# The Suitability of Worm Castings & Compost Tea in Organic Hydroponic Lettuce Propagation

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**Abstract**
The purpose of this experiment was to determine the suitability of using a media composed of coconut coir and worm castings and a compost tea fertilizer for the propagation of lettuce destined for a NFT hydroponic system. Lettuce seeds were germinated in different medias composed of varying proportions of coconut coir and worm castings and fertilized daily with a worm casting based compost tea. It was determined that a media composed of 70% coconut coir and 30% castings fertilized daily with 10mL of compost tea produced the highest quality seedlings.

## I. Introduction

Hydroponic crop production systems are known for their efficiency and sustainability, but due to many of the chemicals utilized (i.e. fertilizers, pH adjusters) are traditionally "inorganic" in nature. With rising demand for "organic" produce and with such products fetching prices upwards of 50% higher in the market there is much interest in converting these traditional systems to ones that meet the criteria to be classified as "Certified Organic". Different approaches to accomplish this goal are currently being investigated, but for the most part this research is being conducted by commercial operations and thus results are proprietary. One approach that has shown great potential is using a "compost tea" as the fertilizer solution and using a compost-based media.

The practice of brewing compost into a "tea" and utilizing it as a supplemental fertilizer for agriculture has been around for a many years. Recent research has suggested that there are significant benefits to using compost tea ranging from increased plant vigor, increased pest and disease resistance, curing of nutrient deficiencies, and even the possibility for its use as a primary fertilizer. Unfortunately this research has focused on the use of compost tea in field agriculture, and few studies have been conducted on its use in hydroponic, controlled environment crop production settings. Because of the positive results found in field studies, this experiment will investigate a potential use for compost tea in a hydroponic lettuce production system.

The most critical ingredient in any compost tea is the compost. There are a number of different types of composts, each categorized based on its method of production. The simplest forms of compost are known as "static pile" and "aerated pile" compost, where organic waste is formed into a mound and allowed to decompose with time, with or without aeration. This method takes a long period of time, and results in only semi-complete decomposition. A much more effective method of producing compost is using worms. These worms consume and decompose the organic waste completely into compost known as "worm castings" or "vermicompost". Since worm castings have a higher nutrient content than other forms of compost they will be used as the compost in this experiment

This experiment will focus on the use of both a worm casting based media and worm casting compost tea in a lettuce propagation system. In the experimental treatments, lettuce seeds will be germinated in a variety of media composed of different ratios of coconut coir to worm castings. The seedlings will be fertilized with 10mL/day of Compost Tea. These experimental treatments will be compared against two control media, Rockwool and Coconut Coir, both fertilized with 10mL/day of traditional half-strength modified Hoagland's solution. The experiment will last 12 days (Day 0-Day 11), the time from seed to transplant in commercial hydroponic lettuce production systems.

## II. Hypothesis

It is predicted that seedling quality will increase as the concentration of worm castings in the starting media increases up to a "critical concentration", after which germination/seedling quality will rapidly decrease. It is also predicted that the seedlings treated with Compost Tea will be of higher quality than those treated with the Inorganic Hoagland's Solution.

## III. Materials & Methods

a) Materials
   1) 130, "Rex" Lettuce Seeds - Pelleted (Johnny's Select Seeds)
   2) 5, 1020 Propagation Flats w/ Humidity Domes
   3) 130, 2" Net Pots
   4) 2, 5mL Plastic Pipets
   5) 1, "Big Daddy" OMRI Certified Cococoir Grow Bag
   6) 1, 30lb Bag of Worm Castings ("Wiggle Worm Soil Builder" Brand, 1-0-0 Guaranteed Analysis)
   7) 10, 1" Rockwool Cubes
   8) Modified Hoagland's Solution (See Supporting Appendices "Document #1")
   9) Compost Tea (See Supporting Appendicies "Document #2")

b) Methods
   1) Each seedling was grown in a 2" net pot. The seeds were planted on 11/3/11 (Day 0) and grown until 11/14/11 (Day 11). Net pots were kept in 1020 propagation flats covered with standard Humidity Domes to prevent drying of media.
   2) Before seeding, the 2" net pots were filled with different media according to the treatment. The Cococoir and worm castings were measured volumetrically to produce the combinations.
      *Treatment #1:* Control - Rockwool
      *Treatment #2:* Control – Coconut Coir
      *Treatment #3:* 100% CocoCoir
      *Treatment #4:* 90% CocoCoir, 10% Worm Castings
      *Treatment #5:* 80% CocoCoir, 20% Worm Castings
      *Treatment #6:* 70% CocoCoir, 30% Worm Castings
      *Treatment #7:* 60% CocoCoir, 40% Worm Castings
      *Treatment #8:* 50% CocoCoir, 50% Worm Castings
      *Treatment #9:* 40% CocoCoir, 60% Worm Castings
      *Treatment #10:* 30% CocoCoir, 70% Worm Castings
      *Treatment #11:* 20% CocoCoir, 80% Worm Castings
      *Treatment #12:* 10% CocoCoir, 90% Worm Castings
      *Treatment #13:* 100% Worm Castings
   3) Seeds were sowed 1/8" deep in media, 1 seed per net pot.
   4) On Day 0, all treatments were watered with an overhead mist for 35 seconds.
   5) Fertilization began on Day 1. Each seedling received 10mL/day of fertilizer applied by hand with a 5mL pipet.
      *Treatments #1-2 (Controls)*: Half-strength modified Hoagland's solution (see Supporting Appendicies Document #1)
      *Treatments #3-13 (Experimental)*: Worm casting based Compost Tea (see Supporting Appendices Document #2)
   6) Photographs were taken daily to monitor growth.
   7) Germination percentage was monitored through Day 4.
   8) Final Data was collected on Day 11.
      i. Percent Root Protrusion – Visually identified and counted
      ii. True Leaf # - Visually identified and counted

iii. Leaf Area – measured with LI-COR Biosciences LI-3100c Leaf Area Meter

## IV. Results & Data

*Table 1*: Germination Percentage by Day

| Treatment | Day 1 (11/4/11) | Day 2 (11/5/11) | Day 3 (11/6/11) | Day 4 (11/7/11) |
|---|---|---|---|---|
| Rockwool Control | 0% | 40% | 100% | 100% |
| Cococoir Control | 0% | 30% | 100% | 100% |
| 100% Coir | 0% | 70% | 100% | 100% |
| 90% Coir | 0% | 20% | 100% | 100% |
| 80% Coir | 0% | 20% | 100% | 100% |
| 70% Coir | 0% | 50% | 100% | 100% |
| 60% Coir | 0% | 20% | 100% | 100% |
| 50% Coir | 0% | 30% | 100% | 100% |
| 40% Coir | 0% | 20% | 90% | 100% |
| 30% Coir | 0% | 30% | 100% | 100% |
| 20% Coir | 0% | 20% | 100% | 100% |
| 10% Coir | 0% | 10% | 90% | 100% |
| 0% Coir | 0% | 30% | 100% | 100% |

Table 1 shows percent germination by day for all treatments. It should be noted that germination was first observed on Day 2, and by Day 4 all seeds had germinated. Germination percentage had the most variation on Day 2, ranging from 10-70%, but the variation followed no specific trend correlating to treatment. By Day 3 all but 2 seeds had germinated, and by Day 4 all seeds had germinated (100% germination was achieved).

*Table 2*: Root Protrusion Percentage by Treatment

| Treatment | % Root Protrusion |
|---|---|
| Rockwool Control | 70% |
| Cococoir Control | 0% |
| 100% Coir | 70% |
| 90% Coir | 100% |
| 80% Coir | 100% |
| 70% Coir | 100% |
| 60% Coir | 100% |
| 50% Coir | 100% |
| 40% Coir | 100% |
| 30% Coir | 100% |
| 20% Coir | 100% |
| 10% Coir | 100% |
| 0% Coir | 100% |

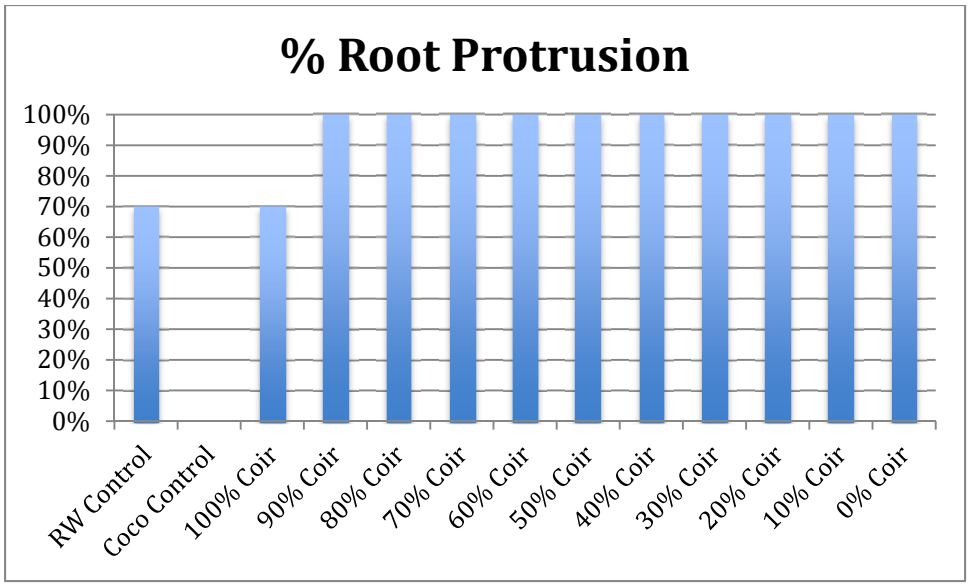


*Figure 1*: Root Protrusion Percentage by Treatment

Table 2 and Figure 1 show the percent of net pots (by treatment) that had roots protruding at Day 11. There was significant variation in the control treatments; rockwool showed 70% with protruding roots while the coconut coir showed 0% root protrusion. Addition of compost tea to 100% coconut coir increased root protrusion to 70%. All medias containing worm castings and treated with compost tea had 100% root protrusion.

*Table 3*: Average True Leaf Number at Day 11

| Treatment | Avg. True Leaf # |
|---|---|
| Rockwool Control | 1.9 |
| Cococoir Control | 1.9 |
| 100% Coir | 1.7 |
| 90% Coir | 1.8 |
| 80% Coir | 1.9 |
| 70% Coir | 2 |
| 60% Coir | 1.8 |
| 50% Coir | 1.4 |
| 40% Coir | 1.6 |
| 30% Coir | 1.6 |
| 20% Coir | 1 |
| 10% Coir | 1 |
| 0% Coir | 1 |

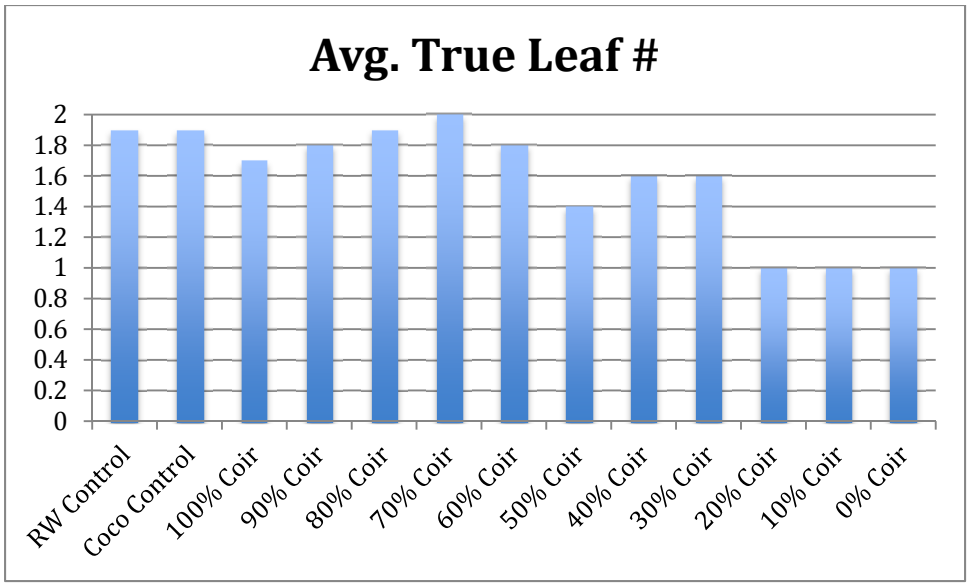


*Figure 2*: Average True Leaf Number at Day 11

Table 3 and Figure 2 show the average number of true leaves per seedling at Day 11 (by treatment). Treatment #6 had the most true leaves, with an average of 2 per seedling. Treatments 1, 2, 3, 4, 5, and 7 closely followed Treatment #6 (>1.7 leaves/seedling). As worm casting percentage increased to 50% and greater a decrease in true leaf number was observed, with 80% castings, 90% castings, and 100% castings producing only 1 true leaf per seedling.

*Table 4*: Cumulative Leaf Area by Treatment

| Treatment | Cum. Leaf Area ($cm^2$) |
|---|---|
| Rockwool Control | 11.24 |
| Cococoir Control | 15.12 |
| 100% Coir | 14.83 |
| 90% Coir | 17.59 |
| 80% Coir | 19.92 |
| 70% Coir | 19.74 |
| 60% Coir | 15.3 |
| 50% Coir | 11.37 |
| 40% Coir | 14.34 |
| 30% Coir | 11.45 |
| 20% Coir | 7.61 |
| 10% Coir | 7.03 |
| 0% Coir | 7.2 |

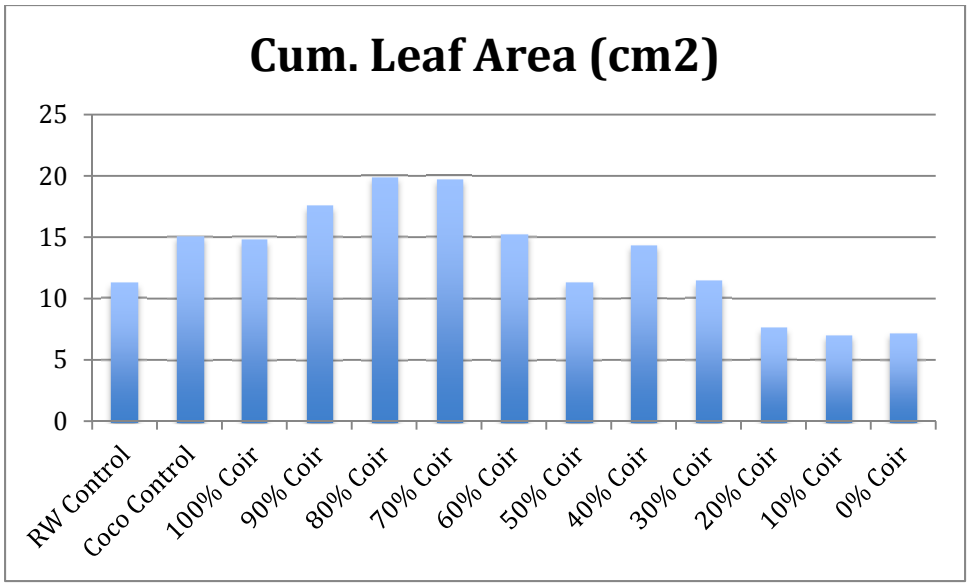


*Figure 3*: Cumulative Leaf Area by Treatment

Table 4 and Figure 3 show Cumulative Leaf Area by Treatment (cumulative for all 10 seedlings). A distinct trend can be noted within the experimental treatments (#3-13), as leaf area increases with increasing casting percentage up to 20%, and after 30% a decline in leaf area is noted. Treatments 4, 5, and 6 produced significantly more leaf area than the controls.

*Table 5*: Average Leaf Area per Seedling

| Treatment | Avg. Leaf Area ($cm^2$) |
|---|---|
| Rockwool Control | 1.124 |
| Cococoir Control | 1.512 |
| 100% Coir | 1.483 |
| 90% Coir | 1.759 |
| 80% Coir | 1.992 |
| 70% Coir | 1.974 |
| 60% Coir | 1.53 |
| 50% Coir | 1.137 |
| 40% Coir | 1.434 |
| 30% Coir | 1.145 |
| 20% Coir | 0.761 |
| 10% Coir | 0.703 |
| 0% Coir | 0.72 |

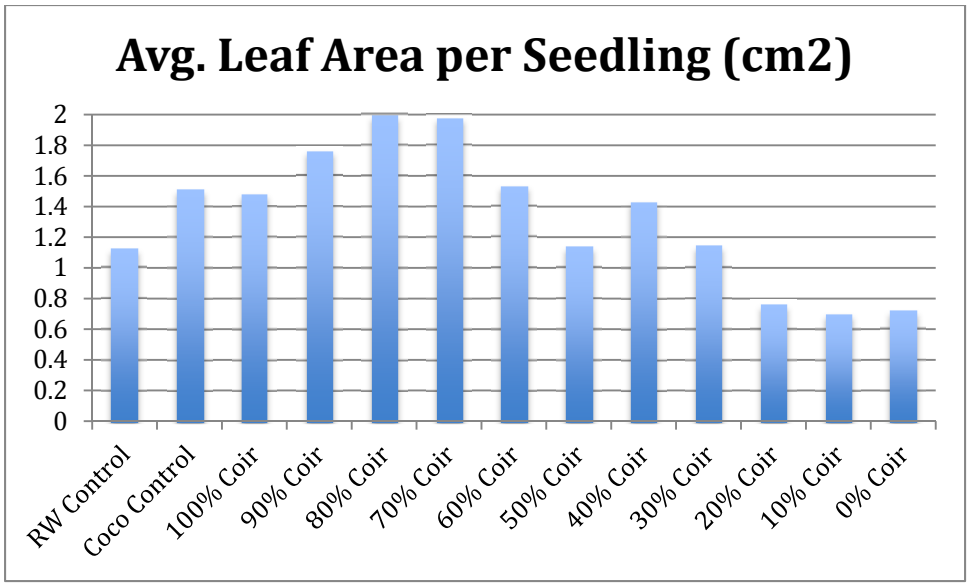


*Figure 4:* Average Leaf Area per Seedling

Table 5 and Figure 4 show average leaf area per seedling by treatment (in $cm^2$). The same trend as with cumulative leaf area can be noted, with Treatment #5 producing the most leaf area at 1.992 $cm^2$ per seedling.

Day 4 (11/7/11)

Day 5 (11/8/11)

Day 6 (11/9/11)

Day 7 (11/10/11)

Day 8 (11/11/11)

Day 9 (11/12/11)

Day 10 (11/13/11)

Day 11 (11/14/11)

*Figure 5:* Growth-Progression Photos (Left to Right, Treatments 1-13)

Figure 5 shows photographs of all treatments from Day 4 (when 100% germination was noted) through Day 11 (end of experiment). Treatments are arranged in vertical rows. Treatment number increases from left to right with Treatment #1 being the leftmost row and treatment #13 being the rightmost row.

**V. Conclusions**

The results from this experiment appear to support the hypothesis. To begin, it was predicted that seedling quality would increase as the concentration of worm castings in the starting media increased up to a "critical concentration", after which seedling quality was expected to rapidly decrease. Although all seedlings germinated and developed through Day 11, the leaf area results show an obvious trend of increasing leaf area as casting percentage increased to 20%-30%, after which a clear decrease can be seen (See Tables 3 and 4 and Figures 4 and 5). In addition to leaf area, true leaf number was highest (2 true leaves/seedling) at 30% castings, although the controls were only slightly lower at 1.9 true leaves per seedling. However, as casting percentage increased beyond 30% a significant decrease in true leaf number was observed, with treatments containing 80%, 90% and 100% castings producing only 1 leaf per seedling (See Table 3 and Figure 2). These results suggest that the "critical concentration" of worm castings in the media is between 20-30%.

It was also predicted that the seedlings treated with compost tea would be of higher quality than those treated with the inorganic Hoagland's solution. While no direct benefit can be observed in the leaf number or area results, treatment with compost tea effectively increased the number of seedlings with roots protruding from the net pot, especially when

combined with a media containing worm castings. The coconut coir control treatment (100% coconut coir fertilized with Hoagland's solution) produced no seedlings with roots protruding, but when 100% coconut coir was treated with compost tea 70% of the seedlings had roots protruding. All treatments containing worm castings and treated with compost tea produced 100% of seedlings with protruding roots (See Table 2 and Figure 1). These results suggest that fertilization with compost tea assists in root development for lettuce seedlings.

**VI. Supporting Appendicies (Attached)**

1. Document #1: Inorganic Modified Hoagland's Solution: Lettuce Recipe
2. Document #2: Compost Tea Recipe