Oregon Department of Agriculture and Oregon Association of Nurseries
Nursery Research Pre-proposal

Date: August 29, 2024.

Project Title: Developing Pulse Electricity as a Fumigant Alternative in Nursery Seedling Beds

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Project background:

This project is in its third year. We aim to develop and evaluate pulse electricity's performance, safety as an alternative to methyl bromide in nursery seedling beds. The Pacific Northwest leads the US in tree seedling production. Tree seedling nurseries often use fumigation and hand weeding to control soil pathogens, nematodes, and weeds. This practice is unsustainable due to increased regulation, costs, and environmental safety. Although pulse electricity is currently used commercially in agronomic crops and golf courses for weed control, we aim to develop it as a tool for soil disinfestation. We will explore Pulse Electric Field (PEF) as an alternative to soil fumigation.

Soil and equipment parameters affect PEF efficacy. The analogy of water moving in a pipe can explain the soil aspects; the current (amperage) is the water flow, the voltage is the water pressure, and the Ohm is the resistance of the pipe (Figure 1). The idea behind the increased effectiveness of PEF is that with high enough voltage, the current can overcome soil and weed resistance (Ohm) and allow more current to pass through the growing media. Conversely, when soil resistance is too low, one cannot sustain a voltage gradient. For instance, if the pipe were broken, the resistance (Ohm) would be too low, and the pressure (Volt) would drop. Low soil electrical resistance occurs when the soil is too wet. The equipment operates best under ideal soil moisture content. As a rule of thumb, a soil moisture ideal for tillage is also suitable for PEF applications.

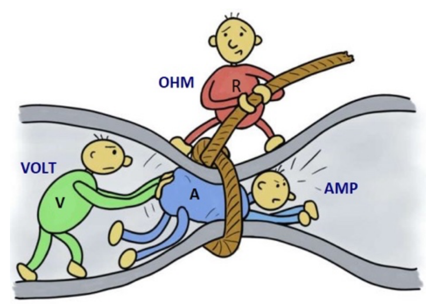


Figure 1. Relationship between resistance (Ohm), difference in potential energy (Volt), and current (AMP). Source https://www.circuitbasics.com/ohms-

In addition to soil conditions, PEF efficacy depends on equipment parameters like electrical field strength or the voltage gradient between electrodes (V/mm), treatment duration (s), pulse frequency, number of pulses per time (Hz), pulse width, or duration of each pulse and treatment temperature. We consider PEF a physical (electricity) and thermal (heat) method because the energy required to kill weed seeds and vegetative propagules will increase soil temperature. We have identified that high voltage and high frequency perform better against nematodes and soil pathogens. For instance, at 100 V/mm and 20 Hz, a 25 J/cc application was ineffective in reducing verticillium counts (Figure 2). By increasing the voltage to 200V and frequency to 80 Hz with the same energy level (25 J/cc), verticillium counts were reduced almost 10-fold. In contrast, weed control requires 250 to 300 J/cc of soil to reduce seed germination by 90% (data not shown). However, we hypothesize that lower energy is needed to kill weed seeds after germination and before emergence. We aim to identify optimum treatment conditions to minimize treatment costs and develop equipment suited for nursery applications. The current proposal would secure the funds necessary to cover part of the salary of a graduate student in Weed Science.

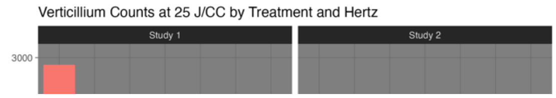
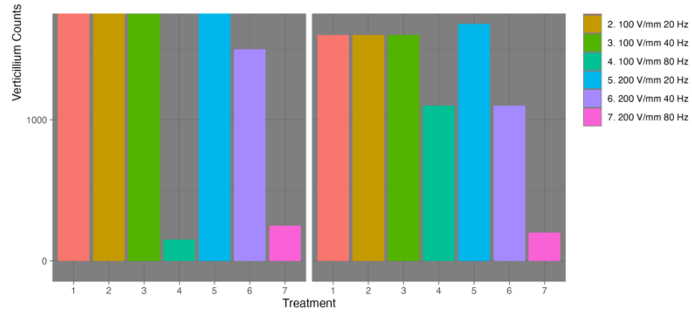


Figure 2. Verticillim dahliae counts after pulse electric field application at 25 J/cc and different field strength (v/mm) and pulse frequency (hz). The most effective treatment was PEF 25 J/cc at 200 V/mm and 80 hz.



Project objectives:

1) **To optimize pulse electricity field applications to control weed seeds in nursery seedling beds**. The long-term goal is to develop new methods to manage weeds and soilborne pathogens. The success of this proposal will reduce production costs and reliance on pesticides and soil fumigants, such as methyl bromide, and enhance the environmental sustainability of the nursery sector.

Methods and Timeline:

This work expands the collaborative work performed by USDA-ARS, OSU Department of Horticulture and Lisi Global researchers. Lisi Global is a private company that has documented the efficacy of pulse electricity in controlling nematodes and soil pathogens (Riga et al. 2020). A commercially available Direct Energy System unit (DES, Lisi Global, Inc.) will generate electric energy. This unit delivers energy via pins or electrodes inserted into the soil in a 2ft swath from the soil surface to a maximum depth of about 10." This video demonstrates the experimental process (https://www.youtube.com/watch?v=SV9zoXpvn84)

Controlled conditions studies: We will evaluate the effect of exposure duration to PEF of weed seedlings. The weed species selected are yellow nutsedge, barnyard grass, and redroot pigweed. Seeds will be planted at various times before PEF treatment, ranging from 0 to 10 days before treatment. Pots will be treated with two energy levels (50 and 200 J/cc) at 200 V/mm and 80 Hz. We will monitor germination and biomass for 28 days after treatment.

Field experiments: Two field experiments will be conducted in 2024-25; one in Boring, OR (JF Schmidt), and the second in McMinnville (Robinson Nursery). Cooperating growers will prepare the field site according to the nursery's standard practices. This study will compare the efficacy of two energy levels (50 and 200 J cm^{-3}) and two application depths (3.5 and 7 inches). A nontreated check will be included as a reference. Electricity will be delivered at 200 V/mm and

80 Hz, as these were identified as the most effective settings for nematode, verticillium, and phytophthora control. The collaborating grower will seed the crop. Weeds that emerge in the plot will be identified at the species level, and the percentage of soil coverage by weeds will be recorded monthly. Hand-weeding will be performed according to the standards of the collaborating nursery. Total hand-weeding time per plot will be recorded to document labor and production costs. One commercially important species will be planted on each experimental plot (e.g., *Acer ginalla*). Crop emergence and height will be recorded throughout the season. Trunk caliper will be recorded before harvest in the fall of the following year. Bare root operations will harvest seedlings and grade their quality according to plant height, trunk caliper, and root and shoot form.

The benefit to the Nursery Industry:
Shade tree production is a significant Oregon industry valued at $118 million yearly. This study addresses the need for non-fumigant alternatives for shade tree nurseries. Our proposal will develop a non-fumigant strategy to manage soilborne pests and pathogens. If successful, our project will reduce industry reliance on fumigants and pesticides, decrease labor demands, promote the longer-term economic viability of the industry, and enhance the sector's environmental sustainability. This public-private partnership allows us to adapt existing and locally available technology to the unique needs of the nursery industry. The research team has a proposal under review with the Horticulture Research Institute.

Budget summary:

	Description	Requested
Personnel		
Graduate student	0.60 FTE ($33,654/ year)	$ 21,840
Employee benefits (OPE)	38% ($7,466)	$ 4,838
TOTAL REQUEST		$26,678

References

Riga E, Crisp JD, McComb GJ, Weiland JE, Zasada IA (2020) Directed energy system technology for the control of soilborne fungal pathogens and plant-parasitic nematodes. Pest Manag Sci 76:2072-2078