THERMAL DISINFECTION OF SOILS WITH RADIOFREQUENCY POWER

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New methods to utilize radiofrequency (RF) power are being investigated as physical (non-chemical) thermal methods for disinfecting and disinfesting various foods and non food materials, including agricultural soils.[1-4]. The RF process operates with electric power that generates a rapidly oscillating electric field between parallel electrodes (RF cavity) forcing dipole and induced dipole molecules to align and reorient to the changing field, causing friction that converts to heat. Many industrial food processes have been proposed, studied, or applied with RF power. Today, RF applications are somewhat limited to frozen foods, fruit juices, post-baking drying, and some pasteurization processes. This is due mostly to the high cost of RF systems (~ $ 2,000/kW or higher) as well as to the many unknowns regarding the RF properties of foods and other materials. At UC Davis, new bands of the RF spectrum (few kHz to < 10 MHz) have been studied and tested successfully allowing new RF systems to be designed and engineered based upon solid state electronics. These new RF systems can be built with significant cost reduction (~ $200-300/kW) and are capable of operating with >90% overall energy-use efficiencies. With these new RF systems, disinfection efficacy for fungi and nematodes and disinfestation effects with various types of soils has been demonstrated in the laboratory. The overall results suggest that using RF power for processing soils may be a competitive alternative to other physical and chemical methods presently under consideration to replace the use of fumigants such as methyl bromide.

Agricultural soils are characterized by a high electrical conductivity and a high heat capacity. These properties allow for high-energy transfer efficiency to soils from an oscillating electric RF field as well as high heat retention. These properties permit the use of long time heating processes, as the accumulated thermal energy (i.e. thermal loads) is more efficiently used in disinfection and disinfestation effects. Because of the large volume (and mass) of soils needing treatment, energy use and heat retention efficiencies are important factors in establishing feasibility for RF processing of soils.

In agricultural soils, specific RF frequencies can penetrate several meters with equal power density and thus deliver thermal energy homogeneously. While soils are tolerant to thermal energy, all biological contaminants are highly susceptible. Materials such as water (a significant component in soils) and most cellulose-based and plastic-made materials are transparent (i.e. non-energy absorbing) to RF, therefore, to conserve energy, soils can be treated with covers or through many thermal or environmental insulators. Being a "heating process", RF-induced disinfection and/or disinfestation is based on the well-established mechanism for the thermal destruction of microorganisms, insects and mites. However, contrary to conventional heat technologies, which rely on surface heating and heat transport dynamics (conduction and convection), RF produces controllable levels of thermal energy with lower energy inputs. The RF approach is not comparable to microwave technologies that have very limited range of penetration, operates at high power densities, and may cause irreversible changes in soils. By contrast, the RF process produced reversible changes in all soil's quality properties except that induces irreversible changes in microbial contaminants due to their higher sensitivity.

A conceptual schematic of a RF system is shown in Figure 1. This system is being designed and engineered for field demonstrations using either a soil band (row) application technique (similar to methyl bromide) or a continuous process. The ability of RF power to achieve temperatures able to induce disinfection and/or disinfestation effects in different soil matrices is shown in Figure 2. Figure 3 (effects on *Fusarium spp.*) and Figure 4 (effects on Nematodes) demonstrate the ability of RF power to control two of the major pests in soils.

Finally, Table 1 (below) compares some of the basic mechanism and advantages of current techniques (methyl bromide) with RF heating processes, while providing some economic estimates based upon laboratory results.

Table 1. Comparative Analysis of Methyl Bromide and RF Thermal Processing

Parameter	**Methyl Bromide**	**Radiofrequency**	**Ohmic**
Type of Technology	Chemical	Electrical	Electrical
Mode of Action	Chemical Toxicity	Thermal	Thermal
Cost Per Acre*	$ 2,000 - $3,000	Spot-Soil $1,200 - $2,400 Band-Soil ~$2,000 - $3,000	Nursery Soils $900 - $2,800
Regulatory Status or Approvals	Scheduled Phase out	No Special Approvals	No Special Approvals
Environmental Impacts	Ozone Layer Depletion	None Expected	None Expected
Worker Safety	Higher Risk	Lower Risk	Lower Risk
Consumer Attitude	Mostly Negative	None Expected	None Expected
Time to Market	N/A	1-2 years	0.5 – 1 year

(*) Assume 90% overall efficiency (combined wall-to-RF and RF-to-thermal) and $0.10/kWh.

REFERENCES

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4. Lagunas-Solar M.C., N.X. Zeng, T.K. Essert, T.D. Truong, C. Piña, J.S. Cullor, W.L. Smith and R. Larraín.. "Disinfection of Fishmeal with Radiofrequency Heating for Improved Quality and Energy Efficiency". Journal of the Science of Food and Agriculture (In Press).

Figure 1. Conceptual Design for a Portable RF-Soil Processing System.

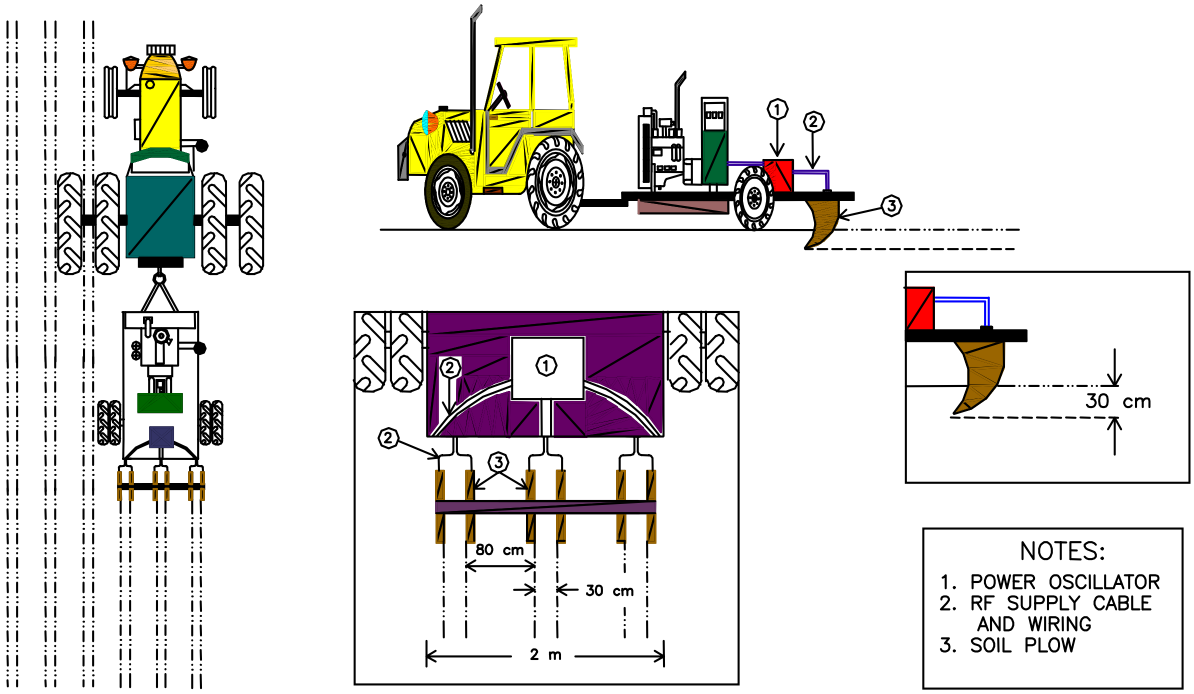

Figure 2. Soil Temperatures vs RF Exposure Time
(Cotton Farm Soil Samples; Geo-13; 500 W; 8/17/00)

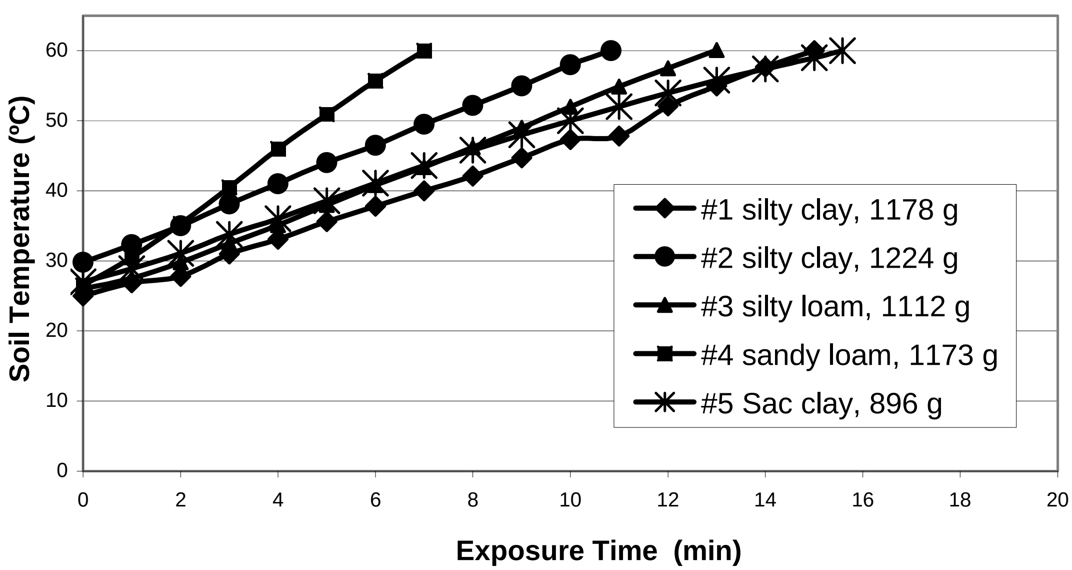

Figure 3. Thermal Effects on Fusarium spp.

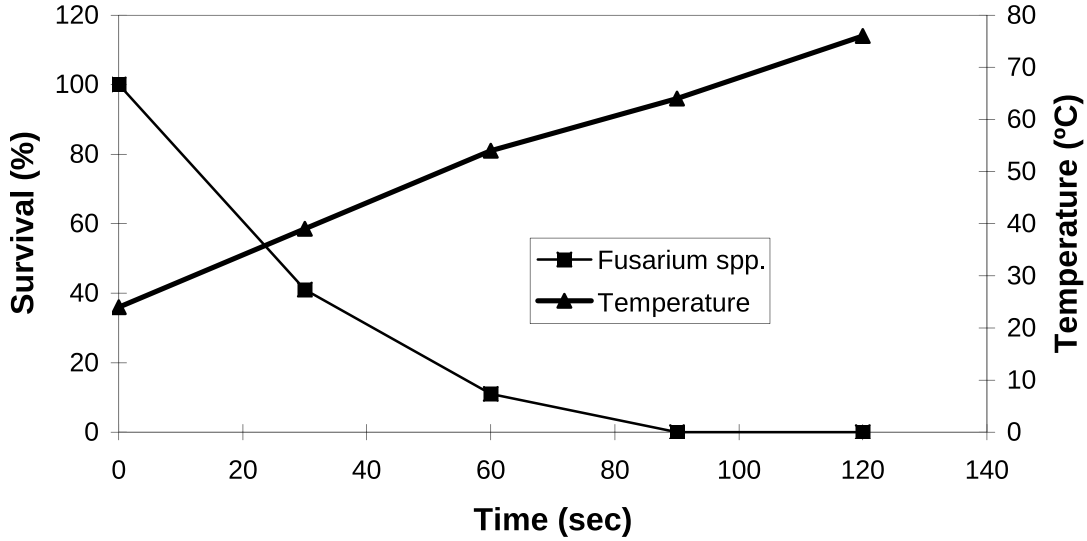

Figure 4. RF Thermal Processing of Nematodes in Soil
Geo-300, 27 MHz, UC Mix Soil (3 kg), 200 Nematodes/Sachet, July 27, 2005