The Effects of Vermicompost Applications on Densities of Aphids and Growth Characteristics in Romaine Lettuce (*Lactuca sativa L. var. longifolia*)

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What is Sustainable Farming?

- Support research and education to help farmers and ranchers mitigate and adapt to climate change.
- Adoption of practices that are profitable and environmentally sound
- Improve production efficiency, productivity, and profitability.
- Improve the quality of surface water and groundwater resources.
- Address threats from pests and diseases.

(USDA, 2020)

Sustainable agriculture has become an important area of study as the trend toward organic produce demand continues to rise (Knutson, 2019).

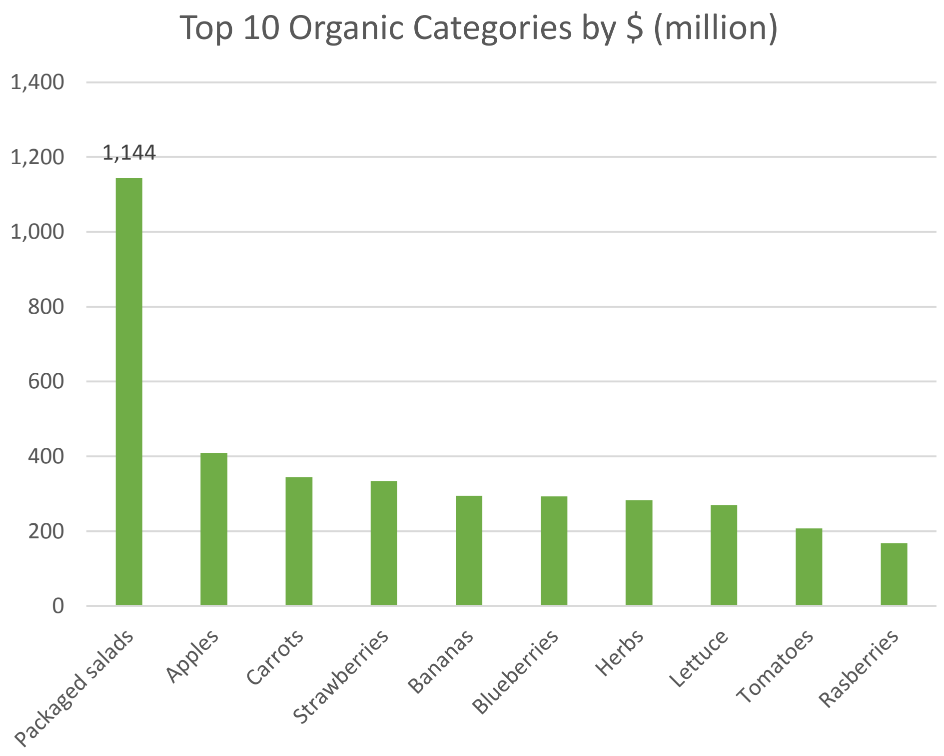
Demand for Organic Products

- Rise in popularity of specialty markets like Whole Foods.
- introduction of organic produce into big-box retailers.
- On average, consumers are paying $1.51 lb. more for organic produce.
- A new “millennial” consumer has a public awareness regarding organic and sustainable products.

(Lutz & Long, 2019)

Demand for Organic Lettuce

- Prepackaged salads account for nearly 20% of all organic sales in 2019 (Lutz & Long, 2019).
- Three-quarters of the romaine lettuce in the U. S. is grown in two regions; the Central Coast and Yuma, Arizona (USDA 2020).
- In 2019, Organic lettuce revenue reached $400 million, an increase of 44% as compared to 2016 (USDA, NASS, 2020).



(Lutz & Long, 2019)

Romaine Lettuce

- Most nutrient-rich of all lettuce varieties.
- Considered “premium”.
- Americans consume 30 pounds of lettuce per person each year. (USDA, 2019).
- Romaine lettuce is expected to surpass the demand for iceberg which is currently the best-selling type of lettuce.

Aphid Infestation

- High marketplace quality standards. (Forbes & McKenzie, 1982)
- Excrement contamination. (Kerns et al, 1999)
- Plant weakening fresults rom sucking of plant nutrients.
- Disease vectors. (UC IPM)

Letter Aphid
Nasonovia ribis-nigri

- Center location of lettuce
- Dispersion rather than colony formation
- Short life cycle/quick reproduction

Green peach aphid
Myzus persicae

- Dark green to yellow, no waxy covering
- Infest in colonies moving up the plant
- Vector of viruses (lettuce mosaic virus)

Earthworms

- *Eisenia foetida* (Red of California), *Lumbricus terrestris*, and *Lumbricus rubellus* are soil-dwelling invertebrate (phylum Annelida) most used in composting processes (Lamim et al., 1998).

- Life span ranges from 3-7 years (Pathma & Sakthivel, 2012).

- Earthworms are decomposers, yet they excrete most of the consumed organic matter half-digested and absorb only a small amount for their growth (Edwards and Lofty, 1977).

- Earthworms can consume animal waste,food waste, sewage sludge and crop residues (Martinkosky, 2017; Rodriquez-Campos, 2014).

Vermicompost

Converting the physical state and microbial composition of organic matter of a two-part process.

PHASE !

- Residing within the earthworm gut, mucus contains protein and polysaccharides, organic and mineral matter, amino acids, digestive enzymes, microbial bacteria, protozoa and micro fungi (Pathma & Sakthivel, 2012).
- Organic matter is blended and ground, while calcium, humic acid are added.
- Combat pathogens and other malignant organisms through phagocytosis and encapsulation (Dvořák, 2013).
- Activation of dormant microbes and germination of endospores. Yeast and fungi pass through unchanged while bacteria and actinomycetes increase from the foregut to hindgut (Parle, 1959).
- Plant residues and polysaccharide are loosely molded together to form partially digested “casts” (Edwards, 2004; Lazcano et al., 2008).

PHASE 2

- Maturation phase, the microbes within the casts double in the first week as microbes take over in the decomposition of the waste. Yeasts increases and fungi, present almost entirely as spores in the gut, start to germinate in the casts (Parle, 1963b).

Potential Benefits

- Review papers have evaluated the low cost method and beneficial effects of vermicompost on plants and soil (Adhikary, 2012; Datta et al., 2016; Joshi et al., 2015).

- Studies have indicated vermicompost improves soil porosity, water holding capacity and improves soil texture (Durak, 2017; Sinha et al., 2011).

- Significant research that has demonstrated worm castings increase yields, plant growth and some resistance to insects when incorporated into soil (Arancon et al., 2005; Joshi et al., 2015; Pathma & Sakhtivel, 2012).

- Vermicompost elicits a protection response within plants deterring crop pests and diseases by repelling them or by inducing biological resistance to fight them (Joshi et al., 2015).

- SUSTSAINABLE OPTION FOR SUSTAINABLE FARMING

Literature Review

- Soil Structure
- Plant Growth
- Humic Acid
- Vermicompost Comparison to Compost
- Heavy Metal Remediation and pH Optimization
- Fertilizer
- Pest Resistance
- Pathogen and Plant Disease Suppression

Soil Structure

Soil Structure

Production of water stable aggregates (earthworm cast)

Reduce soil erosion

Evans et al., 2011

Jonquet et al., 2012

Decrease soil compaction

Jack & Thies, 2006

Joshi et al., 2015

Pathma & Sakthivel, 2012

pH Adjustment

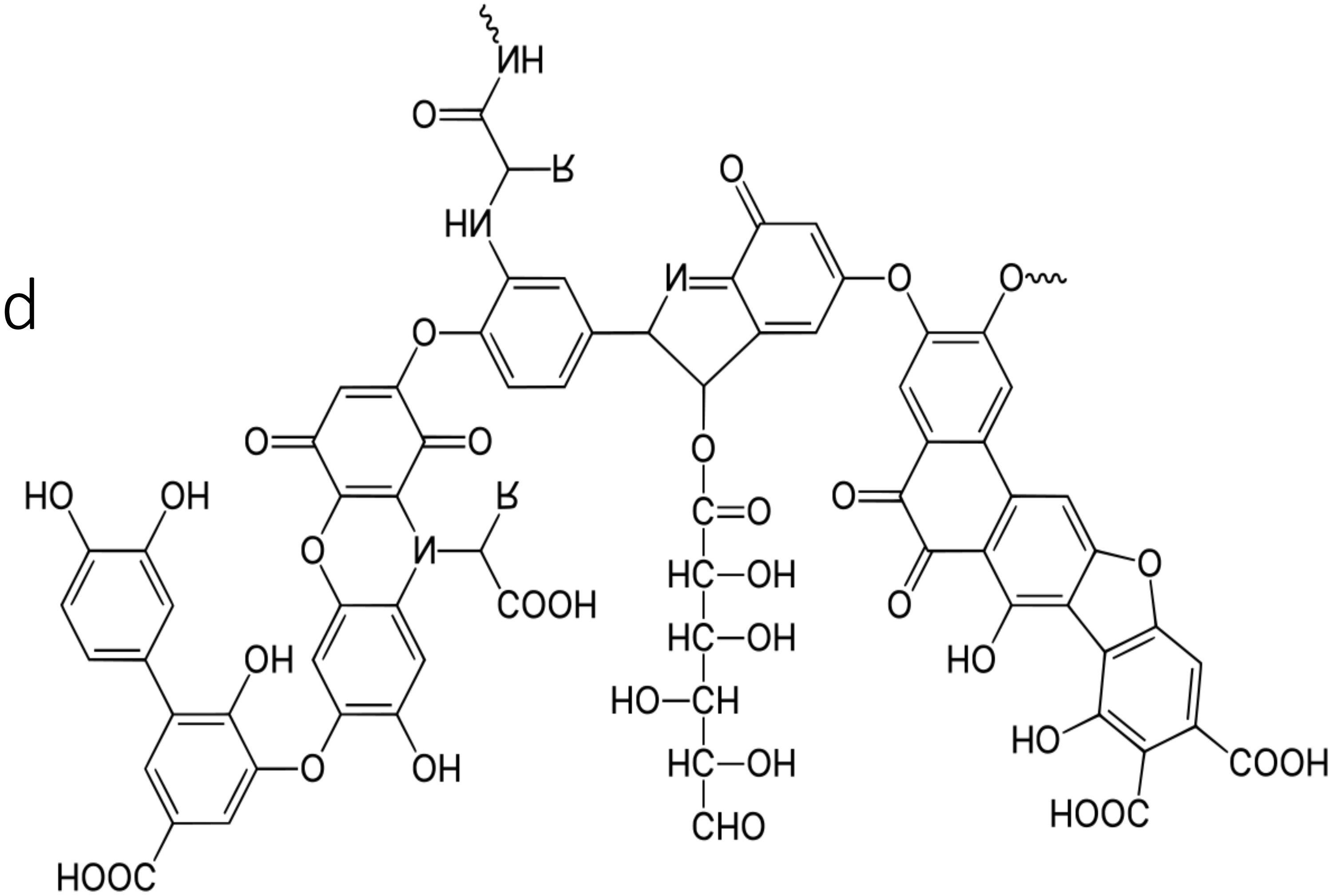
Annapoorter et al., 2011

Plant Growth

Overall plant health

Crop/Plants	Parameters enhanced	Study
Basil (Ocimum basilicum L.)	Wet and dry yield, essence yield, chlorophyll content	Befrozfar et al., (2013)
Marigold (Tagetes), pepper (Capsicum), and strawberry (Fragaria × ananassa)	Plant heights, leaf areas, shoot dry weights, root dry weights, numbers of fruits	Arancon et al., (2003)
Tomato (Lycopersicum esculentum) and Cucumber (Cucumis sativus)	Plant height, leaf area, root dry weight, shoot dry weight	Atiyeh et al., (2002)

Humic Acid



WIkipedia

(Hernandez et al., (2015)

Study

OBJECTIVES

Observe the effects of humic acid on growth and yield maturity

Liquid humates were applied at different concentrations of 10, 15, or 20 mg C L^{-1}

- seedling stage
- 15 days after transplantation

Results

Humates at 15 mg C L^{-1} **reduced lettuce harvest time** by 21 days in the production cycle.

Lettuce **yields were increased** (by the number of leaves on each head) while **quality remained stable**.

Humate application also **decreased total carbohydrate, increased protein, increased N uptake, and stimulated nitrate reductase and phenylalanine ammonia lyase** in lettuce leaves.

Discussion

These studies indicated that plant growth regulators are correlated to the presence of humic acid and benefit plant's growth characteristics.

Atiyeh et al., (2002), Arancon et al., (2004), Edwards et al., (2006)

- Plant growth regulators, symbiotic microorganisms and growth hormones are absorbed by humic acid during vermiculture.

- Increase in humic acid increases plant growth.

Compost
Compared to Vermicompost

Compost vs. vermicompost

Parmeter	Compost	Vermicompost
Temperature	**Thermophilic 45–65 °C**	**Mesophilic 25–40 °C**
Phases	a. Thermophilic phase: active phase of composting; intense decomposition	1. Active phase: earthworms process and modify physical and microbial composition of waste.
	b. Maturation phase: decrease in temperature at mesophilic range; slower decomposition	2. Maturation phase: displacement of earthworms toward fresh layers of organic matter, microbes take over the role of decomposition
Action	Only microbes	Microbes and earthworms
End product	Slightly heterogeneous, stabilized humus-like material	Stabilized, homogenous, finely divided peat-like material
Use	Well established on industrial scale	Not fully adapted on industrial scale
Drawbacks/limitations	Volatilization of NH_3 during thermophilic process	Requirement of maintenance of mesophilic temperature; neutral pH and high humidity
Nutritional quality	**Low nutrient content and low microbial activity**	**High nutrient content and microbial activity**
Economy	**Low price**	**Triple that of compost**

Datta, S., Singh, J., and Singh, S., *2016*

Heavy Metal Remediation and pH Optimization

Liu et al.(2019)

STUDY

OBJECTIVES

- Investigated the potential effects of vermicompost and biochar (charcoal produced by pyrolysis of organic matter, in the absence of oxygen) as a soil amendment on acidic soil that was contaminated with heavy metals .

RESULTS

- Vermicompost increased the previously acidic soil pH level by a range of 0.7 units to 1.5 units.
- Decreased the extractable metals (Cd, Ni, and Cr) in the toxic soil.
- Soil quality was enhanced by the formation of water stable aggregates when vermicompost (stable organic matter) was introduced, which aids in the immobilizing of potentially toxic metal

DISCUSSION

- The high cation exchange capacity and the humic substances in vermicompost has shown to be effective in the remediation of pollutants and absorbtion of heavy metals in soils

Fertilizers

Kale et al. (1992)

STUDY

OBJECTIVES

Studied the effects of reducing the recommended amount of synthetic fertilizer on crops by using vermicompost as organic fertilizer.

PURPOSE

Potential to reduce current levels of recommended fertilizers when amending with vermicompost.

The summer crop of paddy variety “HAMSA” was divided into two plots

- the control plot received the standard dosage of farmyard manure and chemical fertilizers
- experimental plot received half the standard dosage of chemical fertilizers and a vermicompost application.

RESULTS

- Microbial colonization in the experimental plot was found to be higher than the control plot. Mycorrhizae colonization in the roots was considerably lower , 2.85% in the control plot, as compared to the 10% in the experimental plot.
- After harvest, the microbial colonies were significantly higher in the experimental plots, excluding the Actinomycetes.
- A higher level of total N in the experimental plot which received vermicompost amendment with less quantity of chemical fertilizers.

DISCUSSION

- This may be due to the higher count of N-fixers (3.48×10^3) observed in the experimental plot than that of the control plot (2.16×10^3)
- These results showed a positive relationship with vermicompost and the microbes within the soil system

Doan et al. (2013)

Study Example opposing vermicompost results.

Objective

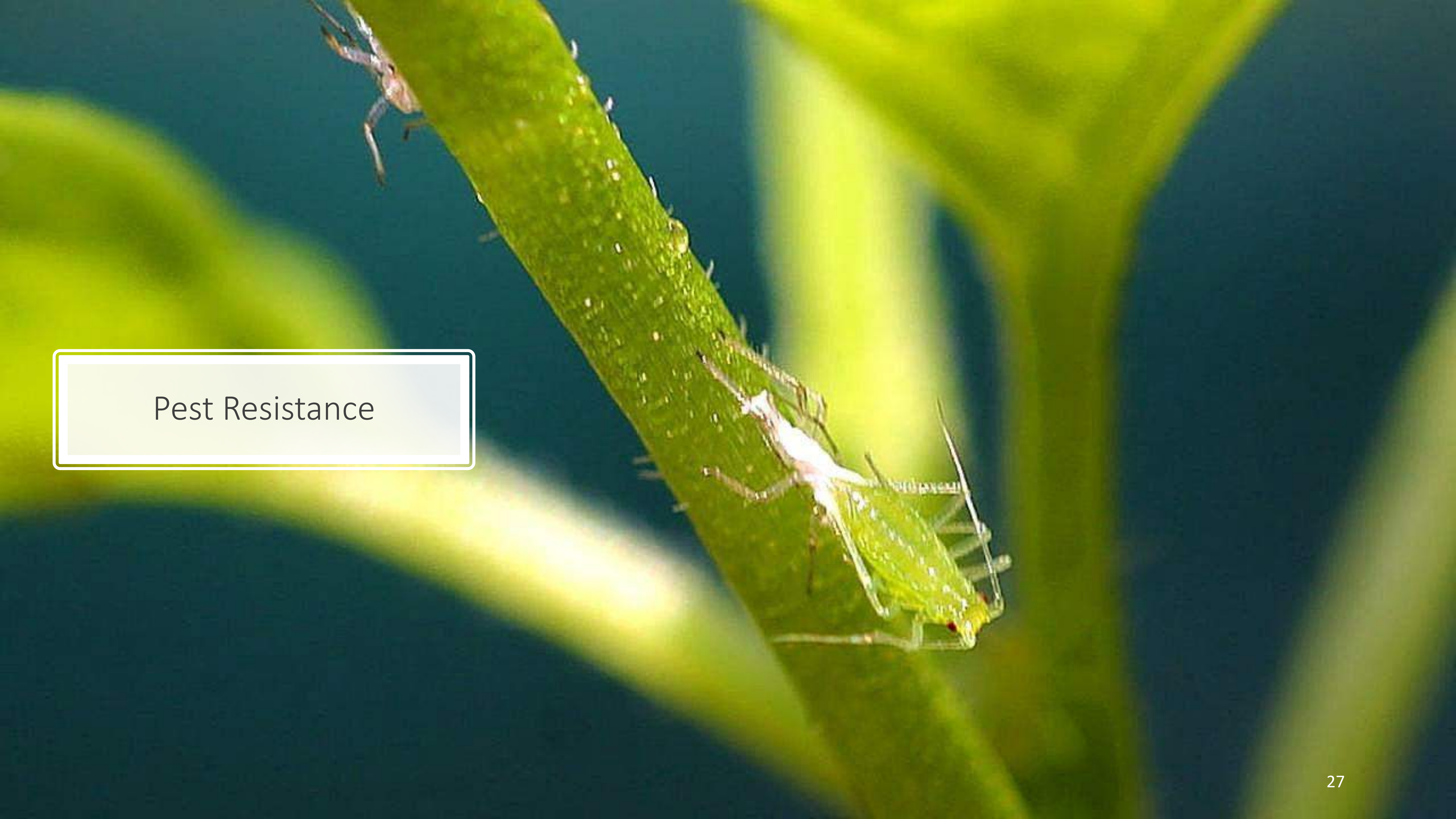
To compare standard compost, vermicompost, and synthetic fertilizers separately in a greenhouse setting with a maize tomato maize cycle.

RESULTS

Vermicompost and regular compost didn’t perform as well as mineral fertilizers.

DISCUSSION

The highly inconsistent nature of composted amendments and the complexity of earthworm interactions, as the probable explanation for the negligible positive effects of vermicompost.



Pest Resistance

Arancon et al., 2005

STUDY

Vermicompost at 0%, 20%, and 40% into a soilless potting medium

OBJECTIVES:

Examined the levels of pest populations and damage by aphids, mealy bugs and cabbage white caterpillars on tomatoes, cabbage, and peppers

PURPOSE:

Determine if vermicompost would effect the plant's natural pest resistance.

RESULTS:

- Significantly suppressed populations of both aphids and mealy bugs on peppers,
- mealy bugs on tomatoes.
- Decreased losses of dry weights of peppers to both aphid and mealy bug infestations
- Significantly decreased losses in shoot dry weights of tomatoes after mealy bug infestations.
- Significantly decreased losses in leaf areas of cabbage seedlings in response to the cabbage white caterpillar infestations.

CONCLUSION:

Implies a systemic resistance in cabbage to pest attacks and could indicate a natural defense protection in plants against pests.

Phenolic compounds act as feeding deterrent

Patriquin et al. (1995)

STUDY

PURPOSE: Change in plant physiology or morphology when subjected to different nutrient levels

RESULTS

- Expressed different characteristics and growth in thickness and degree of lignification of epidermal cells
- Sugar concentrations in the apoplast
- Onset of senescence
- Amino-N in phloem sap
- Secondary plant compounds

CONCLUSION

- The natural defense to pest attacks could be based on a change in plant physiology or morphology, due to a difference in availability of mineral nutrients to plants or on changes in the balance of available nutrients rendering a plant more resistant.

Pathogen and Disease Suppression

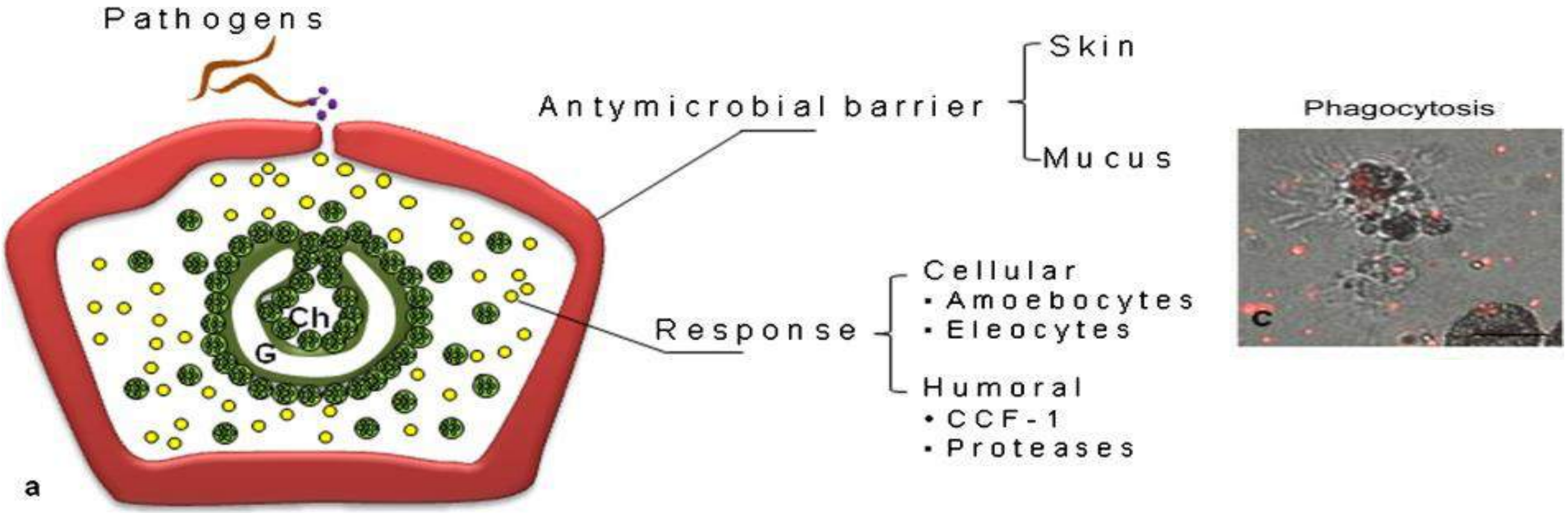
Disease/Pathogen Control

Authors	**Study**	**Results**
Plavšin, Velki, Ečimović, Cosic, 2017	Inhibitory effect of earthworm **coelomic fluid** on growth of the plant parasitic fungus Fusarium oxysporum	**Significant reductions in phytopathogenic fungi-24-72 hours**
Yadav, Tare & Ahammed, 2010	Vermicomposting of source-separated human faeces for nutrient recycling	**Reduce or eliminate pathogenic bacterial populations in most pathogen dense substrates - human**

Coleomic fluid/Coleomycetes

Anatomy of the earthworm immune system and immune effector mechanisms

-Homa, 2019



Methodology

- Objectives
- Hypothesis
- Research design
- Materials/Methods
- Statistical Analysis

Objectives

- Determine the potential effects of solid vermicompost in sustainably increasing pest resistance and improving lettuce health without heavy reliance on synthetic pesticides in organic lettuce production.

- Develop best application method to achieve the best results possible.

Hypotheses

H_1: Vermicompost will have a significant effect on densities of aphids on romaine lettuce.

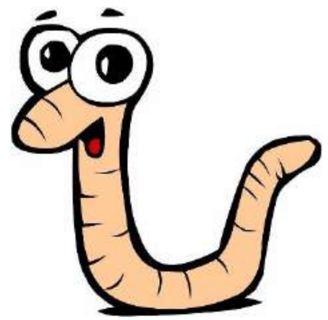
Ho: Vermicompost will have no significant effect on densities of aphids on romaine lettuce.

H_1: Vermicompost will have a significant effect on growth characteristics of romaine lettuce.

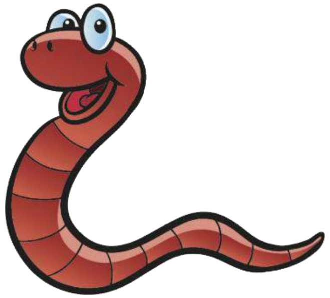
Ho: Vermicompost will have no significant effect on growth characteristics of romaine lettuce.

Independent Variables -Treatments

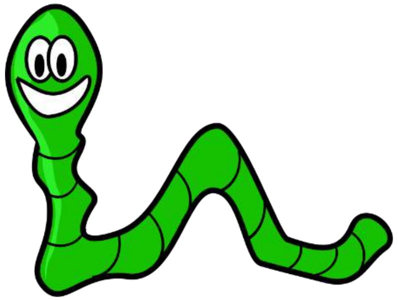
Multiple Variables



Root zone treatment application 6" deep



Top dress treatment application sprinkled on topsoil

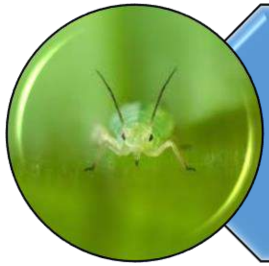


Both treatments application of 1/2 of each

Control Treatment of No application

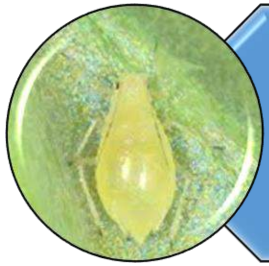
Dependent Variables

Multiple Outcomes



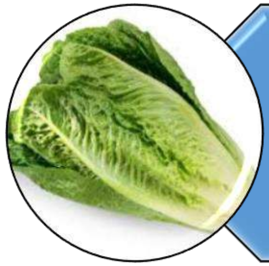
Insect Densities (Lettuce Aphid)

- Outer whirl
- Mid whirl
- Inner whirl



Insect Densities (Green peach Aphid)

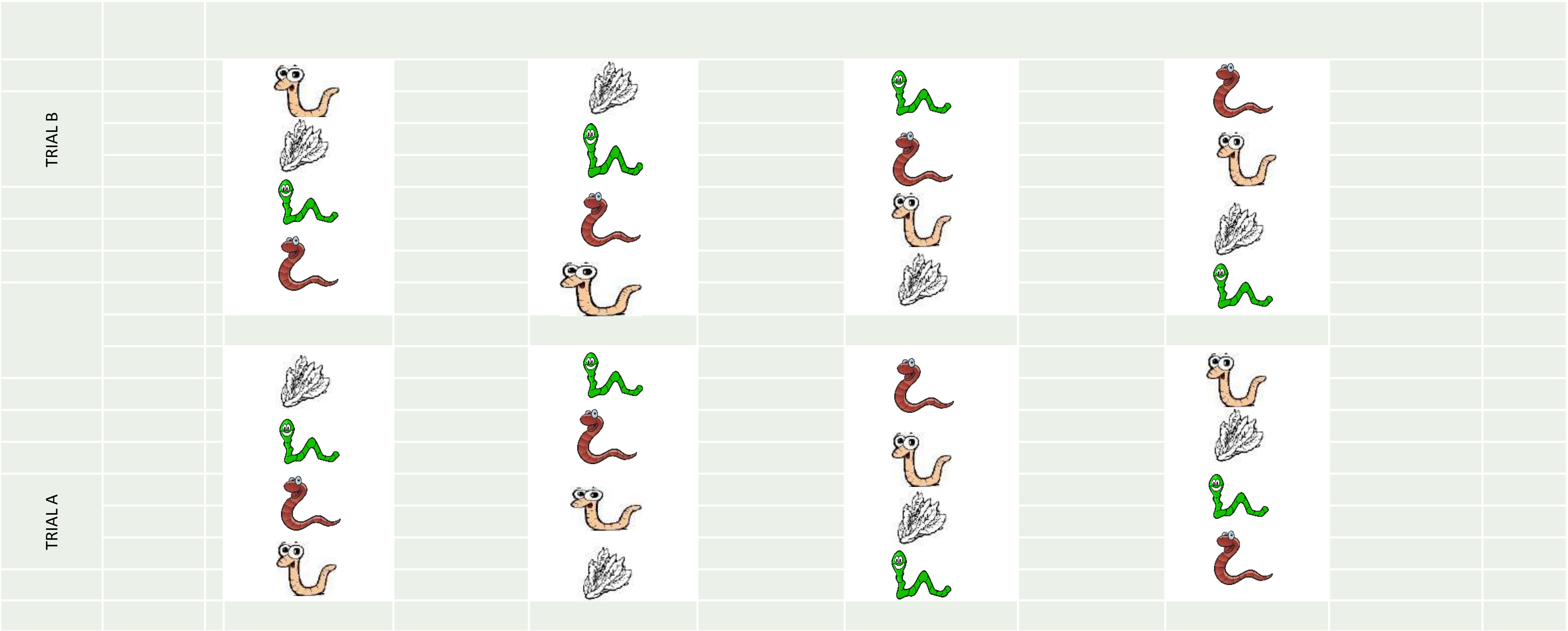
- Outer whirl
- Mid whirl
- Inner whirl



Growth Characteristics

- Head weight
- Head height
- Root mass

Complete Block Design



Vermicompost Root zone

Vermicompost Top dress

Vermicompost Root zone &Vermicompost Top dress

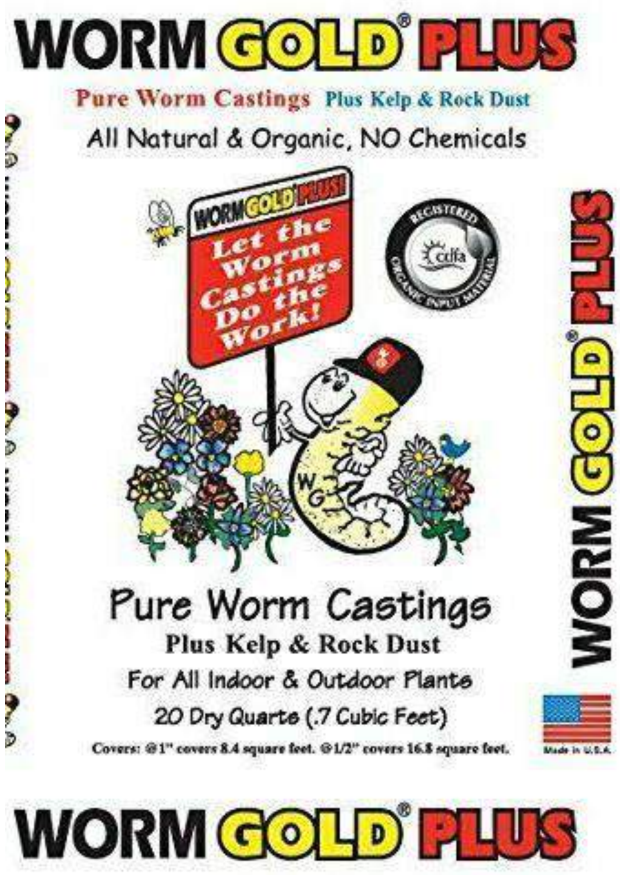
Control No Treatment

4 Replications

Trial A – April-June
Trial B – July-Sept

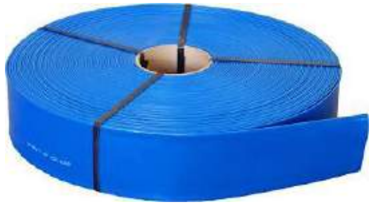
Application Methods

Top Dress Treatment



11 lbs per block

Root Treatment



Dripline Irrigation

Aphid density measurement

Bag 48 sample heads
(3 heads/16 blocks)

Outermost (10 leaves)

Wrapper (10 leaves)

Innermost (10 leaves)

Count and Identify species

Lettuce aphid

Green peach aphid

Weekly Measurements after the initial seedling stage of 3 weeks

(Makenzie & Vernon, 1988)

Growth Characteristic Measurement (Harvest)

ROOT DRY MASS (g)

HEIGHT (mm)

HEAD WEIGHT (g)

Statistical Analysis

SPSS SOFTWARE

STATISTICAL PACKAGE FOR SOCIAL SCIENCE

(IBM VERSION 26)

DESCRIPTIVE STATISTICS

MULTI VARIANCE OF ANALYSIS-MANOVA

SIGNIFICANCE LEVEL

$P < .05$

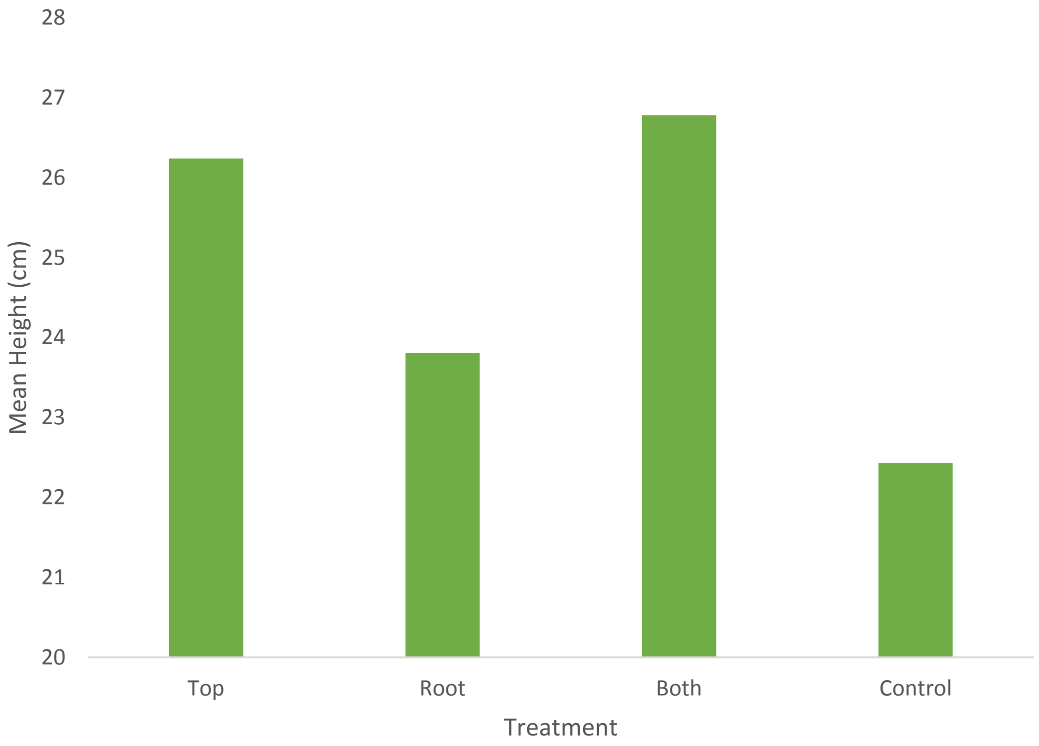
Results – Trial A

There was not was a statistically significant difference in plant height, head weight, and root biomass based on treatments of vermicompost

F (102.368, 0.115) = 1.545, p = .139; Wilk's Λ = 0.721, partial η^2 = .61.

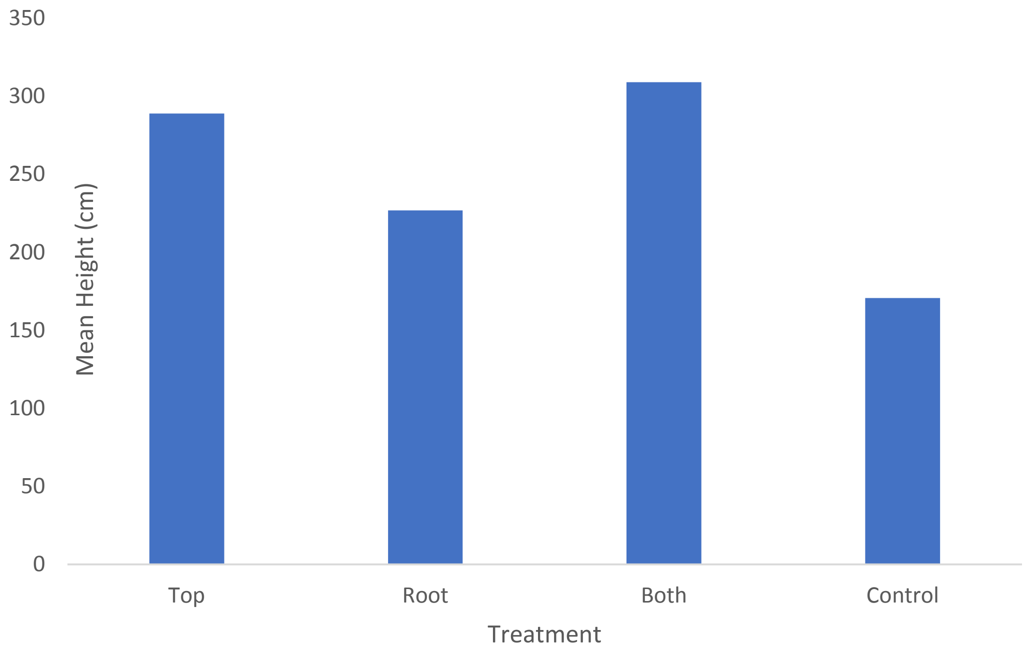
The aphid densities were inconclusive

Height –Trial A



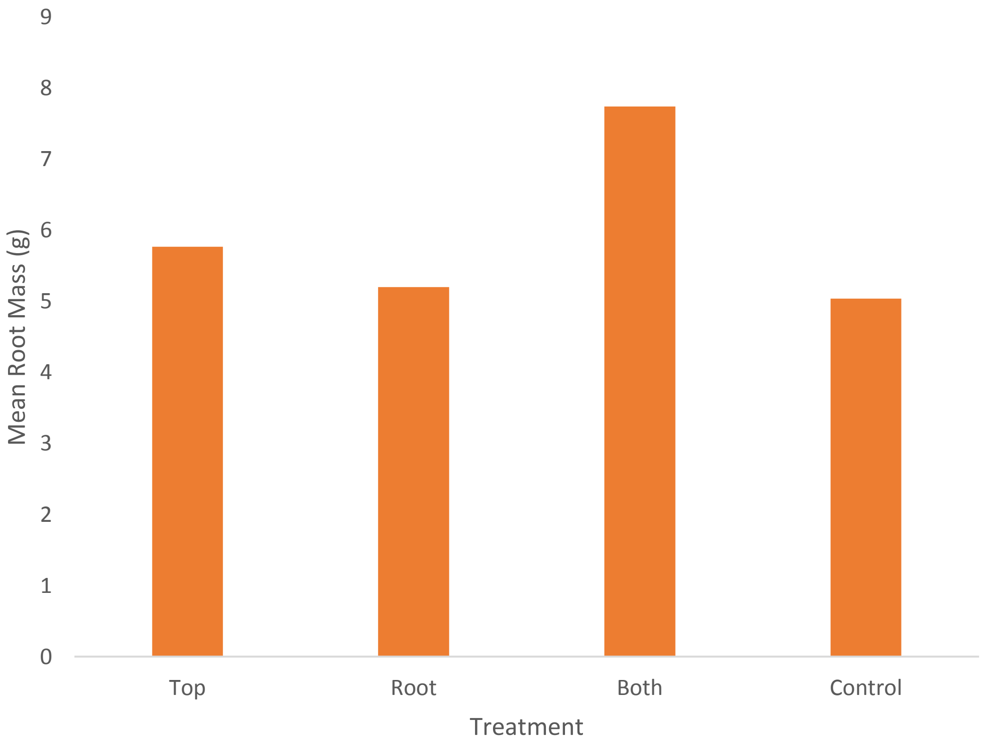
- **The top dress (20.7 cm), root (22.05 cm), and both top and root treatment (21.87 cm) outperformed the control group (23.81 cm).**

Head Weight –Trial A



- **All treatments; top (288.7 g), root (226.75 g), and both (308.81 g) outperformed the control (170.52 g).**

Root mass –Trial A



- **Top (5.77 cm) and root (5.2 cm) and the both treatment (7.74 cm) all performed higher than the control treatment (5.04 cm).**

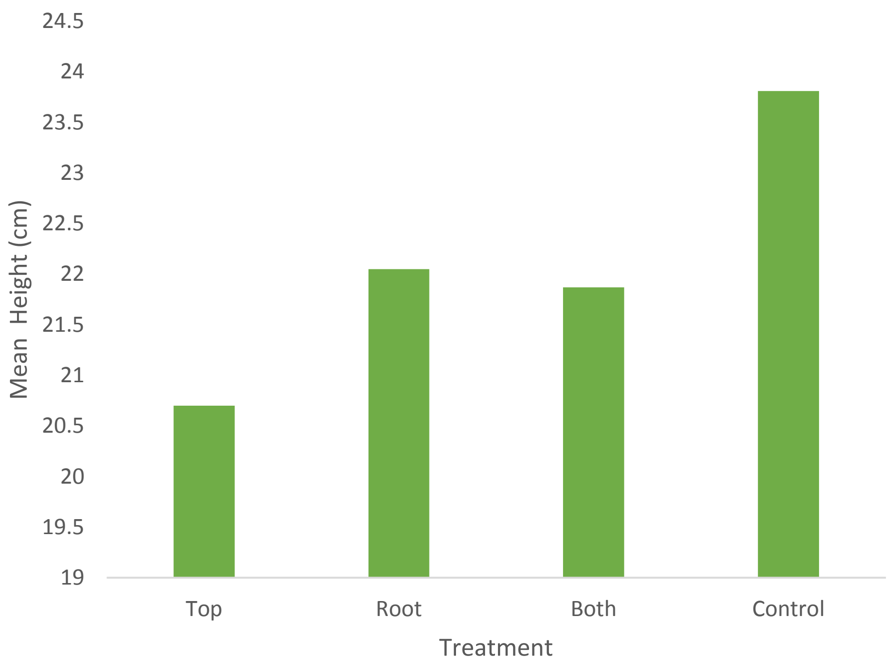
Results – Trial B

There was not was a statistically significant difference in plant height, head weight, and root biomass based on treatments of vermicompost

F (102.368, 0.115) = 1.545, $p = .145$; Wilk's $\Lambda = 0.721$, partial $\eta^2 = .61$.

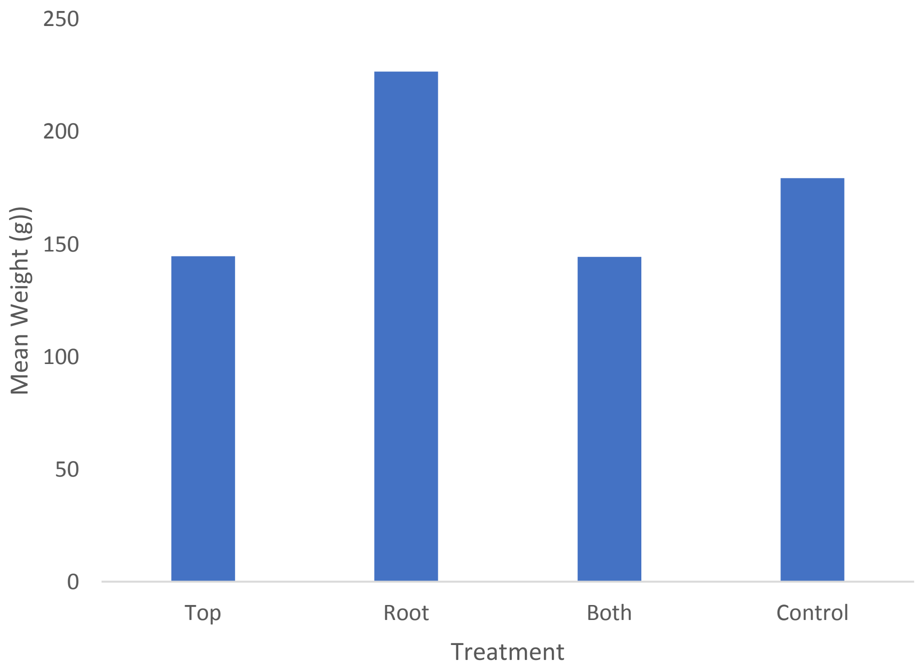
The aphid densities were inconclusive

Height –Trial B



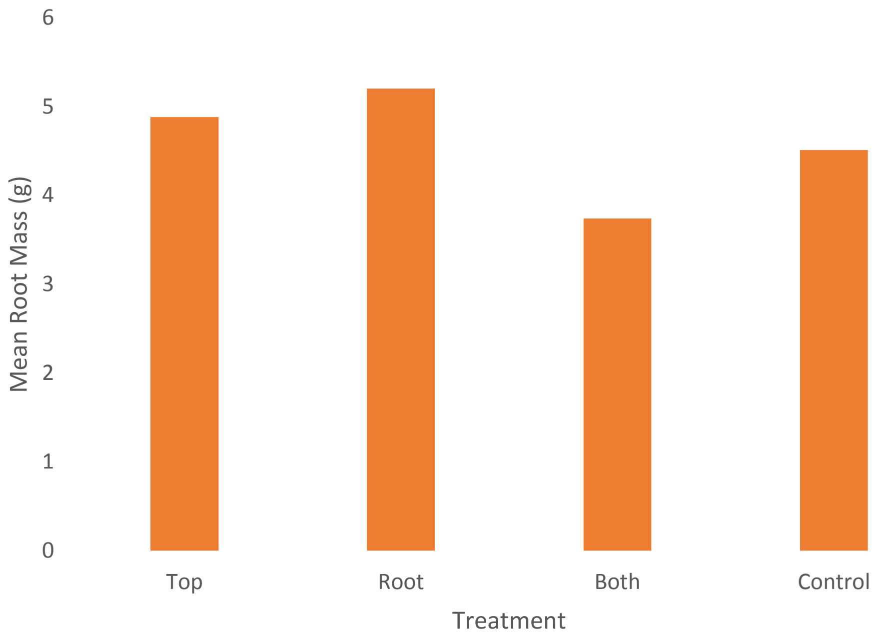
- **The top dress (20.7 cm), root (22.05 cm), and the treatment with both top and root (21.87 cm) all outperformed the control group (23.81 cm)**

Head Weight –Trial B



- **Top dress treatment (144.67 g) and both (144.46 g) were lower than the control (179.40 g), while the root treatment outperformed the control (226.75 g).**

Root mass –Trial B



- **control for root biomass length, top (4.88 cm) and root (5.2 cm) were higher than the control treatment (4.51 cm) yet the treatment for both (3.74 cm) was lower than the control.**

Discussion

Substantial Beneficial Insect Population

- **Lady beetle**
- **Predatory wasp**
- **Green lacewing**
- **Spider**
- **Praying Manti**
- **Srphid fly**

(Dara et al., 2017)

Difference in Trial A vs. Trial B

- **Trend toward growth improvement from vermicompost application.**

- **Warmer temperatures**
- **Vermcompost cured for 1 month in soil before trial began**
- **Fewer weeds**
- **Less crops planted**

?

Finished product variability

A study by Jemal & Abebe (2014), found that Variations in the feed components have been found to yield different results in yield quality.

Each study used a wide variety of vermicomposts which had different feed components.

Resulted in study not finding a significant difference.

Conclusion

Limitations

Future Directions of Research

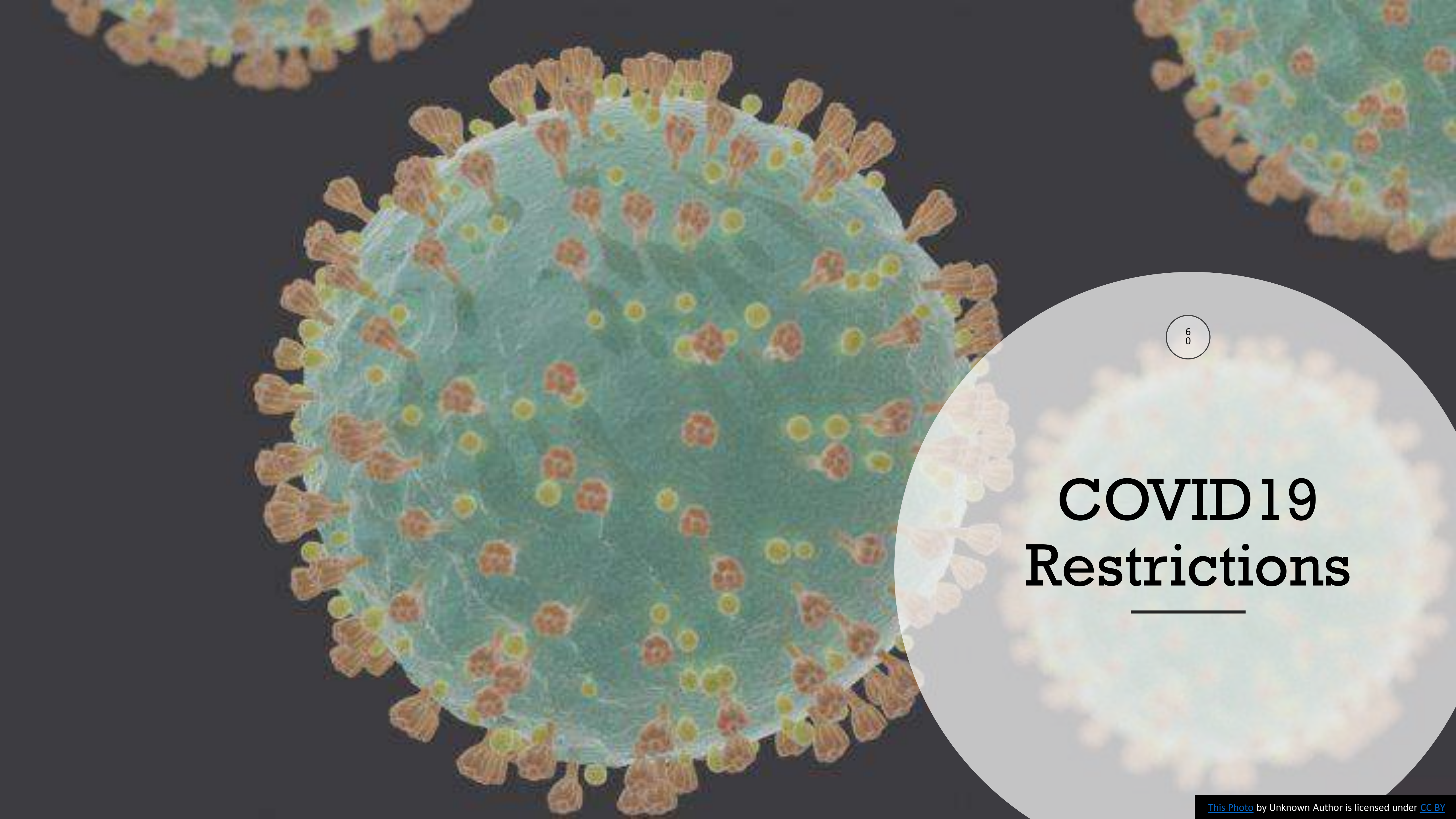
Limitations

Field vs. Greenhouse

- **Weather (Heat/cold)**
- **Insect Pests can’t be controlled**
- **Host Crops nearby**

Chlorine Effect on Microbial Population

- **Municipal Water rather than well or canal water**
- **Tested Weekly average of .03 ppm**
- **Safe drinking level is 4 ppm**
- **Intent of additive is to kill dangerous pathogenic bacteria**



COVID19 Restrictions

Future Directions of Research

Increase understanding of humic acid in plant growth

How to humic acid to achieve desired results in agriculture

Larger field study with several lettuce types.

Incorporating vermicompost tea as an aqueous solution in treatments.

Add aphids to a caged a plot to guarantee the pest population.

Future research providing a cost/benefit analysis of integrating vermicompost methods, into an integrated pest management (IPM) system.

Improve long-range soil fertility.

Reduction in current insecticide cost.

Is it a feasible alternative if proven to be cost effective, consistent, and locally available to the agriculture industry.

Summary

- Leveraging the current trends to transition conventional-farming practices towards organic and sustainable, environmentally responsible farming.
- Many studies have shown the potential for vermicompost to improve soil quality, remediate pollutants, and provide amendments for improved plant growth and health.
- Additional studies have shown vermicompost has the potential to reduce synthetic fertilizer levels, restrict pesticide leeching, and increase natural pest resistance.
- Our research had inconclusive results with aphid densities but did show a trend within our frequency tables that showed the "both" treatment to have a higher mean value, as well as the top and root treatment mean value when compared to the control in Trial A. Although the results from Trial B did not show the same trend, this research shows the difficulty of confounding variables in field trials.
- Important to continue to evaluate and determine the best methods for vermicompost in order to bring alternate solutions to the sustainable farming community.

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