



## Equipment-Related Questions

### **Is CO<sub>2</sub> Enrichment Solutions™ safe to use?**

Absolutely. CO<sub>2</sub> itself is an inert gas therefore there is no fire or explosion risk. The aqueous CO<sub>2</sub> solution itself is drinkable. Consider that a gallon of Coca-Cola has about 30 grams of CO<sub>2</sub> sparged in, whereas the aqueous CO<sub>2</sub> solution made by CO<sub>2</sub> Enrichment Solutions™ has under 6 grams dissolved CO<sub>2</sub> in a gallon of water. While most of the CO<sub>2</sub> in Coke gasses off, the amount of CO<sub>2</sub> left in a Coke when you drink it and the amount of dissolved CO<sub>2</sub> in aqueous solution is safe to drink.

### **Where do I get the CO<sub>2</sub> from?**

CO<sub>2</sub> Enrichment Solutions™ is “ag”-nostic to the CO<sub>2</sub> source. Our technology can utilize CO<sub>2</sub> from several sources including liquid CO<sub>2</sub> micro-bulk tanks or CO<sub>2</sub> gas cylinders from an industrial gas supplier, boiler/CHP offgas, biogas digesters, ethanol plant offgas, and with more recent developments in Direct Air Capture (DAC) we are exploring utilizing this new source especially for growers in regions where CO<sub>2</sub> gas supply is limited.

One of the key features of our aqueous CO<sub>2</sub> infusion is that the CO<sub>2</sub> gas need only be 50 psi in gas form and at room temperature. There is no need for chillers, liquified CO<sub>2</sub> or any pressurized vessels.

### **How much CO<sub>2</sub> gas is used?**

CO<sub>2</sub> Enrichment Solutions™ uses 95% less CO<sub>2</sub> gas to achieve yield enhancement compared to facilities that employ atmospheric CO<sub>2</sub> enrichment up to 1200 ppm. Our technology consumes only ~1MT/ha/month of CO<sub>2</sub> compared to >30 MT/ha/month for atmospheric enrichment.

### **What type of misting system do I need?**

CO<sub>2</sub> Enrichment Solutions™ can be integrated into existing low pressure misting systems or can easily be installed where such systems are not currently in operation. Unfortunately, our technology cannot be integrated into high pressure misting systems.

**What type of water can I use and what is the water usage?**

You can use your standard municipal water source as CO2 Enrichment Solutions™ is designed to produce the aqueous CO<sub>2</sub> solution using nearly any type of water. We do ask for a water report to ensure the water does not include high levels of salts or other potential contaminants that may be harmful to plants. Maximum water usage is ~300,000 L/ha/month.

**Is special electrical required and what is the power usage?**

There is no special electrical required as CO2 Enrichment Solutions™ is designed to integrate into standard greenhouse electrical infrastructure. Any special electrical work that may be needed at some sites can be easily accommodated by the system or the greenhouse maintenance team. Typical pump requirements are either 120-240V. Power usage is ~300 kWh/ha/month to run a 10 HP misting pump, 1 HP infusion pump & CO<sub>2</sub> gas solenoid, and Smart Control System.

**Is there a specific water pressure and temperature required?**

Water inflow through a float valve can be standard municipal pressure and temperature. The pressure of the aqueous CO<sub>2</sub> solution going from the infusion tank to the misters is only about 60 psi (low pressure misting), which a 10 HP pump easily accommodates in a 1-hectare project.

**Does the unit take up a lot of space?**

Not at all. A 1-hectare project only requires a 500-gallon tank for infusion, combined with the infusers/misting pump/CO<sub>2</sub> tank/controller the total space required is only about 8' x 8' area.

**How long does it take to install?**

A Technology Adaption Project (smaller "trial") may only take a couple of days to install the misting & infusion system. A 1-hectare project may take a week depending on available labor. We usually deliver equipment between 30-90 days depending on the size of the project.

**Is any special training required?**

Some training is required for facility management in order to understand the automated controls and basic issues to look out for.

Training is done upon completion of the install. CO2 Enrichment Solutions™ is fully automated therefore very little human intervention is required. Our engineering team also has access to remote control & monitoring. Any functional issues will be alerted to our team and the appropriate action will be taken to ensure minimal down time.

**Can CO2 Enrichment Solutions™ be used outdoors?**

Theoretically yes. Practically and economically, likely no. We are focused on the protected ag market which includes high to low-tech greenhouses, hoop houses, shade/net houses, indoor. The protected ag market is over 700 billion square feet.

**How are issues fixed and at what cost?**

CO2 Enrichment Solutions™ comes with a 100% equipment warranty for a specific time frame depending on the nature of the project. If there are any issues related to the system, our team is available virtually almost 24/7.

**May I use regular spray nozzles?**

In order to maximize the impact of the aqueous CO<sub>2</sub> solution, a very small droplet size of mist is required. CO2 Enrichment Solutions™ includes the specific nozzle size and type required to create a mist with the optimal droplet size. The fine mist creates a microfilm on the leaf surface and it is that thin film of aqueous CO<sub>2</sub> solution that enables the maximum absorption of CO<sub>2</sub> into the plant and maximum growth effect.

**Who manufactures the CO2 Enrichment Solutions™ system?**

The CO<sub>2</sub> infuser is a proprietary device built in-house by CO2 GRO. The Smart Control System is manufactured by CO2 GRO's IoT integration contractor based in Colombia. The misting system is designed specifically for each greenhouse and components are sourced from a number of CO2 GRO partner suppliers. All these components combine to form the equipment of CO2 Enrichment Solutions™, and our core IP is based on the process and method of enriching plants by CO<sub>2</sub> foliar misting, i.e. creating the microfilm and subsequent absorption of CO<sub>2</sub> by the leaf.

## Environment-Related Questions

### **What environmental conditions are monitored?**

A key component of CO<sub>2</sub> Enrichment Solutions™ is our Smart Control System. The system monitors and logs environmental conditions such as light, temperature, humidity, VPD, soil EC & moisture, dissolved oxygen/dissolved CO<sub>2</sub> in the infusion tank, and leaf wetness & temperature. Based on the real-time conditions, the controller will apply the aqueous CO<sub>2</sub> mist to optimize enrichment and results.

### **Is there any effect on humidity?**

There is minimal effect on humidity at greenhouse scale. The aqueous CO<sub>2</sub> solution is applied by fine misting for only a few seconds 2-3 times an hour during the plant's light cycle and is targeted directly to the plant. CO<sub>2</sub> is absorbed within seconds and the water droplets evaporate within minutes leaving very little residual moisture on the leaves. We also control the misting based on real-time humidity conditions, so we will not mist if the humidity is too high.

### **Is there any effect on room temperature?**

Misting can have a cooling effect in the facility which can be beneficial in hot climates. Each facility may have varying levels of cooling impact that may or may not have a significant impact on cooling costs. We also control the misting based on real-time temperature conditions, so we will not mist if the temperature is too low or too high.

### **Is there any effect on air quality?**

While a very small amount of the CO<sub>2</sub> escapes from solution, the amount is insignificant and has virtually no effect on the composition or quality of the air in the grow room. The impact of CO<sub>2</sub> Enrichment Solutions™ is that CO<sub>2</sub> gassing is no longer required, which means people can work in the grow rooms at any time without worrying about high levels of CO<sub>2</sub> when traditionally gassed.

### **Does the aqueous CO<sub>2</sub> solution affect the soil and roots?**

The aqueous CO<sub>2</sub> solution is misted directly on the leaves and canopy above the soil. Targeted application means that practically no CO<sub>2</sub> solution touches the soil or roots directly. Furthermore, the fine mist creates a "film" on the plant surface so the solution does not run off the plant and drip onto the soil.

## Plant-Related Questions

### **As growers, we don't like to make our plants wet**

Aqueous CO<sub>2</sub> misting does not get your plants "wet". The amount of solution applied is very little (few seconds 2-3 times an hour). CO<sub>2</sub> is absorbed in about 60-90 seconds and moisture is evaporated within minutes leaving little residual moisture therefore eliminating any rot risk due to the water.

Our leaf wetness sensor ensures we are misting long enough for the film to remain on the leaf for CO<sub>2</sub> diffusion (absorption) to occur (~2 minutes), and completely dry off quickly thereafter (~5 minutes). There is no rot risk due to the application of aqueous CO<sub>2</sub> solution by misting.

### **Is there any burn risk?**

There is no burn risk due to the application of aqueous CO<sub>2</sub> solution by misting. The very mild pH drop that is formed by the aqueous CO<sub>2</sub> solution is not strong enough to burn the plant or harm people. Since the CO<sub>2</sub> absorbs quickly into the plant, the solution's pH normalizes therefore having no burn risk at all.

### **Is there mold and mildew risk?**

One of the key benefits of CO<sub>2</sub> Enrichment Solutions™ is its suppression of epiphytic microbial pathogens such as molds, mildews and *E. coli*. This benefit is called "Pathogen Perimeter Protection™" and is a function of rapid pH fluctuations on the leaf surface when the aqueous CO<sub>2</sub> mist is applied. For more information on PPP, click [here](#).

### **Can CO<sub>2</sub> Enrichment Solutions™ be used on the entire grow cycle?**

Yes. CO<sub>2</sub> Enrichment Solutions™ can be used from propagation (when the first few true leaves are visible) through to harvest. This may differ in some plants and are addressed with the grower.

### **What are the differences in growth between atmospheric CO<sub>2</sub> enrichment and aqueous CO<sub>2</sub> misting?**

In pepper trials, aqueous CO<sub>2</sub> misting showed similar increases in production as atmospheric enrichment (1200 ppm) compared to ambient conditions (400 ppm).

The difficulty with atmospheric enrichment is when greenhouses vent, it is difficult to maintain CO<sub>2</sub> levels above 400-500 ppm as the CO<sub>2</sub> gas escapes out of the greenhouse. This makes CO<sub>2</sub> a limiting factor to optimizing growth during venting season.

Moreover, in pathogen studies, gassed CO<sub>2</sub> had no impact on bacteria and powdery mildew, whereas it was observed that aqueous CO<sub>2</sub> misting suppressed the spread of bacteria and powdery mildew by up to 99%.

**Since there is more plant growth, are more nutrients required?**

It is not a question of more or less nutrients required. It is a question of having the correct nutrient balance that promotes plant production at elevated CO<sub>2</sub> conditions where growers earn value from.

CO<sub>2</sub> enrichment helps increase the rate of photosynthesis. However, photosynthesis not only affects carbohydrates, but also amino acids, proteins, lipids and other pigments in the leaf.

The macro and micro nutrient balance (N, P, K, Ca, Cu, Mg etc.) will determine how the additional carbon is utilized by the plant. For example in peppers, adjusting the nutrient balance to promote more regenerative growth (flower and fruit to sell) is important, otherwise the plant may produce more vegetative growth (leaves which are not monetizable).

As part of our technology service, we offer “Plant Conditioning Advisory” whereby the grower is requested to perform periodic leaf/foliar nutrient analysis with their lab. Our nutrient advisors review the data and recommend adjustments in the nutrient balance in order to direct the plant to utilize the CO<sub>2</sub> to grow more of the saleable product.

## Misting-Related Questions

### **Where do the nozzles sit relative to the plants?**

CO2 GRO designs the misting system in order for the mist to create the microfilm on the leaves and provide adequate coverage throughout the canopy.

Misting nozzles will typically be between 3 to 6 feet above the plant canopy. The misting system can be adapted to cover flat “sea of green” plants such as lettuce, bedding plants such as roses, and vine crops such as tomato, pepper and cucumber.

### **How far are the nozzles from each other?**

The misting nozzles are placed between 4 to 8 feet from each other depending on the greenhouse design and crops set up.

### **Do we provide installation for the misting system?**

CO2 GRO does not offer direct installation work for the misting system. CO2 GRO provides detailed engineering diagrams, list of materials, plumbing diagrams, wiring diagrams, installation guidelines, standard operating procedures, and virtual/phone support to ensure proper installation and commissioning of the system.

Typically, growers will utilize their own maintenance team for installing the system or hire third-party contractors.

### **What training is provided?**

CO2 Enrichment Solutions™ is designed to be simple and requires low maintenance; nonetheless, for optimal results an engaged grower is required.

Observation of plant responses, data evaluation and continuous improvement practices will allow the grower to get the most from the technology. CO2 GRO views our relationship with our customers as a partnership and continual learning process. As such, we offer continual virtual support and in-person visits once the system is operational.

CO2 GRO also works with regional partners who provide on-the-ground service to our customers when needed with support from CO2 GRO’s project management team.

### **What kind of checks are in place for preventing the system from just dumping excess water onto the plants?**

CO2 GRO’s design team selects and specifies nozzles from quality manufacturers and have been proven to work in the field in many applications.

These nozzles come with a pressure directional check valve to ensure precise misting control. \*Proper installation of misting hangers are key to avoid any leaks. If needed, a hole can be plugged and re-opened a few inches away.

The Smart Control System uses real time environmental data to determine if misting occurs or not. It will not mist if the environmental conditions are not optimal. Additionally, it will send alert emails when any one of several parameters is out of threshold range such as CO<sub>2</sub> concentration in the solution.

**Does CO<sub>2</sub> misting help with insects?**

CO<sub>2</sub> GRO's technology has not shown any effects towards insects. However, CO<sub>2</sub> GRO's technology offers pathogen protection and has been shown to reduce the presence of powdery mildew.

**Do you mist at night?**

CO<sub>2</sub> is used by the plant through photosynthesis, which requires light. If there is enough light in the environment for photosynthesis to occur, the CO<sub>2</sub> can be absorbed and transformed.

The schedule normally follows day, or "light hours" used at each crop, with light sensors to determine if there is sufficient light available. Since there is no light for photosynthesis during the night hours, we do not apply CO<sub>2</sub> misting at night.



## Questions about our technology - how it works

### **Is there a way of measuring the concentration of CO<sub>2</sub> in the water?**

Yes, there are various ways to measure CO<sub>2</sub> concentration in water. One can use a dissolved CO<sub>2</sub> concentration sensor which targets above 1,000 mg/L up to 1,500 mg/L dCO<sub>2</sub> in solution, or a dissolved oxygen sensor targeting <20% or <2 mg/L DO as a good proxy of CO<sub>2</sub> saturation in the solution.

pH can also be used as a proxy indicator of CO<sub>2</sub> concentration in water, which will usually be about 2 points less than normal water (~4-5 pH).

### **How much of the plant needs to be covered with mist?**

The more leaf surfaces that can be reached with the mist the better. This depends on the plant and development stage.

### **Do you have standard operating procedures to maximize CO<sub>2</sub> utilization?**

Yes, the system settings and variables will be clearly examined and determined in accordance with the customer goals, experience with crop, environmental conditions in the greenhouse, greenhouse architecture and geometry, greenhouse automation, controls systems, and much more.

These procedures should be dynamic and change throughout the seasons as we gain experience from previous data.

### **Do you have case studies demonstrating the benefits of CO<sub>2</sub> Enrichment Solutions™?**

We have done studies both in the lab as well as with commercial growers in a variety of crops in regions around the world. Typically, we see 10-30% more production.

With our very low operating costs, the net impact of our technology potentially increases a grower's gross profits by up to 2X. For more information visit our [website](#).

## Questions about the science of the technology - related to crops

### **How does the CO<sub>2</sub> enter the plant?**

There is plenty of research done by CO<sub>2</sub> GRO and University scientists using our technology.

Although the typical method for CO<sub>2</sub> uptake in plants is through the stomata - tiny pores typically found on the underside of the leaf that regulates the intake and release of gases - our technology enables the entire top of the leaf surface to be a pathway for CO<sub>2</sub> to enter the leaf.

The aqueous CO<sub>2</sub> mist droplets fall onto the leaf surface to create a thin microfilm (or microenvironment) which has a higher concentration of CO<sub>2</sub> than inside the leaf; this creates a diffusion gradient which enables the dissolved CO<sub>2</sub> gas in the microfilm to diffuse through the tiny cracks in the cuticle and into the leaf where CO<sub>2</sub> molecules are used for photosynthesis.

During photosynthesis the CO<sub>2</sub> is broken into carbon (C) which is sequestered in the plant for use in building compounds such as carbohydrates, and the oxygen (O<sub>2</sub>) is released back into the atmosphere.

### **Do you see any changes of characteristics in the leaves with the misting?**

Typically, no, if there are any, we end up with healthier, more productive plants.

## Commercial Model

### **How do we buy this technology?**

We have several options to commercially deploy the technology including a Capital Purchase, Commercial PFU (Pay-for-Use) and other flexible financing options.

Growers are welcome to deploy a low-cost Technology Adaptation Project (TAP) for one-year on a smaller section of their facility to test the system which helps CO2 GRO adapt the technology to their unique facility, and for the growers to get comfortable using the technology and see the results.

For more information about deploying a TAP or Commercial project, please contact us.