



Oregon State University

ECE443: Engineering Design Project
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Project Closeout Electric Weed Control

Group #5

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Design Impact Statement

Novel creations can solve many problems that society faces, but also brings a set of new problems when it comes to fruition. An electric weed control device looks to transition the agricultural industry away from herbicide use. A study in 2010 showed that 25 million agricultural workers have been exposed to pesticide poisoning every year [1]. This sort of technology is a game changer in the agricultural industry, but not all communities can afford or benefit from them. Many third world countries would not have the infrastructure to implement such devices. Amish communities are an example of a group of people that would not use the device, despite its advantages [2]. The key environmental impact of this project is the reduction of carbon. Without the need to till, the reduction of fossil fuels usage on farms could be as high as 50-80% [3]. In addition, since the soil is not disturbed, better organic biomass is created. Lastly, the digitalization of equipment will have a large economic impact. Many farmers are begrudgingly transitioning to this new world. Some farmers stated that \$100 or more per acre could be saved in fuel and equipment costs [4]. This technology has a long way to come in order to be perfected and accepted by the majority of communities. This digital revolution is affecting all sectors -- including ones stagnant to change such as agriculture. These new creations are the key to solve many of our problems we face today.

Project Timeline

Week 22

- Change engineering requirements and request approval
- Plant new test subjects (monocots and dicots)
- Pair power supply (Glenn) to electric Probe (Aziz). Check for effectiveness.)
- Test first application on single monocot and dicot.)
- Begin Initial System Checkoff
 - (1) Electric Probe
 - (2) Output Power
 - (3) Plant Material Degradation
 - (4) ** Manual Data Collection **
 - (5) ** Research Summary Graphs **

** Requirement **: To be attempted if the system works effectively.

Week 23

- Continue System Check Off
- Discuss how to pair the Arduino to the electric administration system.
- Replant new test subjects for official data collection.

Week 24

- Get the sensors working on the arduino; update the arduino code
- Improve design of power supply and probe

Week 25

- Work on the GUI code to get the GUI to take in two values form the serial port
- Meetup to pair devices and make minor improvements.

Week 26

- Continue work on the GUI code
- Meet up as a group to put together the final system
- Begin user testing for “ease of use.”

Week 27

- Meet up with the group to redo the wiring
 - Wiring must have connectors
- Shoot the videos for the final check-offs
- Work on Matlab code for the Research Summary Graph engineering requirement

Week 28

- Check off a fully functional final system.
- Documentation of steps and artifacts.

Scope and Engineering Requirements Summary

Data collection

Project Partner Requirement: Data from the system should be collected.

Engineering Requirement: The system will collect voltage modulated for the voltage booster, current of the voltage booster at least 100 times per second (or faster) and temperature and moisture data once per test.

Verification Method: Analysis

Testing Process: _____ 1) Ensure Voltage and current sensors are connected properly.

2) System is turned on.

3) Temperature probe is placed outside to gather ambient temperature.

- 4) Moisture probe is inserted into the soil.
- 5) Reupload the code to the Arduino to start the test
- 6) Open the serial monitor
- 7) The voltage, current, power, and resistance are collected at least 100 times per second; Temperature, and moisture data collected once per test

Testing Pass Condition: The voltage, current, power, and resistance are collected at least 100 times per second; Temperature, and moisture data collected once per test. Data is shown on the serial monitor

Evidence Link:

<https://drive.google.com/file/d/1jrlz1ZQhD09kQWQTp5ct9JI21IMLZXkh/view?usp=sharing>

Data display :

Project Partner Requirement: The system should display data for the user.

Engineering Requirement: The system will display the voltage, current, power, resistance, temperature, and moisture data to the user on a digital display for at least 5 minutes.

Verification Method: Demonstration

Testing Process: _____ 1) Ensure Voltage and current probes are connected to the system.

2) System is turned on.

3) Temperature probe is placed outside to gather ambient temperature.

4) Moisture probe is inserted into the soil.

5) Reupload the code to the Arduino to start the test

6) Open the serial monitor

7) The voltage, current, power, resistance, temperature, and moisture data are collected.

8) Run test for 5 min, ensuring the voltage, current, power, and resistance values are time stamped from the beginning of the test to the 5 min mark

9) Inspect data for time stamps up to 5 min

10) The voltage, current, power, resistance, temperature, and moisture data are displayed on the LCD Display and serial monitor if the sensors are collecting data.

Testing Pass Condition: If the voltage, current, power, and resistance data are time stamped from the beginning of the test to the 5 min mark, the test is passed.

Evidence Link:

<https://drive.google.com/file/d/1IA7oTKpOo3Vq30g2rffNZuGllk4ZrqLO/view?usp=sharing>

Ease of Use :

Project Partner Requirement: The system must be intuitive.

Engineering Requirement: The system will be reported as intuitive by at least 9 out of 10 users

Verification Method: Test

Testing Process:_____

- 1) 10 individuals are chosen.
- 2) Power supply is connected to an electric probe (via male to male banana plugs).
- 3) Plant Cell is chosen (ie. D1-4 ; Dicot row 1, column 4).
- 4) Grounding rod is placed in a chosen cell.
- 5a) Power supply is powered on (Depress On/Off button).

**** PROBE IS NOW ACTIVE, PLEASE KEEP AWAY FROM OBJECTS OR BODY PARTS ****

- 5b) Power supply power output is modified (See instructions below)
 - 5bi) Depress "SET" button (You will see SET highlighted on the display)
 - 5bii) Press Silver Knob (The cursor will move right. This highlighted value is your voltage)
 - 5bb) Turn the silver knob (left: decrease voltage ; right: increase voltage) to range of 0-28V
 - 5biii) Press Silver Knob 3 times (The cursor will move right. This new highlighted value is your current)
 - 5bb) Turn the silver knob (left: decrease current ; right: increase current) to range of 0-5A
- 6) Desired voltage and current should be displayed on the screen.
- 7) User touches the tip of the probe to the plant in chosen cell (electrical arcing to the plant should occur).
- 8) Power supply is powered down (Depress On/Off button).
- 9) Touch probe to the soil of the plant cell to discharge for safety.

10) Probe can now be set down and the system is off and fully discharged.

Testing Pass Condition: If 9/10 users confirm on a signed document that the system was intuitive, then system pass condition successful.

Evidence Link:

https://drive.google.com/file/d/10iY_aZVpaE3tMiYmGUR5jrF6MzOs-F84/view?usp=sharing

Electric probe :

Project Partner Requirement: The system used to kill the weeds should be probe-like

Engineering Requirement: The system will produce a single user-selectable output voltage of at least 5kV administered through a probe

Verification Method: Demonstration

Testing Process: _____

- 1) Place the two probes a user-defined distance apart. This distance in the air has a calculated spark gap of (1mm = 3kV).
- 2) System is powered on.
- 3) Spark is observed
- 3a) Spark gap is measured to be at least 2mm.
- 3b) Measure distance between probe electrodes greater than 2mm using a ruler.
- 3c) Measured distance $\geq 2\text{mm} * 3\text{kV} = 6\text{kV}$ or greater.

Testing Pass Condition: If the desired spark gap length is observed then the system has produced a user-defined single output voltage of at least 5kV successfully.

Evidence Link:

https://drive.google.com/file/d/1g_4su4bq0qtZvsLRvBBPLjQm2aHpYSG1/view?usp=sharing

Manual Data Collection :

Project Partner Requirement: There must be extensive measurements.

Engineering Requirement: The operator will collect plant height and stem diameter on 24 plants (total) (12 monocot and 12 dicot) affected by (0-3) single-applications over 72 hours.

Verification Method: Analysis

Testing Process:_____

- 1) 12 plants (of each type: monocots and dicots) are chosen for measurement (3 plants of each type are control groups -- 0 single applications).
- 2) Initial plant height and stem diameter are recorded.
 - 2b) Plants are administered high voltage (0-3) single applications
 - 2c) Plants' height and stem diameter are recorded at 24, 48, and 72-hour intervals
- 4) Data is collected and written down by the operator.
- 5) Data is manually entered into spreadsheets:
 - 5a) Dicot_Height.xlsx
 - 5b) Dicot_Stem_Diameter.xlsx
 - 5c) Monocot_Height.xlsx
 - 5d) Monocot_Stem_Diameter.xlsx

Testing Pass Condition: If the plant height and stem diameter data on 24 plants (total) (12 monocot and 12 dicot) affected by (0-3) single-applications elapsed over 72 hours is collected, condition is successful.

Evidence Link:

<https://drive.google.com/file/d/1KVmHLEYHnAW7shql7a37k9OlrAF1wTDP/view?usp=sharing>

Output Power :

Project Partner Requirement: The system must use high voltage to kill plants

Engineering Requirement: The system will output a constant voltage of at least 5kV for at least 2 seconds.

Verification Method: Demonstration

Testing Process:_____

- 1) Place the two probes a user-defined distance apart. This distance in the air has a calculated spark gap of (1mm = 3kV).
- 2) System is powered on.
 - 2b) Timer is started.
- 3) Create spark between electrodes for at least 2 seconds to ensure power is on.
 - 3a) Spark gap is measured to be at least 2mm.

Testing Pass Condition: If the system outputs a single constant voltage of at least 5kV for at least 2 seconds, test pass condition is successful.

Evidence Link:

<https://drive.google.com/file/d/1ejRJt95AM9oqvBo9k78PdxZirA4kKlrZ/view?usp=sharing>

Plant Material Degradation :

Project Partner Requirement: Use of the system must result in signs of plant degradation.

Engineering Requirement: The system will result in a decrease in plant health through observable growth patterns within 72 hours of use.

Verification Method: Inspection

Testing Process: _____

- 1) Plant cell number is chosen (ie. D1-4; Dicot row 1, column 4)
- 2) Camera is set up and begins recording
 - 2a) Plant is administered high voltage.
 - 2b) Plant is observed for a 72 hour time-lapse (ie. several pictures over 72-hour interval) to observe growth patterns.
- 3) Plant is visually inspected for signs of health degradation.

Testing Pass Condition: The 72 hour media evidence will display a decline in plant upright posture and wilting of plant material, proving plant material degradation.

Evidence Link:

https://drive.google.com/file/d/1MQkXF2TYJXIo2_4qr5BDUZPW4QGmKLge/view?usp=sharing

Research Summary Graphs:

Project Partner Requirement: There must be extensive data portrayal.

Engineering Requirement: The system will graph plant height and stem diameter vs. application count 24 plants (12 monocots and 12 dicots) over 72 hours.

Verification Method: Demonstration

Testing Process: _____

- 1) Open Requirement_Graphs (Folder)
- 2) Open Research_Summary_Graphs.m

Requirement --> NOTE: Inside you will find Excel datasheets from the "Manual Data Collection"

3) Publish Code in Matlab (This will generate a pdf of all 48 plots)

4) Open Research_Summary_Graphs.pdf

4a) System code is displayed & Graphs of Plant Data:

4aa) [12] Dicot Plant Height vs # of Applications [over 72 hours]

4ab) [12] Dicot Plant Stem Diameter vs # of Applications [over 72 hours]

4ac) [12] Monocot Plant Height vs # of Applications [over 72 hours]

4ad) [12] Monocot Plant Stem Diameter vs # of Applications [over 72 hours]

Testing Pass Condition: If the system successfully graphs at least 16 plots of plant height and stem diameter vs. application count 24 plants (12 monocots and 12 dicots) over 72 hours, test pass condition is successful.

Evidence Link:

<https://drive.google.com/file/d/1RryYJFpIBpCEHSN-TI4tksBeciQ9W9sb/view?usp=sharing>

Risk register

Summary:

Looking back on our old risk register, we had good insight on the majority of the major problems that would arise. Some unexpected problems mostly stemmed from a remote environment where our in person interactions were limited. Our power supply was often volatile in power delivery and we had to ensure that the high voltage would not damage the fragile sensors.

We learned that this sort of application is not only applicable to weed use and may be useful for commercial gardening applications. All the teammates improved their communication skills and the ability to learn and apply many different topics of knowledge.

Risk ID	Risk Description	Risk Category	Risk Probability	Risk Impact	Performance Indicator	Responsible Party	Action Plan
Risk1	The team goes over the given budget.	Cost	30%	L	Not looking for parts from different suppliers. Last minute purchasing. Not having a financial plan.	Glenn	Reduce by having one person manage the financials, plan ahead of time what needs to be bought.
Risk2	The team does not communicate properly/well.	Timeline	40%	M	Not staying active in the text group chat causes miscommunications. Everyone works individually without coordinating with group members.	Aziz	Reduce by communicating more often, meeting with group members to update on progress is very helpful. Speaking of problems when they occur straight away.
Risk3	The power delivery system malfunctions.	Technical	20%	L	Using parts that we did not research enough. Building PCB without making theoretical calculations to see if everything works. Parts not working like they should	Aziz	Get the backup device up and running
Risk4	Plant death does not occur.	Technical	50%	H	Using low voltage boosters. Power supply is not built in a stable way to perform constantly.	Glenn	Reduce by testing everything we build before moving on to next task
Risk5	Having trouble troubleshooting the code or system because of the group being in different countries.	Technical	40%	M	Making a code for a different part than the one used. Not sending the code for testing and adjusting.	David	Retain. This risk can not be eliminated but can be worked with.

Future Recommendations

Recommendation	Reason for Recommendation	Starting point for solution
Bladeless Lawn Mower	The intense heat from the probe's arcing electricity beheaded the monocot samples (common grasses). An electric motor with a charged rod for trimming grass.	Use the same device setup to test effectiveness on varying types of grass and moisture content (to avoid fires). Create a large charged rod with electrodes on opposite ends.
Attaching to a Roomba	The original concept of the design; It would be a good alternative to do instead of the concept our group went with	Taking apart a Roomba to get a grasp on the internal design of the body; Datasheet/blueprint if the circuitry involved
Better power supply	It is recommended to have a better power supply because the power supply the power system we build had a safety feature that cut off the power a lot, and was unreliable in delivering consistent power	Research on different power supplies; which can deliver consistent power
Electric Shears	Cauterizing plants when cuts are made to avoid bacterial infections.	Research on cauterizing cut plants. Find a "woody" type plant, make a cross sectional cut with sheers and apply heat + observe.
Timer module for Probe	A set timer that can allow for a user-defined application period. This would deliver consistent power to the system.	Create a switch that will cut off with time. This can be done with analog or digital applications.
Emergency shut-off system	A safety feature in case the electricity runs rampant/incorrect wiring	Look into different shut-off mechanisms: circuit breakers, relays, etc.
Larger Research samples	More research subjects would lead to more convincing results	Plant additional monocots and dicots for testing.
Different Metrics for Data Collection	Our two metrics (height and stem diameter) were not good indicators of plant health.	CO2 emission from plants would be a good start to know when plants are dying. More rigorous data collection.

References

[1] "Health Risks of Pesticides in Food," Jan-2013. [Online]. Available:

https://depts.washington.edu/ceeh/downloads/FF_Pesticides.pdf.

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[4] "35 Years of No-Till Savings," No-Till Farmer. [Online]. Available:

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