalize cannabis, legal sales will reach a compound annual growth rate of 14% and a whopping USD 30 billion by 2025.[2] Grand View Research, meanwhile, projects that the global cannabis market will hit USD 66.3 billion within the next five years.[3]

As the competition heats up, growers need to differentiate. Among other strategies to grow their businesses, they can develop new cannabis-related products or boost their revenues with brand partnerships. But to demand a higher price per dry weight, growers need to maximize crop quality: Harvests need to have standout color, fragrance, taste and, above all, potency. Market research indicates that quality is the number-one factor influencing the purchasing decisions of cannabis consumers, whether they be regular or social users and regardless of their product of choice.[4]

NUTRIENTS IN CONTEXT

Plant and human nutrition have a lot in common. Just as the essential elements found in the food we eat are the building blocks of human health, so too do nutrients enable plants to grow, flower, fruit and thrive. If you or someone you know has ever suffered from the "winter blues" because of a Vitamin D deficiency, brain fog due to low levels of B_{12} or chronic exhaustion as a result of anemia (blood-iron deficiency), you know how challenging it can be to maximize your potential without the right nutrients.

But optimal health requires more than just optimal nutrition. For example, a diet of fresh, organic food can only do a person so much good without exercise. Sometimes people's genes are at fault for their ailments; most of us are predisposed to one kind of health

1 David George-Cosh, "Pot Sales in Canada to Hit $3.16B in 2020 Despite Slower Growth: Canaccord," BNN Bloomberg, October 31, 2019, https://www.bnnbloomberg.ca/sales-in-canada-s-pot-sector-forecast-to-hit-3-16b-in-2020-amid-slower-growth-canaccord-1.1340822.

2 Iris Dorbian, "New Cannabis Report Predicts Legal Sales To Reach Nearly $30 Billion By 2025," Forbes, September 24, 2019, https://www.forbes.com/sites/irisdorbian/2019/09/24/new-cannabis-report-predicts-legal-sales-to-reach-nearly-30-billion-by-2025/#377bea7f1121.

3 "Legal Marijuana Market Worth $66.3 Billion By 2025 | CAGR: 23.9%" Grand View Research, accessed March 6, 2020, https://www.grandviewresearch.com/press-release/global-legal-marijuana-market.

4 "As 2.0 opportunities emerge, can you still compete with 1.0 strategies?: Canadian cannabis consumer insights for legalization 2.0" (Ernst & Young, 2019) 7.

condition or another. In addition, chronic stress, exposure to toxins like lead or mold and insufficient rest can put people at greater risk of disease or otherwise compromise their growth and health.

Similarly, growers must satisfy three sets of requirements to cultivate healthy, high-quality, high-yield crops:

- **The right cultivar.** Variations in cannabinoid levels are more often due to genetic factors than cultivation methods.[5] Growers need to choose cultivars, or strains, that meet the desired CBD–THC ratios of their target consumers—whether they be recreational or medical users—and tailor their inputs and growing methods to the specific needs of that cultivar.
- **The right inputs.** How much light your plant is exposed to, and when, is crucial. So is selecting the right growing medium.[6] Supplemental CO_2 is a must. Clean water, ideally treated with a reverse-osmosis system, should go without saying. And, of course, plants need the right nutrients applied in the right concentrations and ratios at the right times during their life cycles.
- **The right growing methods.** Crops are strongly affected by their environments, and cultivation techniques make a big difference to the final product:
    - Success begins at the germination stage. If your seedling isn't healthy with strong roots, or your clone came from a nutrient-depleted mother plant, it doesn't stand much of a chance in the long run. Later on, careful trimming and flipping (i.e., transitioning from the vegetative to the flowering phase by abruptly decreasing the daily hours of lighting) can help the plant put its nutrients to good use when done in sync with the individual needs of the cultivar.
    - Grow-room hygiene is vital to keeping plants free of pathogens. Not only should the growing medium be clean but also the air and the rest of the growing environment. Air conditioning and ventilation should be properly cleaned and deodorized on a regular basis. Above all, nothing harmful should be introduced to the plant from the outside.

5 Wouter Vanhove, Patrick Van Damme and Natalie Meert, "Factors Determining Yield and Quality of Illicit Indoor Cannabis (Cannabis Spp.) Production," Forensic Science International 212 (2011): 158–63, accessed March 6, 2020, https://www.ncbi.nlm.nih.gov/pubmed/21737218.

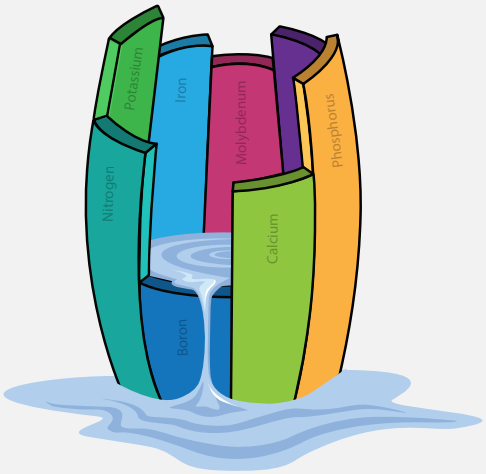
6 Or substrate.

There's no one-size-fits-all approach to growing exceptional plants, and every grower has a preferred methodology. But if growers select the best cultivar and provide the right light, CO_2, clean air and clean water, then nutrients can help plants achieve their greatest possible potential.

SUPERIOR PRODUCT STARTS WITH SUPERIOR NUTRIENTS

Apart from hydrogen (H), carbon (C) and oxygen (O), which plants obtain from air and water, fertilizer regulatory authorities recognize 14 essential mineral elements—those necessary for the life and growth of crops—as "plant food." Other beneficial elements and compounds, as well as the beneficial microbes that inhabit the root zone, are not necessarily required for survival but are desirable for plants. Together, essential and beneficial elements are the most important agricultural inputs. All of these are what growers call "nutrients."[7]

Law of the Minimum



Justus von Liebig's law of the minimum (often called Liebig's law) is a principle developed in agricultural science that states that growth is dictated not by total resources available, but by the scarcest resource. Just as the capacity of a barrel with staves of unequal length is limited by the shortest stave, so a plant's growth is limited by the nutrient in shortest supply.

COVER YOUR BASES

When it comes to nutrients, more isn't necessarily better. Liebig's law of the minimum states that the amount and quality of plant growth

7 In a scientific sense, nutrients are the 17 essential elements: three supplied by air and water and the other 14 supplied in fertilizers. However, growers often speak about nutrients more broadly to include everything they feed to plants. Nutrients may also refer to fertilizer products, including both base nutrients and supplements, generally; hence, "nutrient" companies, producers, etc.

is determined not by the total essential elements available, but by the scarcest essential element. For a plant to thrive, every essential element must be in sufficient supply. If just one essential element is undersupplied, the plant will not reach its potential; indeed, it might not survive. However, plant development can also be hindered by excess nutrients, so careful measurement of nutrient concentrations and ratios, and precise timing of feeding, are important for maximizing quality and yields.

Every essential element plays a role in plant life, so it's important to select a base nutrient that supplies each in the right concentration and all in the right ratios for each phase and stage of the crop life cycle.

MACRONUTRIENTS

Maybe you've tried to lose weight or build muscle by counting your "macros": the amount of protein, fat and carbohydrates in your diet. As the name implies, macronutrients are what an organism needs in large amounts. For plants, macros are chemical elements; all of them can be found on the periodic table. Three are primary macronutrients, three are secondary, but all are essential:

- **Primary:**
  - **Nitrogen (N)** is the core driver of plant growth. It assists in cell division and is a major component of chlorophyll, so it plays an important role in photosynthesis. Proper nitrogen supplementation leads to lush growth and rich green color.
  - **Phosphorus (P)** transfers energy and nutrients within plants. Extra phosphorus boosts plants' ability to produce more buds, faster. Phosphorus also accelerates growth and shortens the flowering phase, so growers enjoy more harvests each year for more annual profit. Increased phosphorus is also linked to higher levels of THC and CBD.[8]
  - **Potassium (K)** plays a key role in protein synthesis and enzyme formation, and it regulates CO_2 intake, making it possible for plants to flower and fruit. It also boosts photosynthesis, making stalks sturdier and plants more resilient.

8 C. B. Coffman and W. A. Gentner, "Responses of Greenhouse-Grown Cannabis Sativa L. to Nitrogen, Phosphorus, and Potassium," Agronomy Journal 69, no. 5 (1977): 832–36.

- **Secondary:**
  - **Calcium (Ca)** supports growth and plant strength. It encourages cell division and fortifies cell walls, making them resistant to dryness, damage and stress.
  - **Magnesium (Mg)** is the central atom of chlorophyll. Without sufficient magnesium, leaves degrade. Yellow leaves with green veins could be a result of magnesium deficiency.
  - **Sulfur (S)** is also necessary for chlorophyll production. It helps plants develop enzymes and vitamins. If a plant is deficient in sulfur, its growth will be stunted.

MICRONUTRIENTS

Also known as trace elements, micronutrients are fed to plants in smaller concentrations than macronutrients and make up a smaller proportion of plant tissue.[9] Seemingly infinitesimal amounts of micronutrients can make all the difference to crop growth. Each of the eight micronutrients plays a distinct role in plant development:

- **Boron (B)** helps mobilize sugars and relocate them to wherever the plant needs it most. Boron deficiency is common.
- **Chlorine (Cl)** has a reputation for toxicity, but it is absolutely necessary in small amounts for plant growth.[10] In conjunction with potassium, it assists in the operation of stomata.
- **Copper (Cu)** is essential for enzyme activity and photosynthesis. You'll see deficiencies in new leaves first.
- **Iron (Fe)** is widely available in most soils, and yet it is one of the most difficult elements for plant roots to absorb. Iron is used to make chlorophyll and is critical for proper functioning of chloroplasts, the cells where photosynthesis takes place.
- **Manganese (Mn)** activates 35 different enzymes and, like many other essential elements, plays a role in chlorophyll production.
- **Molybdenum (Mo)** is the sister element of nitrogen, and deficiencies of the two elements look similar. It's a key component of two enzymes essential to the nitrogen cycle.

9 Sabeeha S. Merchant, "The Elements of Plant Micronutrients," Plant Physiology 154, no. 2 (2010): 512–15, accessed March 6, 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2948994/.

10 Technically, chloride, the ionic form of chlorine, is essential to plants, while non-ionic chlorine is toxic to plants.

- **Zinc (Zn)** is a component of multiple enzymes and is used to synthesize chlorophyll, carbohydrates and auxins, powerful phytohormones that promote plant-cell elongation.
- **Nickel (Ni)** is a component of plant enzymes. Note that nickel never appears on fertilizer labels. That's because it's required in such tiny amounts that water or soil usually provide adequate levels and eliminate the need for nickel supplementation.

Discoloration, "burning," stunted growth or necrosis (tissue death) all indicate nutrient deficiencies. Unfortunately, many nutrient deficiencies look alike, making it a challenge to remedy a problem when it arises. Growers should select their nutrient line carefully to avert these issues and to avoid the pitfalls of overnutrition, which include heavy-metal accumulation and threats to water quality.[11]

FILL IN THE GAPS

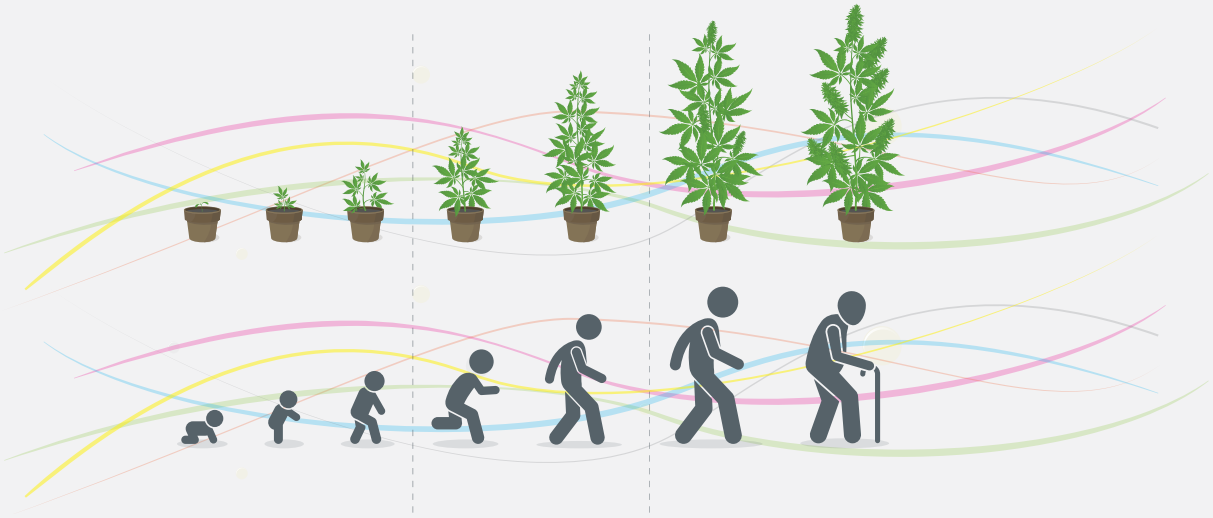
Once the bases are covered with the essential elements, growers can rest assured that their plants will survive. But surviving isn't the same as thriving. Plants' nutritional needs change throughout their life cycles, requiring adjustments to macronutrient and micronutrient concentrations and ratios at different phases of the growing process. Here too, human health offers a fitting analogy. The National Institute of Health (NIH) recommends that children between the ages of nine and 18 consume 1,200 mg of calcium per day to support developing bones.[12] During adulthood, the NIH's recommended intake drops to just 1,000 mg daily. But as humans age (e.g., in the years after menopause, when women's estrogen levels plummet and bone loss is likely to commence), calcium consumption needs rise again.

The crop life cycle has three phases: germination and transplanting, vegetative (growth) and flowering. During the germination phase, plants metabolize nutrients stored in their seeds. As soon as their roots and leaves develop, they are able to absorb nutrients and photosynthesize. Crops that begin as clones rely on water and carbohydrates stored in their stems and leaves to provide the energy needed to develop new roots; therefore, the nutritional health of the mother plant is of the utmost importance. Additionally, rooting

11 Sunil Kulkarni and Ajaygiri Goswami, "Effect of Excess Fertilizers and Nutrients: A Review on Impact on Plants and Human Population," Proceedings of International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM) (Jaipur: Amity University Rajasthan, 2019), accessed March 6, 2020, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3358171##.

12 A. Catharine Ross et al., "The 2011 Report on Dietary Reference Intakes for Calcium and Vitamin D from the Institute of Medicine: What Clinicians Need to Know," The Journal of Clinical Endocrinology & Metabolism, 2011, accessed March 6, 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3046611/.

Both plants and humans need nutrients thoughout their life cycles



hormones such as auxins (available either in liquid, powder or gel form) can support seedling and clone vitality.

At the start of a plant's life, high levels of nitrogen can be detrimental. During the vegetative phase, however, plants need a higher percentage of nitrogen compared to phosphorus and potassium: a high N to P/K ratio. Later, as plants commence flowering, the reverse is true: Plants need a relatively high concentration of phosphorus and potassium compared to nitrogen, although it is important to note that they need all three primary macros throughout their lives. During the flowering phase, plants also require more micronutrients than they needed during early growth. This is due to the complicated process of reproduction. Just as pregnant women are often advised to take folic acid and iron supplements, plants that are starting to bear fruit need more of certain essential elements.

To facilitate the changing nutritional needs of plants, nutrient manufacturers provide feeding charts. A good chart should simplify the feeding process and ensure not only that nutrient minimums are met, but also that maximums aren't exceeded. Product application rates and feeding charts need to be calibrated so that crops are not overfed, which can cause nutrient lockout or "burn"—or both.[13]

13 For example, crops grown in coco coir sometimes suffer both from "burn" due to oversupply of potassium and, more commonly, from calcium and magnesium deficiencies, which is why "cal-mag" supplements are often necessary. Coconut trees, grown near the sea, are rich in potassium, while their husks bond readily with calcium and magnesium. When used as a growing medium, coco coir releases high amounts of potassium; as a consequence, the excess potassium might block—or "lock out"—the uptake of calcium and magnesium, upsetting the delicate balance of the feeding program.

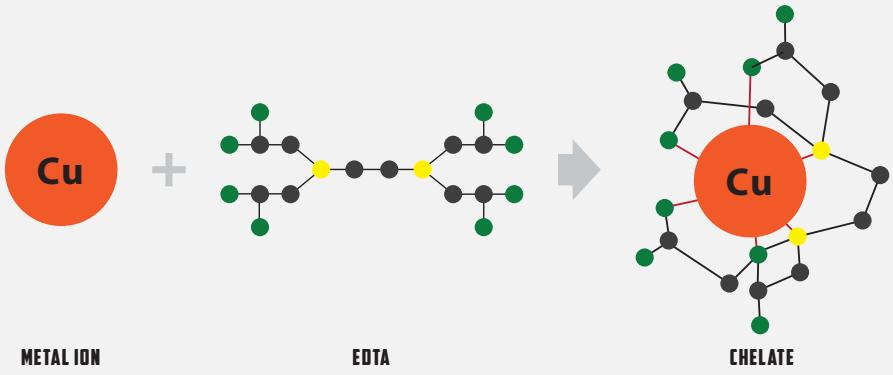
All that said, to maximize their plants' genetic potential, growers need to take their crops beyond the essentials. Just as athletes supplement a normal human diet with additional proteins, carbs, vitamins and minerals, so too should growers supplement the essential elements with unessential but beneficial minerals and compounds.

CHELATORS

In human nutrition, the body's ability to absorb calcium from food depends on its source. Two commonly eaten leafy greens, kale and spinach, illustrate this phenomenon: The calcium in kale is more "bioavailable" (i.e., easier for the body to absorb and use) than the calcium in spinach. Similarly, plants occasionally fail to absorb phosphorus or trace elements, even when they are abundant in the soil. To combat this, growers can employ chelators (pronounced KEY-lators), a term that derives from the Latin and Greek words for claw. Chelators "grab" metals and bond with them, making it easier for roots to take up the copper, iron, manganese and zinc plants needs to survive.

Chelators also facilitate the uptake of essential elements across a wider pH range, so plants can more readily absorb beneficial nutrients. Nutrient mixes lacking chelators can compromise plant health. However, it should be noted that chelators are not merely safeguards against deficiencies; they help optimize nutrient uptake, minimizing the amount of unutilized essential elements in the nutrient solution, thereby increasing yields and crop quality.

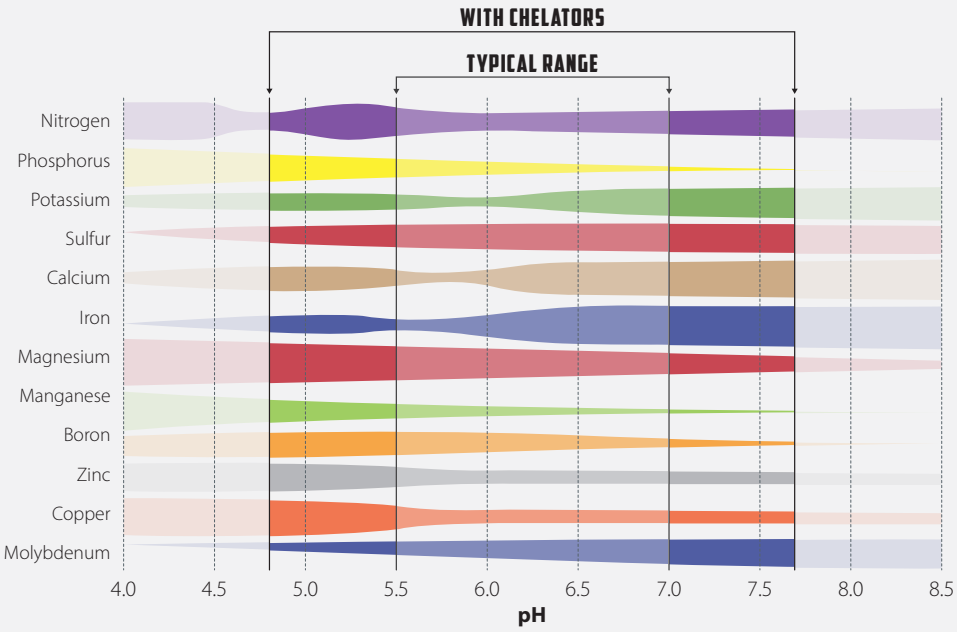
Chelation of metals



A metal ion is grabbed by a chelator molecule to form a chelated ion.

There are two kinds of chelators. Synthetic chelators include ethylenediaminetetraacetic acid (EDTA), which has a variety of industrial and agricultural applications and is sometimes prescribed as a treatment for heart disease in humans. Natural chelators include

Influence of pH on availability of plant nutrients



the beneficial fungi found in soil; humic acid,[14] a key compound in humus, the dark, earthy byproduct of decomposition; and aminos and other organic acids. Growers who use a nutrient line that's rich in diverse forms of chelation can rest assured that their plants will receive the copper, iron, manganese and zinc they need and have the ability to absorb supplemental nutrients.

Natural chelators have additional benefits. For example, humic acid serves as a powerful soil conditioner, increasing not only the cation-exchange capacity of the growing medium but also attributes of its mechanical structure, such as porosity and texture.[15] Organic acids such as aminos also benefit the root zone.[16] There is even evidence that amino acids, found in protein, can be absorbed by plants.[17] A superb source of protein for cannabis crops is hemp seed flour, because it matches the genetic profile of the plants, not unlike the proteins found in natural soils.[18]

14 Including "golden" fulvic acid, the most effective form of humic acid in terms of nutrient uptake.

15 Soil compaction can impede root growth and water retention.

16 Eva Oburger et al., "Interactive Effects of Organic Acids in the Rhizosphere," Soil Biology and Biochemistry 41, no. 3 (2009): 449-57, accessed March 6, 2020, https://www.sciencedirect.com/science/article/abs/pii/S0038071708003714.

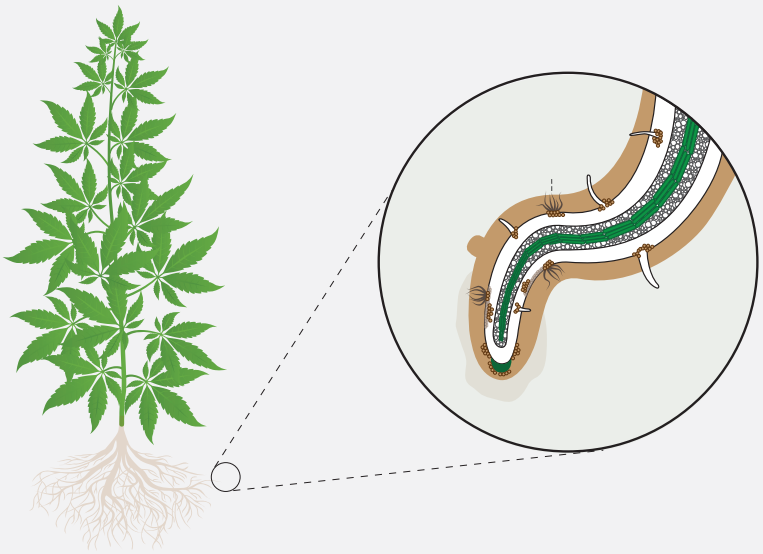
17 Sandra Jämtgård, "The Occurrence of Amino Acids in Agricultural Soil and their Uptake by Plants," PhD diss. (Swedish University of Agricultural Sciences, 2010).

18 Natural soil consists primarily of decomposed plant matter, and plants are naturally accustomed to growing in their "own" soil. Vegetable-based proteins are more suitable for plants than animal-based proteins, because vegetable-based proteins closely resemble the protein profiles of plants. In the case of hemp seed flour for cannabis cultivation, it's an exact match.

BENEFICIAL MICROBES

Perhaps you've heard about the human microbiome, a sprawling community of bacteria that dwell in the body and compose 1–3% of its mass. Recent research has shown that bacteria influence our physical and cognitive wellbeing, playing a role in everything from diabetes to depression.[19,20] Likewise, many of the bacterial species that colonize the rhizosphere—the zone immediately surrounding the plant roots—dramatically influence crop health. Such bacteria are known as plant-growth promoting rhizobacteria (PGPRs).

Rhizosphere



Microbially rich soils also strengthen plant roots and boost their ability to take up nutrients, leading to bigger and better yields.[21] PGPRs recycle waste in the growing medium and break down nutrients so they can be readily absorbed.[22] However, beneficial microbes are absent from hydroponic gardens unless growers

19 Sridevi Devaraj, Peera Hemarajata and James Versalovic, "The Human Gut Microbiome and Body Metabolism: Implications for Obesity and Diabetes," Clinical Chemistry 59, no. 4 (2013): 617–28, accessed March 6, 2020, http://clinchem.aaccjnls.org/content/59/4/617.short.

20 Carl Zimmer, "Germs in Your Gut Are Talking to Your Brain. Scientists Want to Know What They're Saying," The New York Times, 2019, February 8, 2019, https://www.nytimes.com/2019/01/28/health/microbiome-brain-behavior-dementia.html.

21 Pravin Vejan et al., "Role of Plant Growth Promoting Rhizobacteria in Agricultural Sustainability—a Review," Molecules 21, no. 5 (2016): 573.

22 Youry Pii et al., "Microbial Interactions in the Rhizosphere: Beneficial Influences of Plant Growth-Promoting Rhizobacteria on Nutrient Acquisition Process. A Review," Biology and Fertility of Soils 51, no. 4 (2015/05/01 2015): 403-15.

specifically add them to the water; the roots of hydroponic crops need to be inoculated with PGPRs.

Creating an environment conducive to beneficial microorganisms can be tricky. Growers should make every effort to ensure the roots are populated with several species of rhizobacteria. A diverse microbial ecosystem is better positioned to keep harmful microbes in check and to support health and stress resistance in plants.[23]

Moreover, microorganisms, like all living things, require food. Any organic matter will do, but simple sugars provide PGPRs and other beneficial microbes with instant, accessible energy. That's why molasses is sometimes mixed into nutrient solutions. It does provide simple sugars that plants can feed on, but finding the right quantity of molasses can be a challenge. If you feed too many carbs to the roots—more than the beneficial microbes can consume—you run the risk of attracting harmful microbes as well. That's why professional growers apply a carbohydrate supplement that is carefully calibrated to contain no more and no less sugar than the PGPRs need.

BIOCATALYSTS

Growers and consumers sometimes associate hormones with "bad" chemistry—and with good reason. Hormones are frequently used to bypass the laws of nature: to fatten up cattle on industrial farms, for example, or to bulk up athletes' muscle mass. However, biocatalytic compounds such as hormones and enzymes are essential to life because they trigger or stimulate metabolic processes in living cells, setting more complex series of biochemical events in motion. Biocatalysts regulate stages of growth in all living things; in humans, for example, the transition from early childhood to adolescence is biocatalyst-driven.

In contrast to phytohormones—which are natural plant-growth regulators, or PGRs[24]—synthetic PGRs are hormone-like artificial substances. Many synthetic PGRs, such as the various artificial auxins, are as harmless and beneficial as natural phytohormones. However, some PGRs should not be used on anything except ornamental crops.[25]

23 Gabriele Berg et al., "Plant Microbial Diversity Is Suggested as the Key to Future Biocontrol and Health Trends," FEMS Microbiology Ecology 93, no. 5 (2017), accessed March 6, 2020, https://academic.oup.com/femsec/article/93/5/fix050/3744313.

24 Not to be confused with PGPRs—plant growth-promoting rhizobacteria.

25 For example, daminozide, commonly known as Alar, is a pesticide. Although some countries' fertilizer regulatory authorities allow it to be sprayed on fruits with rinds or skins (e.g., apples) and washed off, it should never be used on crops such as cannabis, where it could get caught up in the essential oils. Paclobutrazol, which inhibits gibberellins to produce squat, bushy crops, is another synthetic PGR to be avoided. "Paclo" is used in some countries similarly to daminozide, but in the US it is forbidden to use on food crops of any kind due to cancer risk.

But even when growers apply compounds that contain beneficial phytohormones and enzymes, it's important that the right kinds are present in the right concentrations and ratios to produce desirable results. And it is risk-free to supply them to crops using natural ingredients, rather than in purified or synthetic forms. Two exemplary sources of biocatalysts are alfalfa and kelp:

- **Alfalfa**, Medicago sativa, is rich in auxins, cytokinins, triacontanol and more. It even contains a little, but not too much, extra nitrogen and phosphorus.
- **Kelp**, sometimes referred to as nature's fastest-growing "plant," is actually a complex marine alga. It contains auxins, cytokinins and up to 60 beneficial elements, including all of the micronutrients.

Biocatalysts in alfalfa and kelp perform a number of beneficial tasks:

- **Auxins**, whose name derives from the Greek word for "grow," trigger shoot growth and overall structural development. They also initiate fruiting and flowering, support ripening and promote the growth of adventitious roots.[26]
- **Cytokinins**, by contrast, make plants bushier. They also delay senescence,[27] giving ample time for ripening right up to harvest, and preserve the quality of fruits and flowers after harvest.[28]
- **Triacontanol**, a non-hormonal plant-growth factor found in plant cuticles[29] and beeswax, increases vegetative and floral growth, accelerates the rate of photosynthesis and encourages root development. It is highly prized by rose cultivators because it stimulates the formation of basal breaks in rose bushes.

ADDITIONAL MINERALS

Cobalt (Co), sodium (Na), silicon (Si) and selenium (Se), while not classified as essential, also assist plants. For this reason, they are included in many nutrient formulations. These beneficial elements may help defend crops against disease as well as physical or environmental stressors including heat, cold and UV exposure. However, if mixed in a fertilizer at excessive concentrations, they can

26 Adventitious roots grow from non-root tissue (e.g., in seedlings and cuttings).

27 Deterioration due to aging.

28 It's important to note that it is the auxin–cytokinin ratio (i.e., the balance between these two phytohormones) that determines overall plant development. Too many auxins, and the plant grows too high; too many cytokinins, and the plant grows bushy, which is desirable, but the apex bud might suffer.

29 A plant cuticle is a protective layer covering leaves, young shoots and other aerial plant organs.

be toxic to plants.[30] Once again, more is not necessarily better, which is why professional growers elect to work with reputable nutrient manufacturers.

CHOOSING A SUPERIOR NUTRIENT LINE

As we've seen, plant nutrition is no simple matter. What's more, the amount of good and bad information on the internet, from retailers and in scientific research papers can be overwhelming. Growers already put in enough work getting the other must-haves right—selecting the best cultivar for their customers, maintaining an environment conducive to growth and supplying optimal amounts of water, light and CO_2. They shouldn't have to worry about the ingredients and precise concentrations and ratios of nutrient formulations.

At the end of the day, nutrient producers should be responsible for optimizing their product lines. Many brands aim to capitalize on the complexity of the crop life cycle by offering a wealth of "necessary" (but actually superfluous) base nutrients and supplements marketed to well-intentioned growers. A trustworthy nutrient line keeps things simple, offering a limited range of appropriately priced products and a feeding chart that matches the changing nutritional needs of crops.

30 Simranjeet Kaur et al., "Beneficial Elements for Agricultural Crops and Their Functional Relevance in Defence against Stresses," Archives of Agronomy and Soil Science 62, no. 7 (2015): 905–20, accessed March 6, 2020, https://tandfonline.com/doi/abs/10.1080/03650340.2015.1101070?src=recsys&journalCode=gags20.

When selecting a nutrient line, here's what to look for:

- **Everything you need, nothing you don't.** Overnutrition can do more harm than good. A complete nutrient line should provide crops with the exact nutrient concentrations and ratios they need at each week of their lives. Expansive product lines with unnecessary and expensive bells and whistles spell trouble.
- **High-quality ingredients.** Take a look at what's in the bottles. Nutrients should be made with high-grade raw materials free of toxic levels of heavy metals. They should not contain food-crop prohibited plant-growth regulators. When in doubt, reach out to the manufacturer to discuss any questions you might have about an ingredient. Due diligence pays dividends in clean, healthy crops.
- **A simple, straightforward feeding program.** An optimized product line should offer base nutrients and supplements formulated to work on schedule and in tandem, so that everything stays in balance as crops develop. The entire nutrient program should work harmoniously and complementarily, right out of the bottles, and should come with easy-to-understand feeding charts.

Emerald Harvest checks all the boxes. We take pride in providing a streamlined set of premium base nutrients and supplements that follow a simple yet powerful feeding program. Professional growers worldwide turn to us for our quality ingredients, formulated in precise concentrations and ratios for optimal production, coupled with easy-to-use feeding charts. We aim to make it simple for growers to boost their yields, reach their plants' genetic potential and offer their customers superior harvests.

Contact Emerald Harvest directly for more information about how our base nutrients and supplements help maximize the genetic potential of crops. To set up an appointment with a representative, call 1.866.325.8235 or email info@emeraldharvest.co.

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