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Optimal Application Method of Processed Food Waste to Promote Plant Growth

Identifying Optimal Use of Food Waste is Important

Recently there has been a big push to reduce the amount of waste that is being sent to landfills. In particular, reducing organic waste going to landfill has been a major objective for many provinces and municipalities. Organic food waste is heavy and produces large amounts of greenhouse gas during decomposition. Food Cycle Science provides an alternative solution to sending food waste to landfill by utilizing their FC-30 food processing unit. This is a household unit that reduces food waste volume by 85-93% through a dehydration and grinding process. This process effectively reduces the volume and weight of food waste that was sent to landfill. Additionally by dehydrating and grinding the food waste the FC-30 unit can greatly reduce the amount of greenhouse gas produced from processed food waste. Additionally, finding an alternative use for processed food waste with further aid in efforts to reduce the amount of waste being sent to landfill.

The utilization of the FC-30 unit is particularly useful in areas where people are unable to compost due to a lack of space, and where there is no organics collection program. Previous research has identified that this dehydrated food waste can act as a soil amendment for household garden and landscaping uses. This research has identified that processed food waste can add beneficial nutrients (phosphorus, nitrogen, and potassium) to soil, which helps promote plant growth. Further refining the treatment methods and applications will optimize the utilization of the processed food waste as a soil amendment.

In this study, we seek to assess the optimal application method and usage of the dehydrated food waste produced by Food Cycle Science's FC-30 unit. This will allow people to reduce the amount of waste they are sending to landfill, which will aid in GHG reduction, and promote the optimal growth of household garden plants.

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Background

Food Cycle Science (hereinafter 'FCS') provides alternative solutions for the reduction and diversion of organic food waste from landfill for both residential and commercial/industrial uses. Food Cycle Science provides a residential sized unit, the Food Cycler FC-30, capable of processing 2 L of food waste, through a proprietary process of dehydration and mechanical action resulting in a nutrient rich organic material. This multi-step process can reduce the volume and weight of organic waste by up to 93%.

The Food Cycler FC-30 unit is marketed as a composting alternative for dealing with organic food waste. This solution is particularly beneficial for people who live high density housing or urban areas where space for composting is limited and where no municipal organics collection program are in place. Previous research has identified that the FC-30 can generate a processed food waste (PFW) that exceeds the nutrient requirements for a Non Agricultural Source Material of 13000 ppm (Food Cycler FC-30 PFW - plant available nitrogen + plant available phosphorus + plant available potassium = 29211 ppm). Mixing the material produced by the FC-30 in with soil has been shown to promote the growth of common garden plants. However, the optimal food waste to soil ratio and application method of food waste has yet to be identified.

Project Details

Food Cycle Science partnered with RiverLabs to identify the optimal method of food waste application to garden soil, and assess the nutrient quality of two food waste types: 1) typical household food waste (combination of produce, meat, and other processed food materials) and 2) produce only food waste (raw plant based waste). This study will test the effectiveness of two PFW streams at promoting the growth of common garden plants, specifically tomatoes and marigolds. This information will allow FCS to develop and include proper instructions with the Food Cycler FC-30 units on 'How-To Apply the Processed Food Waste' to promote growth in household gardens and flower beds.

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Growth Study

Two types of feedstock were tested:

- typical household food waste
- produce only food waste

Typical household food waste

Includes: meat, potatoes, vegetables, bread, and gravy collected from St. Hubert's, Cornwall

Produce only food waste

Includes: fruit, vegetables, and other produce collected from Farm Boy, Cornwall

Growth Plots

For each feedstock PFW, a 1.8 m x 2.4 m x 0.25 m garden plot was constructed and illuminated with artificial growth lights. Each plot was divided into 30 equal and isolated sections measuring 0.9 m^2 square foot and a depth of 0.25 m.

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Growth Plot

6	7	8	9	10
1	2	3	4	5
6	7	8	9	10
1	2	3	4	5
6	7	8	9	10
1	2	3	4	5

Treatments

Each individual section was randomly assigned a specific treatment. The treatments were broken down based on the application method and the planting schedule.

Applications:

- PFW was spread over the surface of the soil
- PFW was tilled into the soil

Planting Schedules:

- Plant Immediately after PFW application
- Delay planting by 1 week after PFW application
- Delay planting by 2 weeks after PFW application
- Delay planting by 3 weeks after PFW application
- Delay planting by 4 weeks after PFW application

Tomatoes

Surface treatment	**Section #**
Immediate	6
1 week delay	5
2 week delay	8
3 week delay	10
4 week delay	4
Tilled Treatment	**Section #**
Immediate	3
1 week delay	9
2 week delay	1
3 week delay	2
4 week delay	7

Marigolds

Surface treatment	**Section #**
Immediate	10
1 week delay	5
2 week delay	6
3 week delay	4
4 week delay	1
Tilled Treatment	**Section #**
Immediate	3
1 week delay	8
2 week delay	7
3 week delay	2
4 week delay	9

Control

Tomato	**Section #**
Immediate	8
1 week delay	5
2 week delay	10
3 week delay	4
4 week delay	3
Marigold	**Section #**
Immediate	7
1 week delay	6
2 week delay	1
3 week delay	2
4 week delay	9

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Growth Conditions

The PFW and soil were combined at a volume ratio of 1:15 (PFW:soil). Each treatment plot had 6 seedlings that were removed from a planting tray and transplanted into the assigned section. Growth period was established at 6 weeks from transplanting to growth plots. All plants were watered daily with an equal amount of water as to maintain approximately 40% moisture. For all treatments a negative control was incorporated by planting following the schedule and omitting the addition of PFW. Each plot was illuminated with a grow light (agrobrite, 120V-60Hz-3.64A-432W) fixed 1.2 m above the growth plots. The lights were scheduled to be turned on for 14 hours on and turned off for 10 hours.

Example of a single growth section (Tomatoes grown in tilled household food waste)

Analyses

Data Analysis

Over the course of the growth study, measurements of stem height (shoot length) and the number of leaves were collected at the time of planting and each consecutive week until the end of the study. At the end of the study, both the wet and dry weight of the plants were collected as a measure of total biomass.

Soil and Food Waste Analysis

One sample of PFW for each feedstock (typical household and produce only) was collected and sent to A&L Laboratories to be analyzed for plant available nutrients, metals and pathogens. Soil samples were collected to assess their quality after being treated with food waste. Five samples were collected from control plots, and five were collected from both the produce and dinner food waste treatment plots. For both household dinner waste and produce waste, soil samples were comprised of 2 samples from the best performing tomato section and marigold section. Additionally, 1 sample was collected from the worst performing section.

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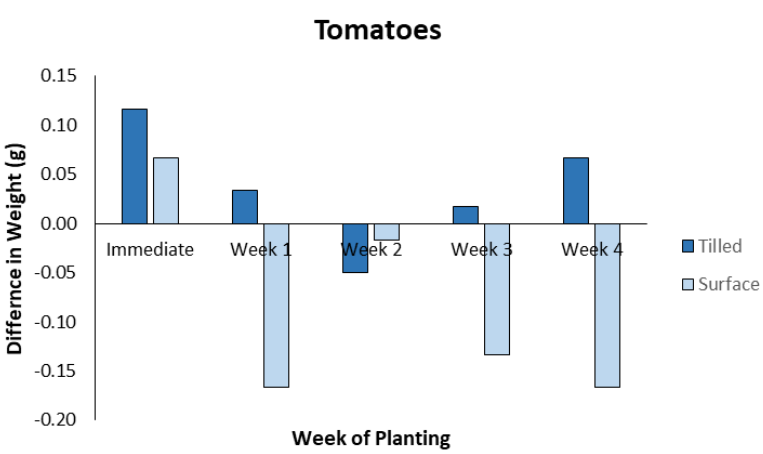
Growth Study Results

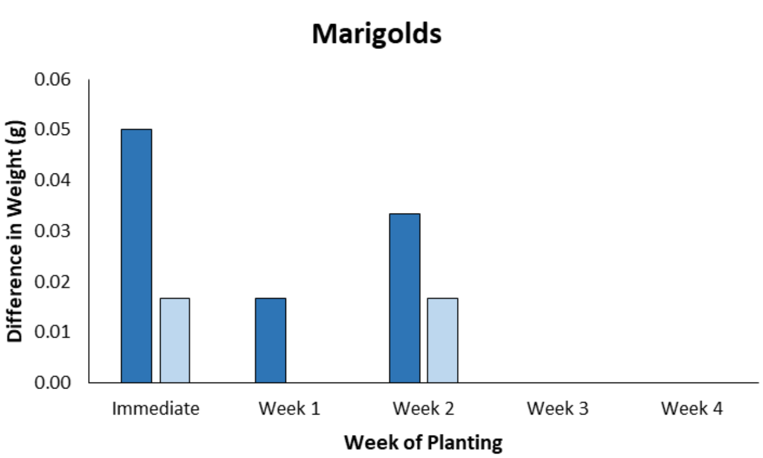
Produce Food Waste

The optimal treatment conditions for both tomatoes and marigolds are:

- Tilled application of PFW
- Planting immediately – 3 weeks after application of PFW

This was determined through multiple measures of growth, the most important being weight of plants (indicator of total biomass).





Figures represent difference between treatments and controls (Treatment – Control weight)

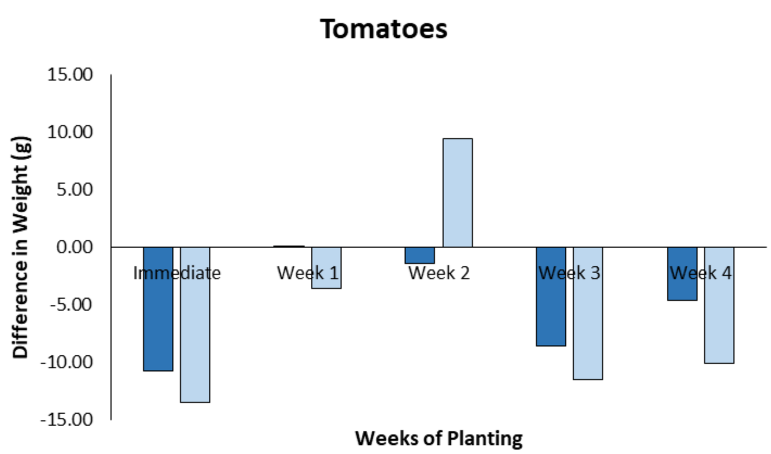
Household Food Waste

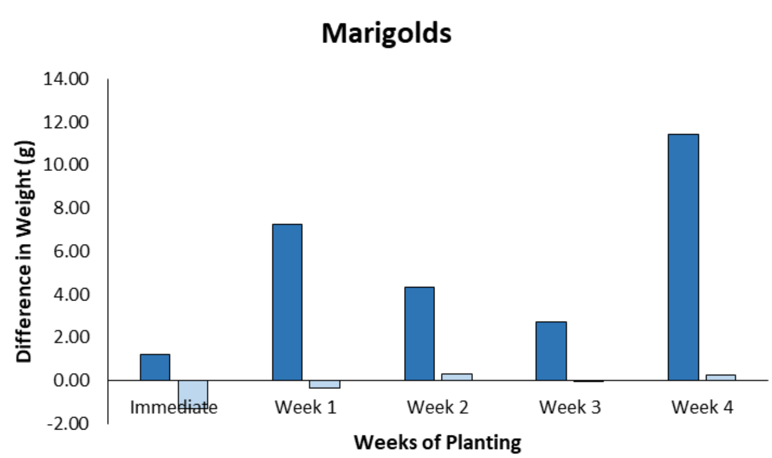
The optimal treatment conditions for marigolds are:

- Tilled application of PFW
- Planting 1 – 4 weeks after application of PFW

Tomatoes performed worse in treatment groups compared to control groups

This was determined through multiple measures of growth, the most important being weight of plants (indicator of total biomass).





Figures represent difference between treatments and controls (Treatment – Control weight)

Food Waste Nutrient Profile

Household PFW had higher levels of phosphorus, nitrogen, and ammonia compared to produce PFW. However, household PFW has a very high concentration of sodium.

Produce PFW was found to have higher levels of potassium compared to household food waste.

	Household Food Waste	Produce Food Waste
Sodium (ppm)	7470	1058
Potassium (ppm)	8100	20,300
Phosphorus (ppm)	15,500	2100
Nitrogen (ppm)	47,600	13,900
Ammonia (ppm)	303.21	157.36
Organic Matter (ppm)	905,500	933,300
E. coli (CFU/g)	<10	<10

Soil Nutrient Profile

Soil was collected and analyzed from control sections, and from high and low preforming sections (determined by measures of plant growth). Soil treated with PFW, as compared against control plots, were found to consistently have higher levels of nutrients. Compared to each other, soil amended with processed household PFW had higher levels of phosphorus compared to plots amended with produce PFW. Potassium levels were found to be consistently higher in soils amended with produce PFW. Sodium content was found to be similar between controls and produce PFW sections, but significantly higher in soil amended with household PFW. All of these results indicate that the nutrient and metal profiles of the soils match the nutrient profiles of the PFW stream that was used to treat the soil.

Soil Sample	Phosphorus (ppm)	Potassium (ppm)	Sodium (ppm)
Control – Immediate	74	443	92
Control – 1 week delay	78	461	98
Control – 2 week delay	72	438	93
Control – 3 week delay	69	631	172
Control – 4 week delay	65	366	85
Household – Tomato (Surface - 2 week delay)	212	586	433
Household – Marigold (Tilled - 4 week delay)	318	690	441
Household – Tomato (Surface – Immediate)	145	732	369
Produce – Tomato (Tilled – 1 week delay)	124	1228	139
Produce – Marigold (Tilled – 1 week delay)	83	828	115
Produce – Tomato (Surface week 4)	108	1274	122

Control
High Performing Sections
Low Performing Sections

Key Findings

The growth study demonstrated that tilling the PFW from the FC-30 unit into soil is more effective at promoting plant growth as compared to a surface treatment of the PFW. The study also indicated that, generally, delayed planting after PFW application, by up to four weeks improves the effectiveness of the processed food waste at promoting plant growth. By delaying planting, microbial action may break down a greater amount of the PFW, making nutrients more available within soil, which can then be utilized by the plants.

One exception to the finding that tilled treatments of PFW were beneficial at promoting growth of plants compared to other treatments was tomatoes grown in household food waste. Other than a two week delayed planting with a surface treatment of PFW, the control outperformed all treatments with PFW. The one surface treatment that outperformed the control was a result of one tomato plant that was significantly larger than any other plant. However, the finding that household food waste inhibits the growth of tomatoes is likely a result of tomatoes being sensitive to the high concentrations of salt present in the household waste. Since tomatoes are relatively salt intolerant (Cuartero and Fernández-Muñnoz, 1999), the high concentration of sodium likely contributed to the stunted growth.

The results of the PFW and soil analysis indicates that the two food waste streams have differences in key nutrients required for promoting plant growth. Due to varying concentrations of nutrients between the two PFW streams, creating an optimal soil amendment would be accomplished through combining both household dinner waste and produce waste. This mixing of PFW streams would generate a soil amendment that is able to provide all necessary nutrients for promoting plant growth and would also reduce the relative concentration of sodium.

Recommendations

After reviewing all of the growth study results, and analyses of PFW and soil nutrient profiles, we highlight the following recommendations:

- A combination of both processed household and produce food waste would generate an optimal soil amendment. This combination would incorporate all necessary nutrients to promote plant growth.
- Tilling PFW into soil, compared to leaving PFW on the surface of soil, is more effective at providing nutrients and promoting the growth of plants.
- Delaying planting by 1-4 weeks after the application of PFW to soil allows for the breakdown of the PFW, which makes more nutrients available for uptake by growing plants.
- One recommendation would be to be mindful of the sodium content of food waste being incorporated into the PFW that will serve as a soil amendment. Food with too high of concentration of sodium could have a detrimental effect on the growth of plants.

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