

Alternative Approach for Soil Sterilization in Strawberry Rootstock and Fruit Productions

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Summary:

The following grant proposal is written to request the amount of \$50,000.00 in order to conduct research regarding an alternative approach for soil sterilization within strawberry rootstock and fruit growing productions. Historically, a mixture of methyl bromide and chloropicrin has been utilized as the primary pre-plant and / or post-harvest soil fumigant in the strawberry industry. A fumigant is a volatile chemical substance that is injected into the soil to eliminate insects, fungi, nematodes, weed seed, and essentially all and any form of life in order to sterilize the soil to ensure a successful, clean, disease-free crop (Becker, 2005).

Although the combination of methyl bromide and chloropicrin is a highly effective approach to sterilizing soil, there has been controversy over the safety of this product in past years due to the health concerns induced by exposures to these chemicals. The growing public concern is primarily concentrated in central California, in the San Joaquin Valley, where a predominant amount of strawberry rootstock and fruit is produced. Since 1985, more than 1,600 California residents have been affected by exposure to methyl bromide / chloropicrin and it is essentially a matter of time before the chemicals are prohibited for use as a soil fumigant (Hanson, 2015).

This being said, an alternative approach to soil fumigation and sterilization must be put into action in order to continue producing disease-free planting stock and fruit. This grant would be utilized to conduct research on an alternative approach known as steam sterilization. Soil pathogens, diseases, and pests are killed one of two ways; chemically, as described above by the use of a combination of methyl bromide and chloropicrin, or by the use of heat (Hanson, 2015). By injecting steam into the soil, the heat (if at a high enough temperature), should be able to eliminate all undesirable plant pathogens and pests that the chemical approach can, but in a safer and more environmentally friendly manner. One might ask, why has steam sterilization not been put into effect years ago as a soil sterilization practice if it is just as effective? The issue is that steam sterilization has been primarily used on a small acreage scale in hoop houses and small open field plots. This research will be focused on how to develop a steam sterilization method that will be applicable and efficient on a large scale; referring towards hundreds or thousands of acres.

Research and outreach would be performed by a qualified individual from the University of California, Davis, who has experience and connections in the strawberry rootstock and fruit growing industries. This individual will be responsible for conducting research on the affordability, safety, effectiveness, and efficiency of a steam soil sterilizer. Responsibilities would also include informative outreach events held for the concerned general public, as well as field day events for strawberry nursery stock operations and fruit producers by informing and answering questions related to this alternative fumigation approach.

By implementing the use of steam sterilization, the controversy, public concern, and health effects caused by methyl bromide / chloropicrin will effectively be eliminated. As strawberry operations begin searching for new ways to fumigate soils, having hypothesized, tested, and evaluated the results of steam sterilization, farmers may be better able to make an informed decision about adopting the new practice of steam sterilization. Accepting a new

approach of soil fumigation is in the near future, and steam is at this point, one of the only alternatives to the traditional chemical based approach. Utilizing a successful and effective steam sterilization method would be of great significance to the general public, as well as to the strawberry industry.

Objectives:

1. Research will be conducted on developing a large scale steam soil sterilization method in the San Joaquin Valley of California. This will be performed by an experienced and qualified individual from the University of California, Davis with networking connections throughout the strawberry industry. Research is to be completed, evaluated, and presented to the concerned general public, as well as strawberry rootstock and fruit growing operations who will be interested in adopting and incorporating the technology into their farm systems through outreach and field day events. Outreach events will be held in central locations (*refer to Education Outreach Plan Section*) and Field Day events will be performed on 50 acre parcels of several private landowners' fields in the same locations as outreach events. This will be completed and performed by the year 2024.
2. After the research is completed, the stakeholders, including rootstock nurseries, fruit growing operations, farm management, and labor will assemble and form a meeting in Redding, California to discuss the results, findings, and future of a commercialized steam sterilization machine by March 1st, 2024.
3. The University of California, Davis researcher will meet, discuss, and propose an idea to Sioux Corporation and Hummert International, two companies involved in smaller-scale steam sterilization, to see if there is interest in developing large scale steam sterilization machines for use in the strawberry industry. This will be conducted by June 1st, 2024.
4. A steam sterilization approach, once implemented, will reduce environmental and human health concerns for the local communities residing within close proximity to where soil is being fumigated with methyl bromide and chloropicrin. By eliminating the possibility of exposure to methyl bromide and chloropicrin, these communities will no longer fear or risk injury or illness from these chemicals by the year 2025, given that strawberry operations have access to this information and research. It is estimated it would take roughly a year to adopt and begin exercising this new technology.

Stakeholder Collaborators:

There are several groups of stakeholders involved in this issue that will be affected by this proposed solution. The concerned general public, those of whom are residents nearby the application sites, schools, and bystanders will be involved, included, and informed throughout the entire research assignment. These individuals will be welcomed to informative outreach events held by the researcher from the University of California, Davis, who is a stakeholder in the project as well. These outreach events will be held every quarter of the year to share new information that has been discovered.

Strawberry operations, encompassing rootstock nurseries, fruit growers, farm labor, management, and a soil scientist from the University of California, Davis are also stakeholders, and will be invited to field day events where the researcher will present information from the research and findings of a commercialized steam sterilization machine. During these field day events, once a large scale steam sterilization machine has been developed, the researcher will allow the farm operations and their employees to examine the machine operate and witness its progression and effectiveness as time advances. The soil scientist will examine and obtain soil samples that will be tested to determine the presence of weeds, disease, and soil microbes. These field day events will be held every quarter of the year to physically demonstrate progress on a steam sterilization machine.

A board of directors will be assembled and will consist of owners and managers of major strawberry operations that will be directly affected by the implementation of a steam sterilization machine. Quarterly, the board of directors will perform an assessment on the researcher's progress and success of communicating his or hers newly discovered information. The board of directors will participate in outreach and field day events, as well retrieve information from the general public and farm workers who attend the events through surveys and questionnaires to reveal the effectiveness of the researcher's efforts.

Relevance Summary:

The strawberry industry's livelihood depends on this research in order to establish an effective alternative approach to soil fumigation. Methyl bromide and chloropicrin fumigants have fought long and hard in controversial battles with stakeholders about health and safety issues, but the end of this war is near, and these chemicals will soon be phased out for agricultural use indefinitely.

This suggests that farmers must adopt a non-fumigant method of soil disinfestation in order to continue providing strawberries for the world. A steam sterilization approach is likely the superlative option. Very few commercialized steam sterilization machines exist today, and those that do cover roughly one acre in a day's worth of operation (Samtani et al., 2019). Research must be conducted on how to develop a larger scale, efficient steam sterilizer that can cover a greater amount of acreage per day, 30 acres or more.

A steam sterilization method would improve the profitability for stakeholders as well as agricultural farm fuel and natural gas providers. Farm profitability would increase with the adoption of this technology by greatly reducing labor costs and operating costs. When chemically fumigating, soil conditions must be ideal which requires irrigation and tillage. Once soil conditions are ideal, a large crew operating several tractors with implements called "fume rigs" apply the fumigant and a thin plastic film over the soil. Roughly ten days later, another crew comes into the field with tractors which cut and wrap the plastic into large rolls. These large rolls are then hauled out of the field, placed on a semi-truck, and hauled once again to be disposed of. Unfortunately, this plastic is no longer being accepted as recyclable within recent years, causing it to be hauled to landfills in which these facilities charge an extreme amount of money to dispose of the plastic film. By adopting a steam sterilization method, a one person crew could operate the machine, reducing a tremendous amount of labor costs. Also, with no need for

a plastic film to prevent off-gassing of fumigants; the costs of applying, removing, hauling, and disposing of the plastic in a non-environmentally friendly manner would be eliminated, greatly reducing farm costs and thus increasing farm profitability. An increase in profitability of agricultural farm fuel and natural gas / propane providers would occur as well in that a steam sterilization machine would operate off of diesel fuel, natural gas, or propane in order to heat water in a boiler which creates the steam that is injected into the soil.

Adoption of a steam sterilization machine would also enhance the quality of life for farmers / agricultural workers, communities, and society as a whole. By discarding the use of chemical fumigants, farmers, agricultural workers, and communities would no longer face possible exposure to these toxic agents. According to the EPA, the use of methyl bromide and chloropicrin has been indicated as an ozone-depleting substance. By using an alternative approach, the Earth's ozone layer would benefit, as well as society as a whole (Becker, 2005).

Benefits and Impacts to Agriculture:

As with acquiring and implementing almost any new agricultural technology, comes both benefits and impacts to the agricultural industry. There are several key benefits to using a steam sterilization approach over chemical fumigation; however, the most important revolves around the safety of rural communities impacted by fumigation, including the farm workers that are directly handling the chemicals. By prohibiting the use of methyl bromide and chloropicrin and adopting an alternative steam sterilization approach; individuals in rural communities, schools, daycares, bystanders, and farm workers would be at no risk of exposure to health damaging chemicals off gassing from local strawberry fields. Over 33,000 acres of strawberries in California would no longer utilize these toxic fumigants as a means for soil sterilization (California Strawberry Commission, 2018). Exposure to these chemicals has been a major concern for decades, and eliminating this concern would be a win for every stakeholder involved.

As explained in the relevance summary section above, operation profits will increase, however these profits will likely be seen to increase in the *long run* rather than the *short run*. In the short run, profits may initially decrease. This would be due to the high fixed costs associated with purchasing a newly researched and designed piece of costly technology. Years of research and development, designing, testing, evaluating results, redesigning, testing once again...etc. will cost strawberry operations a significant amount of upfront cost when purchasing this product. Operating the steam sterilizer may also seem costly in terms of fuel consumption, whether that be diesel fuel, natural gas, or propane. Generating steam through a boiler requires a significant amount of fuel source; however, the costs eliminated by adopting a steam sterilizer (reduced labor costs, equipment costs, maintenance costs, etc.) will outweigh the additional fuel costs associated with operating this machinery. This being said, society at large will benefit as well by reducing the use of ozone-damaging chemicals and health risks due to exposure of these toxic chemicals.

Evaluation / Stakeholder Adoption:

The project data, outputs, and outreach / field day events will be evaluated and assessed by a board of directors of whom will be owners or managers of major strawberry operations in

northern California and in the central valley of California; regions that will be directly affected by the new research and technology. At each quarter of the year, the board of directors will perform an evaluation on the chosen individual performing research and conducting the outreach / field day events. The board of directors will participate in each quarterly event and also interview and obtain information from the general public and farm workers who attend the events through surveys and questionnaires that reveal how much information and knowledge these individuals have obtained from these events. The surveys and questionnaires will be completed at each quarter as well, and will provide the board of directors insight into how stakeholders' knowledge, awareness, and attitudes about the issue change overtime. Stakeholders' opinions and constructive ideas will also be considered by the board of directors and shared with the researcher.

Evaluations will address the researcher's effectiveness of presenting and communicating information to these stakeholders. Once evaluations are completed and discussed upon by the board of directors, a meeting between the directors and the researcher will take place where both positive and negative attributes of his or her performance will be discussed. The researcher will utilize this feedback to improve communication amongst stakeholders at outreach and field day events in the future.

Educational Outreach Plan:

There will be two primary modes of educational outreach provided by the researcher. The researcher will communicate his or her findings through outreach and field day events. Outreach events will be held quarterly, on the dates January 1st, April 1st, July 1st, and October 1st respectively. Times for these events will be held at 6:00 p.m. in hopes of participant availability. A dinner at each event will be served. Outreach events are open to any stakeholder interested in the research being conducted, however will be directed more towards the general public and those concerned with traditional fumigation methods (local residents, community members, nearby school faculty, etc.). During these outreach events, more energy will be focused on describing the safety of a new steam sterilization approach as opposed to the traditional chemical method. Outreach events will take place at central locations throughout the state of Oregon and California where methyl bromide / chloropicrin fumigants have been traditionally used (January 1st – Merrill, Oregon / April 1st – Macdoel, California / July 1st – Red Bluff, California / October 1st – Manteca, California).

Field day events are not open to all stakeholders or the general public and are designed to educate and demonstrate a steam sterilization machine in action to strawberry rootstock and fruit growing companies, the farm managers, and farm workers employed within these organizations. Field day events will be held quarterly, on the dates January 1st, April 1st, July 1st, and October 1st respectively. Times for these events will be held at 12:00 p.m. and lunch will be served. During these field day events, the stakeholders invited will have the opportunity to observe a steam sterilization machine operate and examine its effectiveness. The researcher will present information on his or her work from the previous months on any new findings and research discovered. Field day events will be held in the same locations and same days as outreach events (January 1st – Merrill, Oregon / April 1st – Macdoel, California / July 1st – Red Bluff, California / October 1st – Manteca, California).

Outreach Event Information:

<i>Date</i>	<i>Time</i>	<i>Location</i>	<i>Method of Networking</i>
January 1 st , 2021	6:00 pm	Merrill, Oregon	Outreach Event
April 1 st , 2021	6:00 pm	Macdoel, California	Outreach Event
July 1 st , 2021	6:00 pm	Red Bluff, California	Outreach Event
October 1 st , 2021	6:00 pm	Manteca, California	Outreach Event
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January 1 st , 2022	6:00 pm	Merrill, Oregon	Outreach Event
April 1 st , 2022	6:00 pm	Macdoel, California	Outreach Event
July 1 st , 2022	6:00 pm	Red Bluff, California	Outreach Event
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October 1 st , 2023	6:00 pm	Manteca, California	Outreach Event

Field Day Event Information:

<i>Date</i>	<i>Time</i>	<i>Location</i>	<i>Method of Networking</i>
January 1 st , 2021	12:00 pm	Merrill, Oregon	Field Day Event
April 1 st , 2021	12:00 pm	Macdoel, California	Field Day Event
July 1 st , 2021	12:00 pm	Red Bluff, California	Field Day Event
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Conclusion:

It is imperative at this time, research be conducted in order to implement a commercialized steam soil sterilization method that replaces the traditional, toxic fumigants, methyl bromide and chloropicrin. The latter will soon be phased out and prohibited for use in the agricultural industry, leaving strawberry businesses helpless if no emphasis is put forth to develop an efficient mode of steam sterilization. \$50,000.00 will kickstart this research expedition, and I'm confident that with hard work and dedication, a large scale steam sterilization method will be operational in the near future when needed by the industry. Thank you for your consideration.

References

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