Saying Goodbye to Soil Fumigants:

An Effective and Responsible Approach

While the routine use of pre-plant soil fumigants has become standard practice for many growers over the years, problems with product availability, safety restrictions, ecological concerns, and soil sustainability have begun to call the practice into question. Growers are now faced with a dilemma: Fumigation has been an easy solution to many causes of decreased crop yields, but what options are available that are as effective to protect yield yet still responsible when it comes to health, safety, and environmental impact?

This article highlights sustainable alternatives to soil fumigation, including the combination use of two specific Huma Gro® products, Promax® and Zap®, that provide effective nematicide/fungicide actions while building a vigorous soil biology for the natural improvement of soil health.

Soil fumigation has been routinely used on sensitive annual crops such as strawberries, carrots, bell peppers, tomatoes, cantaloupes, and potatoes since the 1960s. Soil fumigant products are typically applied in the fall after harvest or in the spring as a pre-plant soil preparation. The process involves having trained/certified operators inject a gas—usually with an active ingredient of chloropicrin; dazomet; 1,3-dichloropropene; metam sodium; metam potassium; and/or methyl bromide—into crop soil that has many times been covered with a tarp to prevent the gas from escaping into the atmosphere. As this gas works its way through the soil it kills many types of pests, including organisms such as nematodes, various soil-disease pathogens, and some weed seeds.

http://ucce.ucdavis.edu/files/repository/calag/img6703p186.jpg

Over the years, the U.S. Environmental Protection Agency (EPA) has implemented increasingly stringent restrictions on soil fumigation to protect the health of farm workers and the populations of nearby communities. These restrictions include requiring protective clothing and breathing protection for fumigant handlers and applicators; creating buffer zones around fumigated fields to protect occupants of nearby homes, schools, and businesses from drifting poison fumes; and establishing safe re-entry intervals for when farm workers can come back into the fumigated fields. Immediate symptoms of fumigant exposure can include burning eyes, nausea, headaches, asthma attacks, and throat irritation. Long-term exposure to soil fumigants—including through groundwater contamination—can possibly lead to cancer, reproductive harm, and developmental delays in children, among other claimed side effects.

In addition to EPA restrictions due to health concerns, the widely used fumigant ingredient methyl bromide has been singled out as an ozone-depleting chemical. The Montreal Protocol, an international treaty signed by the United States, required that methyl bromide be completely phased out as an agricultural pesticide by 2005. As alternatives have been difficult to identify, these phase-out dates have been pushed out year by year through EPA action.

Some growers, particularly potato growers, have been avid users of soil fumigants to prepare their fields for new plantings. In the past, as much as 90% of potato acres in the state of Washington were fumigated, along with 82% of the potato acres in Oregon and 50% of the Idaho

potato acres. Growers used the fumigants because of their ability to control a wide range of pests and because of the resultant increases in crop yields. Other crop growers such as strawberry growers, for example, saw their yields nearly quadruple in the decades after fumigants were first used. Many growers attributed this tremendous yield success to fumigant use.

Advances in Understanding Soil Microbiology

In addition to the long-known negative health effects of soil fumigants on humans, more recent developments in the understanding of the importance of biodiversity in the soil solution has led many to believe that the use of soil fumigants damages the long-term sustainability of soil fertility. Fumigants kill almost everything in the soil, including the beneficial bacteria, fungi, and other micro- and macro-organisms that keep the soil healthy and fertile. In recent years, soil scientists have developed a much better understanding of the plant-microbial interaction. In exchange for what they want, some soil microorganisms break down nutrients and provide them to plants in a form that the plants can easily use. Others help protect plants from many types of diseases and predators, as well as create a soil structure that is beneficial to the absorption and flow of necessary oxygen, carbon dioxide, and water, improving plant respiration and hydration.

When soil fumigants sterilize the soil, they not only kill off all the beneficial microorganisms, they also set up conditions that make the soil and crops more vulnerable to future pest invasions. In healthy soils, biodiversity helps to control damaging pests by giving them competitors that "out-eat" and "out-survive" them. This has been termed "competitive exclusion." When the good competitors are killed off in fumigation, the door is left wide open for the damaging pests to come back stronger than ever; hence, the need for year-after-year applications. Also, without the beneficial microorganisms being available to provide nutrients to plants in a form that they can easily consume, growers are forced to increase the amount of fertilizers they use to sustain previous yield levels—increasing inputs but decreasing productivity. This may also explain why there is an increased need for applying more pesticides, as well.

Sustainable Alternatives

Soil fumigants were tantalizingly easy for growers to use because one application process had so many good immediate outcomes. So, with fewer effective soil fumigants available and costs rising to meet the restrictions associated with fumigant application and use, what alternatives do responsible growers have if they want to grow premium crops in a cost-effective *and* sustainable way? They begin by providing sound soil stewardship that puts the soil microorganism ecology, or "microbiome," back in balance.

To do this and replace fumigants, it is likely going to require multiple practices that may change as individual crop-growing circumstances change. Some of these practices include:

- **Using Disease-/Pest-Resistant Varieties of Cultivars:** These are available for some crops but not for others. We expect them to become more available in the future, so growers should always be on the lookout.
- **Green Manures:** Certain crops (e.g., Brassicas) that are incorporated into the soil before they reach maturity have proven effective in managing specific pests, such as nematodes. Sweet corn used as a green manure has proven effective in suppressing *Verticillium* wilt in potato fields. The addition of organic matter into the soil in general has a positive effect on yield in its own right.
- **Soil Solarization:** Placing plastic sheets over moist soil during periods of high temperature can kill many disease-causing organisms, nematodes, and weed seeds; however, this practice is most effective only in hot, dry climates and may have damaging effects on beneficial microbes as well.
- **Crop Rotation:** Depending on the target crop, there are rotational crops that can play an important role in an integrated pest management strategy. Rotating wheat and/or barley with potatoes, for example, allows growers to apply nightshade-weed herbicides to the rotated crop, since they cannot be used directly on potatoes.

- **Using Less Harsh or Natural Nematicides/Fungicides:** Sometimes all that is needed is an effective organic or natural nematicide/fungicide, particularly when paired with some of the other practices outlined above.

This last practice area is where Huma Gro® can help, with its combination of **Promax**® (an OMRI-Listed, broad-spectrum, organic soil fungicide/nematicide) and **Zap**® (formulated to feed the native beneficial soil microbiology, creating biological balance and diversity).

With **Promax**®, being an organic product in no way diminishes its effectiveness. Increased grower usage backed by years of field trials and university-based research reports testify to how well it works against many types of soil-borne diseases and plant parasitic nematodes (see the list on Page 4; view reports and testimonials at https://humagro.com/case-studies).

Along with its effectiveness, the **Promax**®-followed-by-**Zap**® application offers many advantages when compared with fumigants:

- **Zero Buffer Zone: Promax**® has a zero buffer zone and can be applied anywhere without restrictions.
- **Zero Re-Entry Interval: Promax**® has a zero re-entry interval, meaning that you can spray and walk. **Promax**® can be applied anytime throughout the growing season without harming the plants or damaging the roots.
- **Zero Residue:** With its active ingredient of thyme oil, **Promax**® can be applied up to the day of harvest and still be safe. Also, **Promax**® will not pollute the waterways or destroy the ozone.
- **Reapplication Friendly:** Nematode eggs are often buried deep in the soil, and a new wave can emerge weeks after any type of treatment. With **Promax**®, you can do another application whenever it is needed without all the fuss, expense, and risk associated with harsher products or fumigants. This ability to apply whenever it is needed can save crops and preserve yields that might otherwise be lost if a grower is reliant on fumigant technology that can only be applied when there are no crops in the field.
- **Prevents Resistance:** The technology behind **Promax**® is 100% natural, which prevents soil organisms from developing resistance and allows **Promax**® to continue to be effective even after multiple applications.
- **A Plan for Sustainable Soil:** Huma Gro® **Promax**® followed up with **Zap**® helps restore a healthy microbial balance for soil sustainability and fertility. Growers who look beyond the current crop understand the importance of long-term soil sustainability for future crops. Huma Gro® offers an effective and responsible approach, whereas fumigants are only concerned with sterilizing the soil.

For more information or a free consultation:

Contact Huma Gro® at https://humagro.com/promax **or call 1-800-961-1220.**

To view the entire Huma Gro® product catalog online, go to http://bit.ly/HumaGroCatalog2017.

Resources

- Californians for Pesticide Reform. *Fumigant Pesticides Put Central Coast Communities At Risk.* March 2015. Available at https://www.panna.org/sites/default/files/WatsonvilleFumigants201503FINALc.pdf.
- CropLife Foundation. *The Importance of Soil Fumigation: Pacific Northwest Potatoes*. 2016. Available at https://croplifefoundation.org/wp-content/uploads/2016/06/potatoes_fumigants.pdf.
- Soil Fumigants Website. Available at http://www.fumeinfo.org/en/about.
- U.S. Environmental Protection Agency. Soil Fumigant Chemicals. Available at https://www.epa.gov/soil-fumigants/soil-fumigant-chemicals.
- U.S. Environmental Protection Agency. *Soil Fumigant Mitigation Factsheet: Implementation Schedule, March 2012*. Available at http://www.cdpr.ca.gov/docs/license/pubs/fact_sheets_soilfum.pdf.

PROMAX®

Zero-Residue Crop Protector

Guaranteed Analysis

Active Ingredients:

Thyme Oil	3.5%
Inert Ingredients*	96.5%
Total Ingredients	100.0%

**Contains water, molasses, glycerin*

Physical Properties:
Form: Liquid
Appearance: Hazy to opaque, brownish, slightly acidic, with a unique characteristic odor.
Weight: 8.34 lb/gal, 1.00 kg/L
pH: 6.5–7.5

Caution:
Keep out of reach of children.
Harmful if swallowed. Exposure to this product's mists or liquid may cause severe irritation to the eyes and may cause irritation to the skin and respiratory tract.

Storage and Handling Precautions
Store in a cool, dry, well-ventilated area, away from incompatible materials and products. To protect eyes and skin from contact with this product, applicators and other handlers must wear a long-sleeved shirt, long pants, shoes and socks, protective eye wear, and chemical-resistant gloves made of neoprene, nitrile, or natural rubber. Avoid breathing vapors, aerosols, or mists. Use with adequate ventilation. Keep the container tightly closed when not in use. Wash thoroughly with soap and water after handling this product.

Disposal Considerations:
If this product is disposed of as shipped, it does not meet the criteria of a hazardous waste as defined under 40 CFR 261, in that it does not exhibit the characteristics of a hazardous waste of Subpart C, nor is it listed as a hazardous waste under Subpart D due to toxicity. As a non-hazardous liquid waste, it should be disposed of in accordance with all local, state, and federal regulations. Consult state or local officials for proper disposal method.

Conditions of Sale:
The information contained in this bulletin is believed to be accurate and reliable. Buyer and user acknowledge and assume all liability resulting from the use of this material. Follow directions carefully. Timing, method of application, weather, and other factors are beyond the control of the seller.

OMRI LISTED For Organic Use

Minimum Risk Pesticide
EPA FIFRA 25(b)
Exempt Product

Broad-Spectrum Soil Fungicide and Nematicide

Huma Gro® PROMAX® is an organic-listed, EPA-exempt crop protection product. It is a protective and curative pesticide recommended for control of plant parasitic nematodes and soil-borne diseases. The mode of action is as a contact killer. There is no restricted use, so it can be applied throughout the entire growing season.

Integrated Pest Management:
PROMAX® is formulated to deliver maximum performance while minimizing residual effects. PROMAX® is compatible with most insecticides, miticides, fungicides, herbicides and fertilizers; therefore, it is considered as an ideal product in tank mix strategies and in rotation programs.

Plant Parasitic Nematodes and Crops *(including, but not limited to)*	
Burrowing (*Rodopholus*)	Tree fruits (bearing and nonbearing): apples, cherries, citrus, peaches, pears
Lance (*Hoplolaimus*)	Cotton, turf grass
Lesion (*Pratylenchus*)	Carrots; cucurbits (cucumber and melons); potatoes; sweetcorn; tree fruits (bearing and nonbearing), citrus, peaches; turf grass
Reniform (*Rotylenchulus*)	Cotton, tomatoes, tree fruits
Ring (*Circonemoides*)	Cucurbits, peppers, potatoes, tomatoes, turf grass
Root-knot (*Meloidogyne*)	Carrots, cotton, cucurbits, onions, peppers, potatoes, tomatoes, tree fruits (bearing and nonbearing), citrus, turf grass
Soybean Cyst (*Heterodera*)	Soybean
Spiral (*Helicotylenchus* and *Rotylenchus*)	Carrots, sweet corn, sweet potatoes, turf grass
Sting (*Belonolaimus*)	Carrots, cotton, cucurbits, peppers, potatoes, tomatoes, tree fruits (bearing and nonbearing), citrus, turf grass
Stunt (*Tylenchorhynchus*)	Carrots, cucurbits, onions, peppers, tomatoes, turf grass

Soil-Borne Diseases and Crops *(including, but not limited to)*	
Club Root (*Plasmodiophora brassicae*), **Black Rot** (*Xanthomonas campestris*)	Broccoli, Brussels sprouts, cabbage, cauliflowers
Anthracnose Fruit Rot (*Colletotrichum* sp.), **Charcoal Rot** (*Macrophomina* sp.), **Crown Rot** (*Fusarium* sp.), **Damping Off** (*Fusarium* sp., *Phytophthora* sp., *Pythium* sp., *Rhizoctonia* sp.), **Grey Mold** (*Botrytis* sp.), **Root Rot** (*Fusarium* sp., *Cylindrocarpon destructans*, *Pythium* sp., *Rhizoctonia* sp.), **Stem rot** (*Phytophtora* sp., *Sclerotium* sp.), **Verticillium Wilt** (*Verticillium* sp.)	Asparagus, beans, cole crops, cotton, cucurbits, eggplant, lettuce, onions, peas, peanuts, peppers, potatoes, nuts (almonds, walnuts), small fruits (strawberries, cranberries, raspberries), sweet potatoes, tobacco, tomatoes; tree fruits (bearing and nonbearing): apples, apricots, cherries, peaches, citrus, mangoes, pineapple, plums; turf grass, ornamentals and flowers (azalea, geranium, impatiens)
Stem Rot (*Sclerotium rolfsii*)	Peanuts, tomatoes, peppers
White Rot (*Sclerotium cepivorum*)	Garlic

For best results, 7–10 days after the final PROMAX® treatment is completed apply Huma Gro® ZAP® at 1 gal/acre (10 liters/hectare) for stimulation of the soil biological community.

Application Instructions:

- This product mixes readily with water. To prepare the spray mixture, fill the mix or spray tank with three-fourths of the required amount of water then add the proper amount of PROMAX®. Complete filling the mix or spray tank with the balance of water needed.
- It is important when using PROMAX® as a protective or a curative fungicide and nematicide that material be incorporated into the soil. This can be accomplished as a soil drench, mechanical incorporation, or as an in-furrow application watered in.
- Higher rates should be used as a curative, on heavy soils, in fields with a history of disease problems, or when weather conditions are expected to be favorable for rapid disease growth or nematode activity.
- Use a lower rate as a preventive or on light infestations.
- Repeat every 15 to 20 days for disease or nematode control as indicated on chart.
- Consult your local HUMA GRO® Representative for crop-specific recommendations.
- SHAKE WELL BEFORE USING. This product will separate. Constant tank agitation is required to ensure a homogeneous spray mixture.

METHOD OF APPLICATION	*SUGGESTED RATE PER ACRE/HECTARE*
Soil-banded, injected, side dress, drip tape, or micro sprinklers	Up to 1 gallon/acre, 10 liters/hectare
Soil broadcast spray incorporated	Up to 2 gallons/acre, 20 liters/hectare

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HUMA GRO

ZAP®

Sustainable Soil Fertility

Guaranteed Analysis 8-0-0

Total Nitrogen (N) 8.00%
- 3.0% Ammoniacal Nitrogen
- 2.0% Nitrate Nitrogen
- 3.0% Urea Nitrogen

Sulfur (S) 1.00%
- 1.00% Combined Sulfur (S)

Iron (Fe) 0.10%
- 0.05% Chelated Iron (Fe)

Manganese (Mn) 0.05%
- 0.05% Chelated Manganese (Mn)

Zinc (Zn) 0.05%
- 0.05% Chelated Zinc (Zn)

Derived From:
Urea, Ammonium Sulfate, Ammonium Nitrate, Iron HEDTA, Manganese EDTA, and Zinc EDTA. (Chelating agents are Hydroxyethylenediaminetriacetate and Ethylenediaminetetraacetate.)

Physical Properties:
Form: Liquid
Appearance: Clear to hazy, brownish, very slightly acidic,having a unique characteristic odor.
Weight: 9.18 lb/gal, 1.10 kg/L
pH: 5.5–6.5

Caution:
Keep out of reach of children.
Harmful if swallowed. The liquid and mists may be irritating to the eyes and skin. Inhalation of mists may be irritating to the entire respiratory tract.

Storage and Disposal:
Keep product in original container. Do not transfer into food or drink containers. Triple rinse when empty for recycling. Always dispose of container in accordance with local, state, and/or federal regulations. Do not store this product below 50°F (10°C) or above 90°F (30°C).

Conditions of Sale:
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The Solution for a Strong, Healthy Soil

Huma Gro® ZAP® complexed with Micro Carbon Technology® is an organic-based formulation of nutrients for feeding the native beneficial soil biological balance. ZAP® feeds a strong, vigorous soil biology, which indirectly results in the natural improvement of soil health.

How ZAP® Works:
- Effect on soil environment surrounding roots: ZAP® enhances activity of beneficial microbes detrimental to soil-borne diseases and plant-parasitic-nematodes.
- Effect on the plant: ZAP® improves root growth and, as a result, reduces susceptibility to secondary root infections.

Benefits of Use:
- Improved plant health and disease resistance
- Beneficial suppressiveness of soil pathogens and nematodes
- Rapid improvement in beneficial soil microbial activity
- Establishment of soil biological balance and species diversity
- Reduced need for chemical pesticidal controls

Application Instructions:
See table below for specific rate instructions. Do not apply this product in concentrations greater than 10%. SHAKE WELL BEFORE USING.

METHOD OF APPLICATION	*SUGGESTED RATE* *Field Crops / Tree or Vine Crops*	
Soil banded, injected, side dress, drip tape, or micro sprinklers	Up to 1 gallon/acre, 10 liters/hectare	Up to 1 gallon/acre, 10 liters /hectare
Sprinklers: solid set, drag lines, linear, or pivot @ 100% speed	Up to 2 gallons/acre, 20 liters/hectare	Up to 2 gallons/acre, 20 liters/hectare
Soil broadcast spray incorporated, flood or furrow irrigated	Up to 3 gallons/acre, 30 liters/hectare	Up to 3 gallons/acre, 30 liters/hectare

Powered by MICRO CARBON TECHNOLOGY®

****This Product Contains Micro Carbon Technology® (MCT), a proprietary blend of very small organic molecules that allow for more effective absorption of nutrients by plants.***

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HUMA GRO®