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The Ozone Application for Control of the Root-knot Nematode in Tomato Greenhouse

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ABSTRACT

Ozone(O_3) is a beneficial gas which is used for elimination of microorganisms. This gas provided from O_2 and it is very unstable and reactive. The Ozone can be used as a disinfectant, decolorizer, detoxifier, precipitant, coagulant and also for removing taste. In this paper, the ozone used to control root-knot nematode in potato greenhouse. Ozone generator that designed for this purpose, produced 36 mgO_3/m^3. Ozone is injected to water with venture and greenhouse irrigated with ozonated water. After 20 days it is shown that disease have been controlled and stoped, crop increased between 30% and 40%, weeds decreased and plant's daily growth enhanced.

Introduction

Ozone (O_3) or trioxygen is a molecule with three oxygen atoms that is very unstable and reactive and recognized as a disinfectant for water in 1886. In 1893, first ozone drinking water treatment was done in Netherland. Now, it is used for many water treatments in all of the world. Ozone is so reactive and we can't storage into the container. In comparison with O_2, O_3 is an extremely active molecule, probably by factor of 1,000 times and sometimes referred to as activated oxygen. You can imagine ozone as a regular O_2 molecule with a very nervous, active, reactive, excitable, energetic, corrosive and lively O_1 atom as a side kick. Ozone is very disinfectant and oxidizer, in a way that any pathogen or contaminant that can be disinfected, altered or removed via an oxidation process will be affected by ozone [1-6].

Furthermore, the Ozone is 20 to 50 times more effective than chlorine. It breaks down large and long chain molecules into smaller building blocks [7]. It is well document as producing high kill rates when exposed to Micro-organism (Funguses, Bacteria and Viruses) [8].

The mechanisms of disinfection using ozone are mainly…

- Direct oxidization/destruction of the cell wall with leaking of cellular constituents outside of the cell
- Reactions with radical by-products of ozone decomposition in water (when ozone decomposes in water , the free radicals – hydrogen proxy (HO_2) and hydroxyl (OH) – that are formed, have great oxidizing capacity and play an active roll in the disinfecting process).
- Damage to the constituents of the nucleic acids within the cells of the organism
- Breaking down of the carbon-nitrogen bonds leading to depolymerization (dissolving) [8].

Regarding to the greenhouse sanitation and disinfection is a primary necessity for insuring a healthy crop. Some greenhouse use chlorine bleach, quanternary ammonium, or hydrogen peroxide. These chemicals are undesirable because they leave behind a chemical residue. Ozone is a better course of action. It is much stronger and faster acting sanitizer than those other options. It does not leave behind a chemical residue. Considering increasingly focus on organically grown products in today's market, ozone is a good alternative, since it is on the National Organic List [9].

Hence, the Ozone cannot be stored or conveniently purchased by the gram, pound, gallon or ton, it must be produced on site as needed, where needed and when needed. Researchers have discovered or devised many ways to produce ozone. All of the following processes can be used: The electrical discharge (corona discharge), electrolytically (electrolysis an acid), Photochemically (ultraviolet radiation (UV light)), radiochemically (high energy irradiating of oxygen will produce ozone) and other ways such as reacting yellow phosphorous with oxygen [7].

The solubility of ozone in water is quite good, about 10 to 15 times greater than oxygen under normal drinking water treatment condition. About 0.1 to 0.6 liters of ozone will dissolve in one liter of water [10]. There are three basic methods generally used for ozone placed in the water:

Aspiration – via turbines or high speed agitators

Eduction – via a venture, with full or side stream flow

Pumping – via diffusers or fine air stones

The size of ozone gas bubble is extremely important point. Bubble sizes of to 3 microns is desired, but for good gas to liquid transfer, the smaller the better [7].

Nematodes are simple roundworms. Colorless, unsegmented, and lacking appendages, nematodes may be free-living, predaceous, or parasitic. Many of the parasitic species cause important diseases of plants, animals, and humans. Other species are beneficial in attacking insect pests, mostly sterilizing

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or otherwise debilitating their hosts [11]. Root-Knot nematodes are microscopic worms that live in soil and feed on the roots of many common garden crops (Figure1).The nematodes gets its name because its feeding causes galls (swellings or "knot") to form on the roots of infected plants(Figure2) [12].

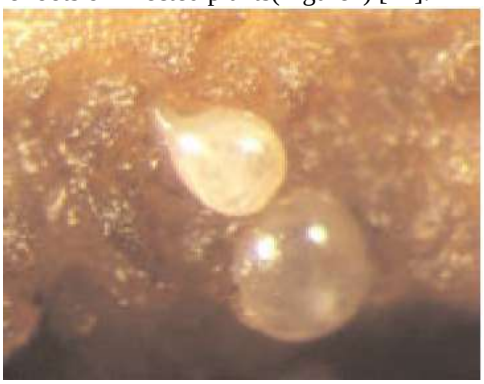

Figure1. Mature female root-knot nematode feeding on root with round egg sac containing about 500 eggs attached at the end of the nematode [12].

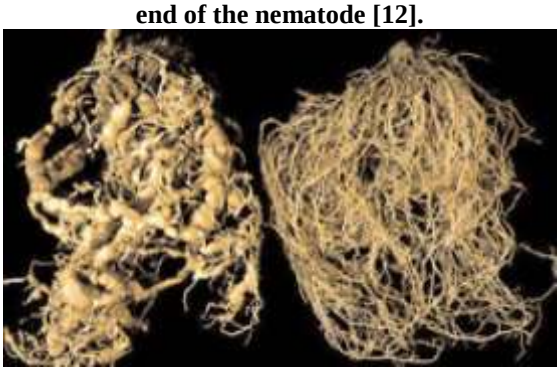

Figure2. Root-knot nematode-affected root system on left, healthy on right [12]

Nematodes feeding damage the roots system, decreasing the amount of water that can be taken up by the plant [12]. However, we employed the Ozone for control of this type of nematode in potato greenhouse.

Materials and methods

This research was performed in potato greenhouse with 5 months plants that all of them had root-knot nematode. Two comparisons between them performed:

-Plants were irrigated with ozonated water

-Plants were irrigated with non ozonated water

Two steps are used to determine the amount of ozone, for design its generatore, required. First is the CUMULATIVE need, which is the number of milligrams of ozone necessary to oxidize the number of milligrams of contaminates present. This is the stoichiometry of the reaction representing the consumption of ozone, normally in mgO_3/mg substance. Second is the DISINFECTION calculation, measured in mg/L of ozone over a specific period of contact time, usually minutes.

This is concentration & time (C t) needed for inactivating living organism, from single cell to higher life forms [7, 13]. For deal and disinfect with all nematodes we need 1.00 mgO_3/L and 5.0 Ct [7, 13]. Ozone generator that produced $40mgO_3/m^3$ were designed and used. Water that use for irrigate greenhouse was ozonated with this ozone generator by venture. The schematic of this method is illustrated in figure3.

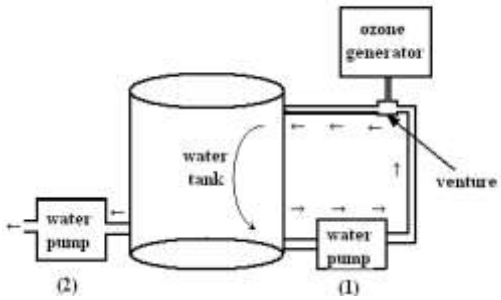

Figure3. Ozone mix with water by venture and water pump

Water pump(1) suck water from tank and circle it on a way that is shown with barbs in figure3. High speed water flow that is provided with water pump(1) mix ozone with water by venture. Water pump(2) irrigate greenhouse with ozonated water.

Results and discussion

After 20 days and 5 times irrigation with ozonated water, plants were begun to growth. Plants that were irrigated with non ozonated water were withered. Figure4 displays plant roots after 20 days.

Figure4. Right: plant was irrigated with non-ozonated water. Left: plant was irrigated with ozonated water.

Figure4 illustrates that plant irrigated with ozonated water have new roots and its nematode was controlled and stoped. In this research, results were shown that application of Ozone was very better than other chemical harmful materials which farmers used in past and it is a new and effective treatment for controlling Root-knot nematodes which can replace with previous treatment. Also, areas that irrigated with ozonated water, weed population decreased, because ozone oxide weed's outer membrane and don't let them to growth.

The pH that measured every day demonstrated in figure5

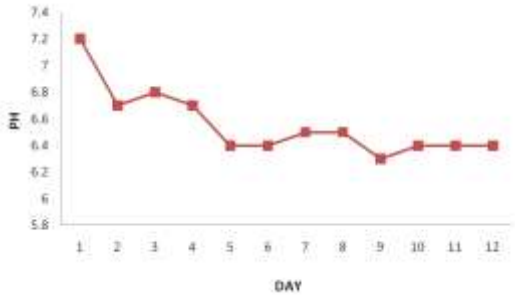

Figure 5. Soil pH after 12 days in area that irrigated with ozonated water

The pH curve presented in figure5 shows that the soil pH value decreased and provides good condition for plants growing. The phenomena were related to formation of H^+ ions (or decomposition of OH^- ions) [14]. Agriculture soil has about 45% soil mineral particles, 5% of organic matter, 20-30% of water

and 20-30% air. Because of the ozone generator convert about 10% of O_2 molecule to O_3, the O_2 dissolved in irrigated water have been increased and provides enough oxygen for roots. Also, after use of ozonated water, crops weight increased about 30-40%.

Conclusions

Ozone has stronger and faster acting than other chemical materials and farmers can use it for sterilize soil and fight with root nematodes. Ozone can effectively improve plant production and increase greenhouse crops. Also, ozone can control and eliminat weeds from greenhouses and is able to decrease pH soil and provide comfortable condition for plant growing.

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