Influence of Windrow, Vermiculture, and Black Soldier Fly Larvae Composting on Tatsoi (*Brassica narinosa*) and Red Amaranth (*Amaranthus cruentus*) Plant Growth: Case Study of VEGGI Farmers Cooperative in New Orleans, Louisiana

Danielle Tam Ngo

ABSTRACT

The field study was performed as a case study of Village de l'Est Green Growers Initiative (VEGGI) Farmers Cooperative in New Orleans, Louisiana. Three compost varieties were tested on tatsoi (*Brassica narinosa*) and red amaranth (*Amaranthus cruentus*): windrow, vermiculture, and black soldier fly (*Hermetia illucens*) larvae (BSFL) compost. This research project builds knowledge upon the relationship between these three compost varieties to plant growth. The three compost treatments were tested for potassium and phosphorus concentration and total nitrogen to determine whether these minerals had beneficial effects on the crops' growth. Plant growth was measured through seasonal growth rate and end-of-season height, biomass, and nitrogen content. Patterns between treatments and growth metrics were analyzed using permutation and paired t-tests. Overall, tatsoi grows the best with vermicompost, and red amaranth grows the best with BSFL compost. These patterns may be attributable to the high nitrogen and potassium content of vermicompost and the high phosphorus content of BSFL compost. However, none of the observable patterns are statistically significant, which indicates the need for more intensive studies between compost varieties and plant growth. It also indicates that compost varieties may not be best suited to combat VEGGI's poor soil conditions or agricultural methods. These results will inform VEGGI about the composts' properties as a soil amendment and plant growth supplement, to increase their community's food security and maintain sustainable agriculture practices.

KEYWORDS

permutation tests, soil amendments, soil contamination, sustainable agriculture, urban agriculture

INTRODUCTION

Urban agriculture is a growing practice to ensure local food sources to communities in need. Urban communities, disconnected from agricultural fields, are often strained by the limited access and steep prices of fresh produce. Across the nation, there are "food deserts," which the USDA defines as a census-designated area with a high concentration of low-income households without a full service grocery store within a one-mile radius (USDA 2013). Communities have begun to organize and convert vacant lots into gardens, share collective farming wisdom, and increase local access to fresh produce (Wortman and Lovell 2013). While urban agriculture is a critical means for community food access, it frequently suffers with soil contamination from prior industrial land use and inadequate regulation of chemical waste (D'Emilio et al. 2013, McClintock 2010). With the high costs of remediation and limited farming opportunities, urban agriculture must be sustainable to ensure the longevity of local food sources.

Composting is one sustainable agriculture method used to combat poor quality or contaminated soil. Compost is a type of soil amendment made of decomposed carbon and nitrogen rich material (Brink 1993). Depending on its composition, it can uptake, neutralize, or block contaminants from absorption by target crops (Haug 1993). Overall, compost can replace the need for synthetic agricultural chemicals to improve the physical texture or chemical quality of soil. There are many composting methods, but not all have been tested and applied comparatively on all crop and field conditions.

In New Orleans East, Louisiana, Village de l'Est Green Growers Initiative (VEGGI) Farmers Cooperative operates on contaminated soil. After the *Deepwater Horizon* Oil Spill in 2010, the City of New Orleans and Tulane University School of Public Health and Tropical Medicine tested and found the soil positive for pyrene, arsenic, and hydrocarbons (Nguyen, *personal communication*), all of which are toxic to plant and human health (Ganeshamurthy et al. 2008). However, the Vietnamese community in the New Orleans food desert must travel five miles to the closest grocery store (USDA 2013), so there is high need for a local food source. In 2011, VEGGI Farmers Cooperative transformed a vacant lot into a profitable urban farm to meet community need. Given their soil conditions, the cooperative farmers are interested in using compost as a soil amendment to sustainably support optimal growth of their crops.

In this case study, there are three composting methods of interest with varied advantages, disadvantages, and requirements. Windrow composting is straightforward and creates large quantities of compost, but requires heavy labor and large biomass demands (Adams and Frostick 2009). Vermiculture composting, "vermicomposting," uses worms (*Eisenia fetida*) to expedite and create a more stable compost, but it is small-scale and moisture intensive (Frederickson et al. 1997). Black soldier fly larvae (BSFL) composting uses larvae of black soldier flies (*Hermetia illucens*) to expedite the process and increase ammonium content, but has high maintenance demands and a long initial development period (Green and Popa 2012). These three have not yet been tested in a side-by-side field comparison. The growers lack experience and knowledge in composting for long-term soil amending (Nguyen, *personal communication*). Comparing the requirements and effectiveness of these composting methods will provide the Vietnamese growers adequate knowledge of compost to improve the health of their soil and their community.

This study will evaluate which compost is most effective for plant growth rate, crop yield, and nitrate levels. These metrics should indicate progress in the quality (nitrate levels, a marker of nutrient transfer from soil to plant) and quantity (growth rate, crop yield) of the crops. This field-based comparison will discern the advantages and disadvantages of these composts and note their applicability on VEGGI's contaminated soil. The two crops, tatsoi (*Brassica narinosa*) and red amaranth (*Amaranthus cruentus*), were chosen from VEGGI's seasonal summer crops to represent two different crop families and observe potential response variances. The study will allow VEGGI to learn more about the effectiveness of these composting methods for their operations.

METHODS

Study site

I studied the urban farm of VEGGI Farmers Cooperative. The farm is located at 14000 Dwyer Boulevard New Orleans, LA 70129 (30˚02'23.38''N 89˚55'10.55''W) at sea level (Figure 1). The Industrial Canal and Maxent Canal surround the farm as they connect the Mississippi River to Lake Pontchartrain. The waters have unsuitable levels of fecal coliform, bacterial colonies, and dissolved oxygen for human use (Wickliffe, *unpublished data*). Hurricane Katrina (2005) and

Hurricane Isaac (2012) flooded the farm site extensively. The soil at the farm tests positive for high levels of arsenic, pyrene, and hydrocarbons (Nguyen, *personal communications*).

Figure 1. Aerial view of VEGGI's farm site in New Orleans East, taken March 5th, 2013. The farm site is within the square, at the intersection of Maxent Canal (1) and Industrial Canal (2). Image taken from Google Earth 7.1.

It is a 1-acre plot that grows seasonal vegetables and herbs (Figure 2). VEGGI built up the land with 500 yd^3 of single grind mulch, one layer of cardboard sheet mulching, and one cover layer of single grind mulch. All crops are grown on raised beds, built by layers of double grind mulch, chicken manure, and finished compost (chicken, horse, and cow manure, clay, sand, and wood chips). VEGGI has yielded produce for market during the summer and winter seasons since 2011. The crops are seasonal with emphasis on Vietnamese and heirloom varieties: beans (*Phaseolus vulgaris*), cucumbers (*Cucumis sativus*), squashes (*Cucurbita pepo*), eggplants (*Solanum melongena*), peppers (*Capsicum annuum*), okra (*Abelmoschus esculentus*), mirlitons (*Sechium edule*), herbs (*Ocimum basilicum, Mentha spp., Anethum graveolens, Melissa officinialis, Allium schoenoprasum*), and mesclun mix components (*Brassica juncea*).

Figure 2. Aerial views of the farm site over time. Hurricane Katrina landed in New Orleans East August 29th, 2005. (Top Left) Taken on August 16th, 2005 (Top Right) Taken September 1st, 2005 (Bottom Left) Taken March 30th, 2006 (Bottom Right) Taken March 5th, 2013. Images taken from Google Earth 7.1.

Field set up

My experiment used four raised bed rows on the farm. The rows ran from east to west. On the east side, nearby trees shaded the rows in the morning. The east side also has a small swamp. On the west side, the rows received the most direct sunlight. The rows were watered by drip tape irrigation and by hand. My experiment occurred in two concurrently running trials within each row (Figure 3). One trial used tatsoi (*Brassica narinosa*) and the other used red amaranth (*Amaranthus cruentus*). Each row was 25 meters long, fitting two experimental replications 12.5 meters long. Every replication had four treatments of 3.13 meters. The treatment order was randomized to combat possible bias from treatment leaching or geophysical characteristics of the plot. For instance, the farm site is known to flood on the south side after moderate to heavy rains. The source of drip tape irrigation is at the southeast corner of the experimental rows. The main line heads south to north, and the drip tapes extend from east to west.

Rep 1	B	D	A	C	**Rep 2**	D	C	B	A
Rep 3	B	D	C	A	**Rep 4**	A	B	D	C
Rep 5	C	A	B	D	**Rep 6**	A	D	B	C
Rep 7	C	A	D	B	**Rep 8**	A	C	B	D

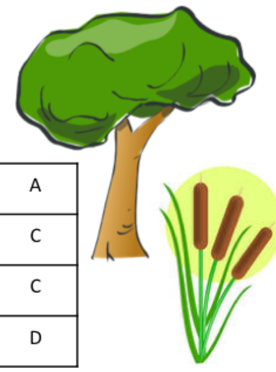


Figure 3. Diagram of experimental rows and treatment order. Row 1 is in the northwest corner of the plot, and row 8 is in the southeast corner of the plot. (A) Windrow Composting (B) Vermiculture Composting (C) Black Soldier Fly Larvae Composting and (D) Bedding Soil Control.

Procedures & equipment

I conducted my experiment in the 2013 summer season. Prior to the start of my experiment, VEGGI staff prepared all of the compost treatments. Compost and control samples were sent to Louisiana State and Georgia State University to test for total nitrogen, heavy metals, and water soluble potassium and phosphorus by combustion and colorimetric analysis. During the season, I fed and performed general maintenance of each composting system. For the windrow compost, grass clippings were the main carbon source, and okara, a byproduct of tofu production, was the main nitrogen source. For the vermicompost, red wiggler worms (*Eisenia fetida*) of varying levels of maturity were purchased online from a rabbit farmer in Poplarville, Mississippi and fed a diet rich in leafy greens. For the BSFL compost, the colony was purchased online through The Worm Dude, a company in San Jose, California, and fed a diet rich in decaying food, okara, and farm byproducts. The bedding soil control was purchased from Laughing Buddha Nursery, a local New Orleans producer. The bedding soil is the same substance that comprises much of the raised beds. The tatsoi and red amaranth seeds were purchased online through Johnny's Selected Seeds, a company based in Winslow, Maine.

For each experimental row, I dug furrows and placed 275 cm^3 of the appropriate compost for each treatment. The treatments were .3 meters apart. The seeds were planted within the compost. Tatsoi was planted June 12th, 2013 and harvested on August 5th, 2013. The red amaranth was planted July 18th, 2013 and harvested on August 12th, 2013. The plot was watered daily and weeded by hand as necessary. No synthetic chemicals were used. The average summer daytime temperature was within 30-35˚C with 80% humidity. Full sunlight occurred during the hours of 8 AM to 7 PM.

During the experiment, I measured the height of the plants twice a week. For each treatment, I randomly selected three plants to sample. I measured plant height (cm) from the base, where it emerges from the soil, to the topmost part of the plant. I also recorded general observations and conditions on weather and plant health. I rated any plant damage due to suspected pests on a scale of 1-3. I indicated 1 to negligible damage from pests or health; 2 to minor holes, tears, and spotting; and 3 indicated substantial pest damage, wilting, and spotting that threatened the survival of the plant.

At harvest, I removed all the plants in a treatment plot, shook off loose dirt, and weighted the collective fresh biomass (g). I also sent samples of tatsoi and red amaranth leaves to plant analysis labs at Iowa State University to test for nutrient content. For each treatment, a sample constituted at least 4 grams of leaf material or enough leaves to cover 5 cm^2. Samples were carefully inspected and washed to prevent any interstate transfer of pests and disease.

Statistical analysis

I used permutation tests and paired t-tests to analyze the data. My research questions for tatsoi and red amaranth compared the growth rate and end-of-season height, biomass, and nitrate content. I used R to perform nonparametric permutation tests between the different compost treatments for their growth rate (R Development Core Team 2006). For end-of-season height, biomass, and nitrate content, I performed paired t-tests and used Excel to display the data comparatively. Permutation tests were chosen over ANOVA and Kruskal-Wallis tests because it provides a more accurate p-value from non-Normal data. The permutation tests function with nonparametric data sets, concatenating the order of the paired data sets to compare the differences in means to the means of the two data sets.

RESULTS

Field set up

The most impactful field variables on the experimental plot were extreme weather and poor irrigation. Plants on the west side were overexposed to sunlight. Plants on the west side, especially the southwest side, were also furthest from the water source and received the least amount of water throughout the season. As a result, many of these plants wilted or died prematurely. Plants on the east were closest to the swamp and showed higher prevalence of pests and disease. The plants that showed the most resilience and success throughout the season were in the center of the experimental plot, with balanced levels of sunlight, water, and protection.

Background nutrients of compost treatments and control

I found negligible, but subtle, differences in the nutrient content of each treatment that could be extrapolated for more nuanced applications. Nitrogen (N), phosphorus (P), and potassium (K) were measured since they are key nutrients to plant growth. Total N was measured as a percentage of mass (Figure 4), and P (Figure 5) and K (Figure 6) were measured as concentrations (mg/Kg). I assumed the bedding soil, used as the control, had an average NPK profile because of its high compost content. These figures vary in metrics and scale due to the spectrum of compostable materials, but they are similar to 1.82% N, 1.29% P, and 1.25% (Abdelaziz et al. 2007) or 11,400 mg/kg N and 1,780 mg/kg P (Jugnia et al. 2012). Amongst the treatments, the vermicompost had notably high levels of total N (1.35%). The windrow compost had balanced concentrations of P and K. Between vermicompost and BSFL compost, BSFL compost has more P than vermicompost (816 vs. 516 mg/kg) while vermicompost has more K than BSFL compost (6378 vs. 5494 mg/kg).

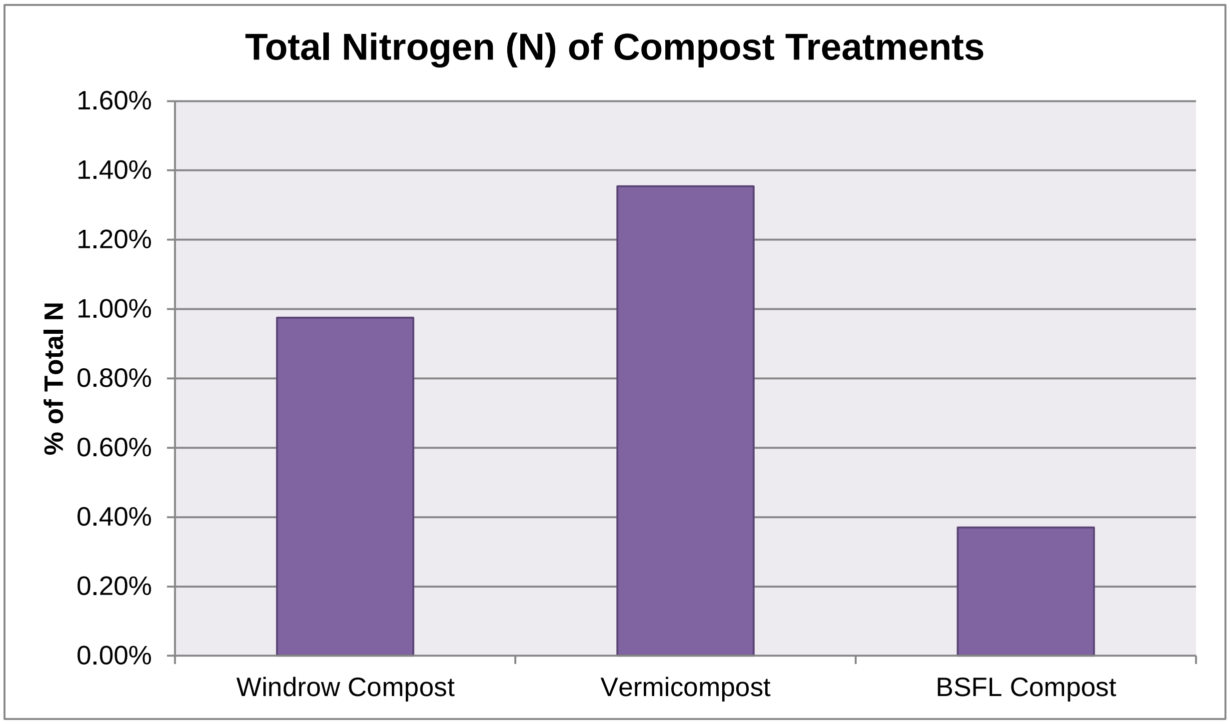


Figure 4. Total N (n=1) of composting treatments as percentage of mass. Windrow compost has 0.98%, vermicompost has 1.35%, and BSFL compost has 0.37% nitrogen.

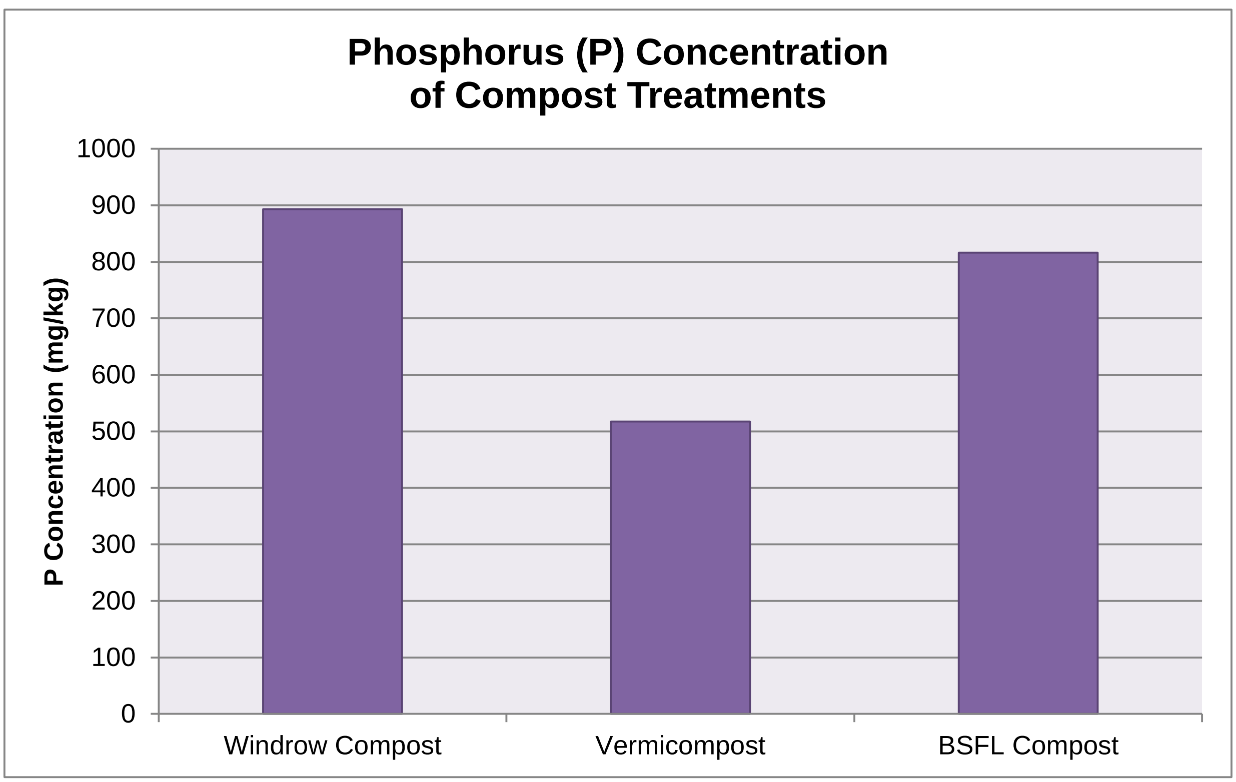


Figure 5. Concentration (mg/kg) of P of compost treatments. Windrow compost has 893 mg/kg, vermicompost has 517 mg/kg, and BSFL compost has 816 mg/kg.

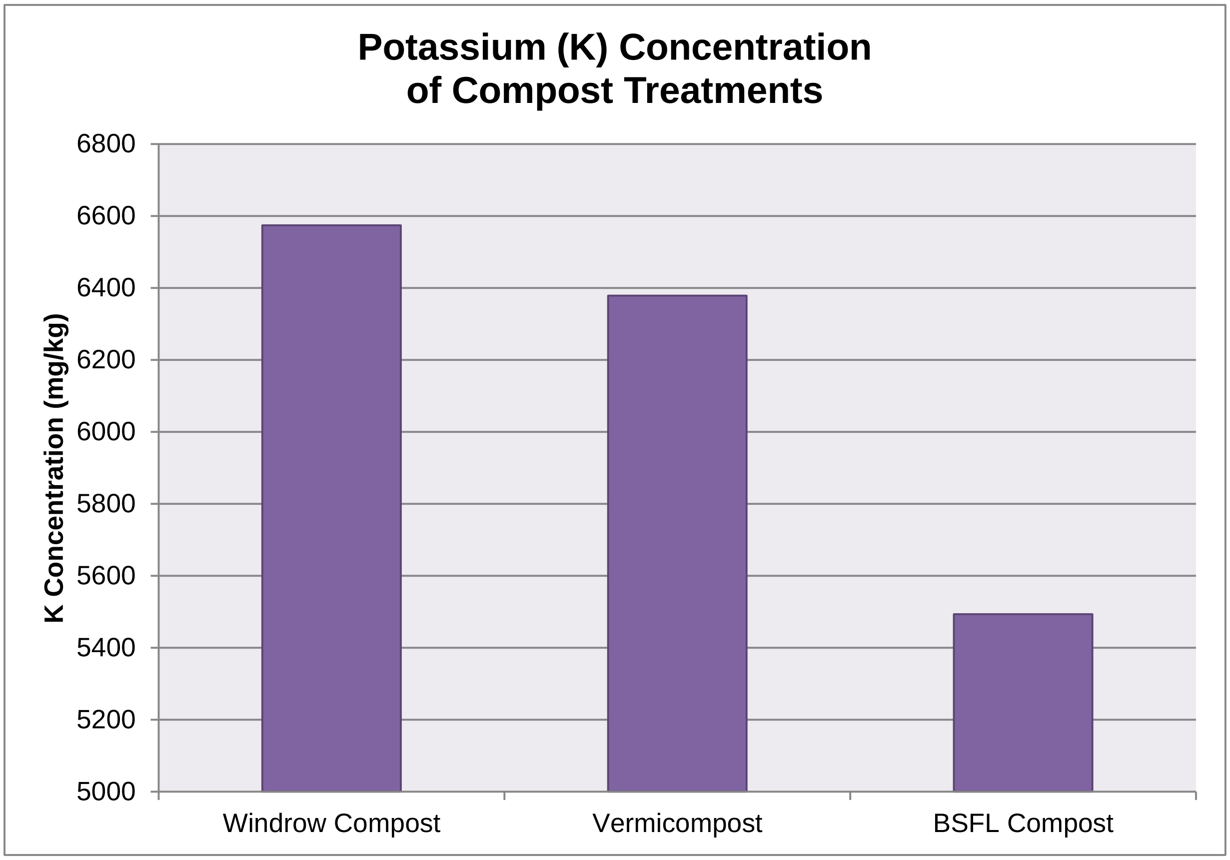


Figure 6. Concentration (mg/kg) of K of compost treatments. Windrow compost has 6574 mg/kg, vermicompost has 6378 mg/kg, and BSFL compost has 5494 mg/kg.

Growth rate data

The growth rates of tatsoi and red amaranth have subtle differences between treatments. All the relationships were not statistically significant, with p-values of 0.63 (Table 1). Qualitative comparisons between treatments show that the control performed the best in terms of having consistently positive growth rates throughout the season. The advantage of the control over the three treatments is most apparent with the tatsoi.

For the tatsoi, the BSFL compost performed the worst by starting with the smallest sprouts and growing at the slowest rate. The vermicompost accelerated and windrow compost plateaued mid-season. For the red amaranth, the windrow compost performed the worst. The BSFL compost surpassed the vermicompost after a third of the season, but slowed down to end with plants of the same average height.

Table 1. P-values between each of the treatments, determined from permutation tests ran in R Studio. $p < .05$ is our measure of statistical significance.

	Tatsoi	Red Amaranth
Windrow vs. Vermiculture	0.627	0.626
Windrow vs. BSFL	0.628	0.627
Windrow vs. Control	0.626	0.627
Vermiculture vs. BSFL	0.627	0.626
Vermiculture vs. Control	0.626	0.626
BSFL vs. Control	0.629	0.629

End-of-season plant height data

The correlation between treatments and end-of-season plant height was stronger in the tatsoi versus the red amaranth. In the tatsoi, the control grew the tallest overall plants at 7.88 cm, almost thrice as big as the BSFL compost plants at 2.85 cm (Figure 7). In the red amaranth, the windrow compost grew the shortest plants (10.48) compared to three other treatments (16.13-18.5 cm) (Figure 8).

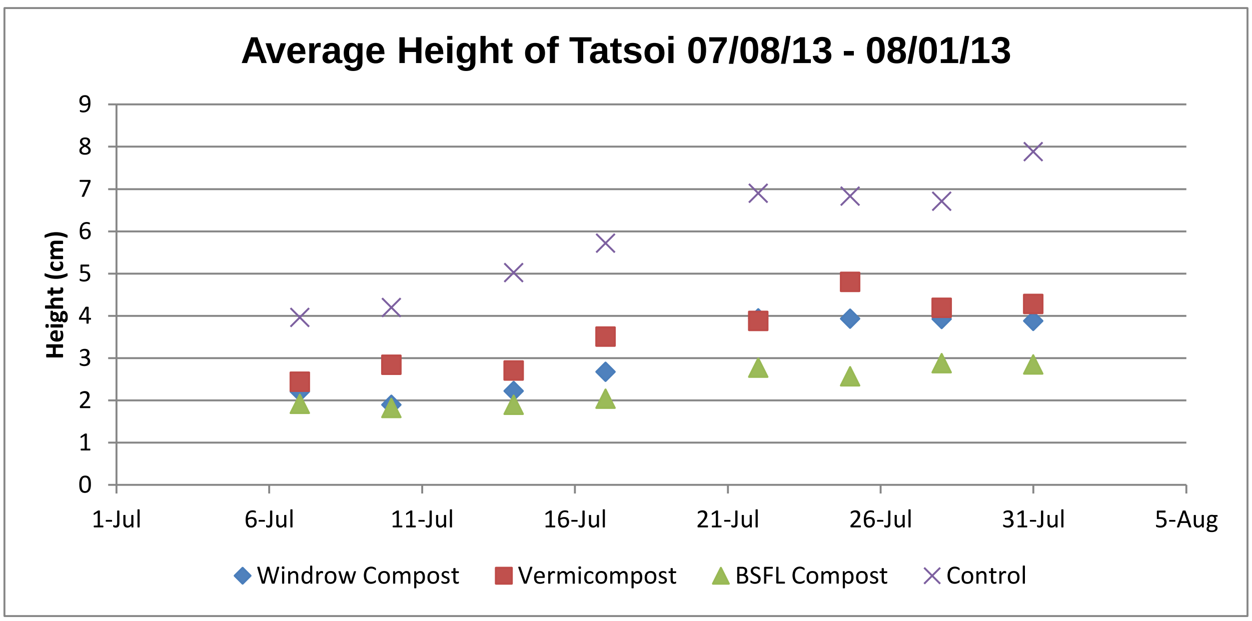


Figure 7. Average height (cm) of tatsoi over July 8th, 2013 to August 1th, 2013. All treatments wilted at the end of the season, resulting in declining averages. At the peak, August 1st: windrow compost (3.88 cm), vermicompost (4.28 cm), BSFL compost (2.85 cm), and control (7.88 cm).

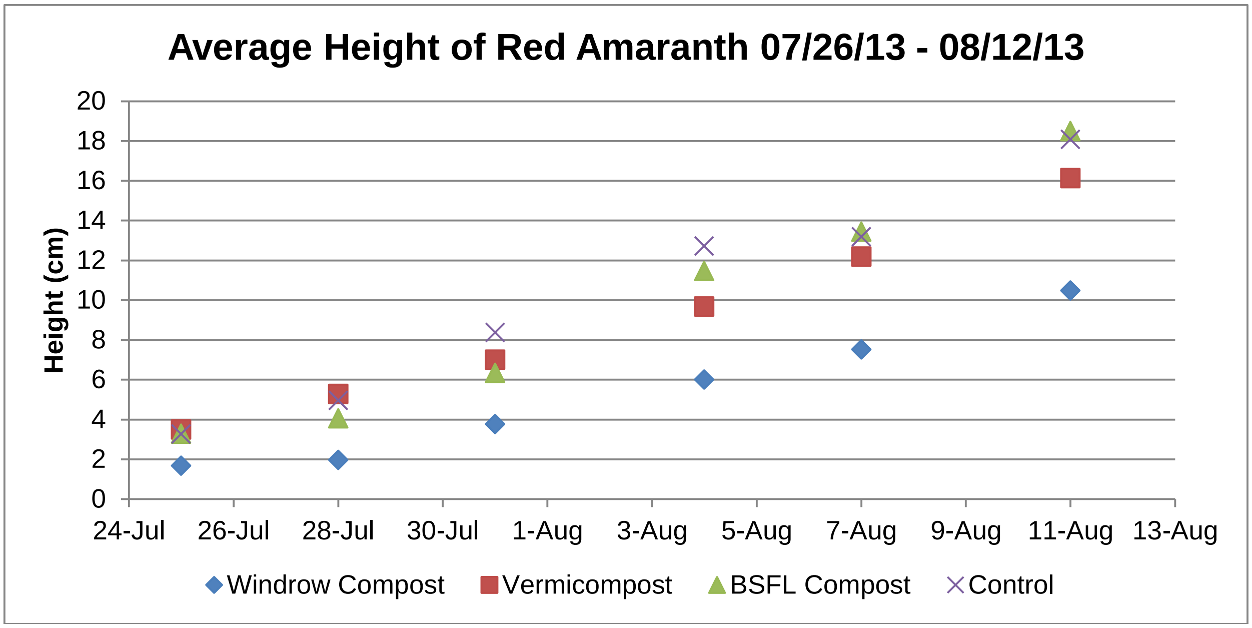
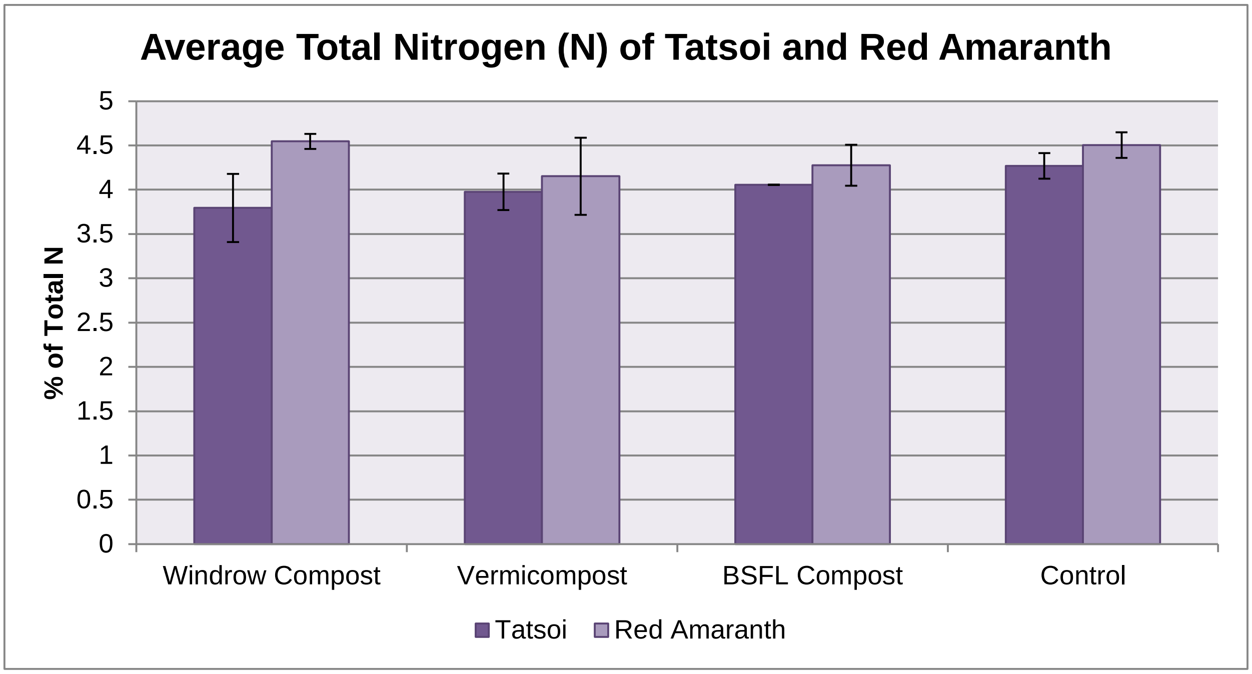


Figure 8. Average height (cm) of red amaranth over July 26th, 2013 to August 12th, 2013. At the end, windrow compost (10.48 cm), vermicompost (16.13 cm), BSFL compost (18.5 cm), and control (18.08 cm).

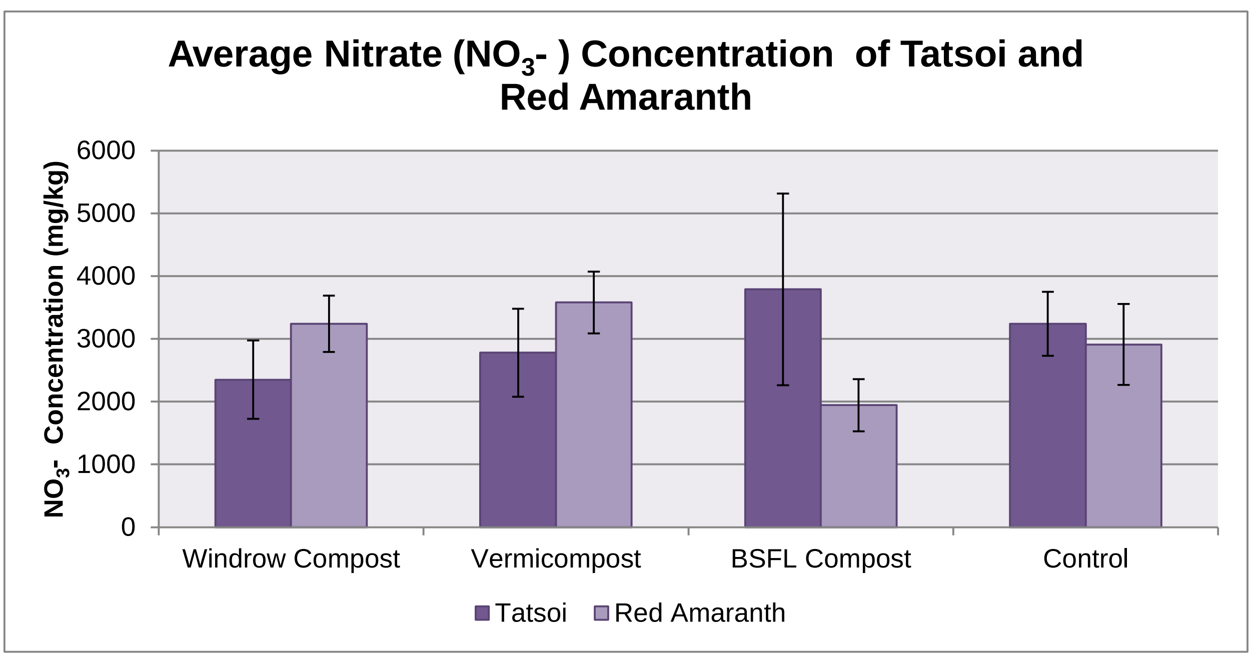
End-of-season nitrogen content data

The compost treatments had varied responses on the total N and nitrate (NO_3-) concentration for the tatsoi and red amaranth. For total N (Figure 9), the tatsoi had the most correlation but higher inconsistency between composts. The red amaranth had the least significant differences at the end-of-season, but responded with the highest standard error (SEM) towards vermicompost (0.44%). For NO_3- concentration (Figure 10), the results were more inconclusive and polarizing to BSFL compost. The tatsoi responded the best to BSFL compost but with the most variation (3790 ± 1527.25 mg/kg). The red amaranth responded the worst to BSFL compost with the least variation (1943.2 ± 414.84 mg/kg).



	Tatsoi	Red Amaranth
Windrow Compost	3.79 ± 0.38	4.54 ± 0.08
Vermiculture Compost	3.97 ± 0.20	4.15 ± 0.43
BSFL Compost	4.05 ± 0.00	4.27 ± 0.23
Control	4.26 ± 0.14	4.50 ± 0.14

Figure 9. Average total N (% of weight) found in end-of-season leaf samples of tatsoi and red amaranth. Averages and standard errors of the mean are displayed in the key below.

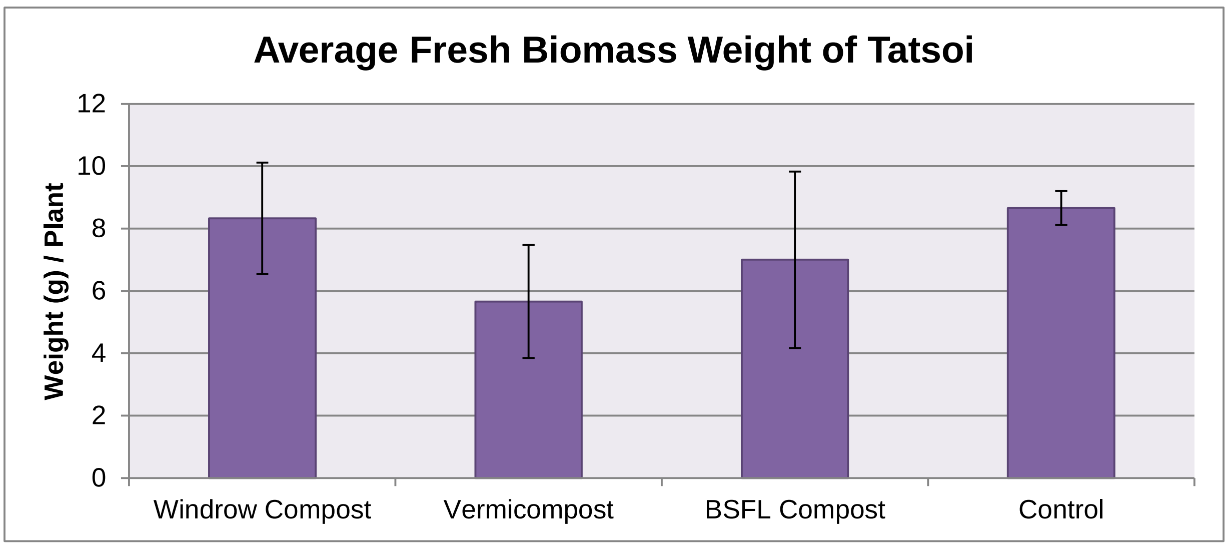


	Tatsoi	Red Amaranth
Windrow Compost	2350 ± 635.16	3240 ± 447.01
Vermiculture Compost	2786 ± 700.99	3580 ± 492.13
BSFL Compost	3790 ± 1527.35	1943 ± 414.84
Control	3240 ± 509.92	2911 ± 646.78

Figure 10. Average total NO_3- concentration (mg/kg) of tatsoi and red amaranth. Averages and standard errors of the mean are displayed in the key below.

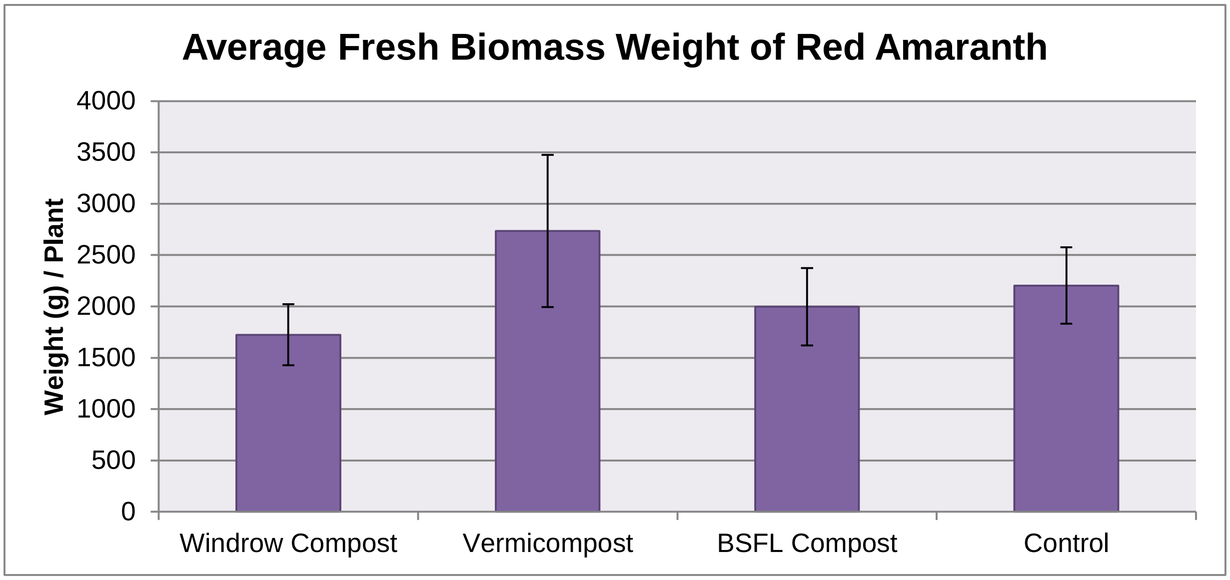
End-of-season biomass data analysis

The end-of-season fresh biomass of both tatsoi (Figure 11) and red amaranth (Figure 12) were heavily affected by the weather. The differences between treatments and crops are near indistinguishable due to their inconsistency and variability.



Windrow Compost	8.33 ± 1.78
Vermiculture Compost	5.66 ± 1.82
BSFL Compost	7.00 ± 2.83
Control	8.66 ± 0.54

Figure 11. Fresh biomass weight of tatsoi. Data collected when tatsoi was harvested on August 6th, 2013. SEM listed below.



Windrow Compost	1723.65 ± 298.13
Vermiculture Compost	2735.84 ± 740.86
BSFL Compost	1995.80 ± 376.24
Control	2203.16 ± 371.43

Figure 12. Fresh biomass weight of red amaranth. Data collected when red amaranth was harvested on August 12th, 2013. SEM listed below.

DISCUSSION

The results of this research project generates small insights to the different effects of composts upon plant growth and nutrient transfer. Although nonsignificant, the results were positively correlated and have nuanced distinguishes between the two classes of crops, *Brassicas* and *Amaranthus*. The nuances between windrow, vermiculture, and BSFL compost can be extrapolated to enhance particular crop qualities for farmers. For growth rate and end-of-season height, the control performed the best overall for both tatsoi and red amaranth, while the three compost treatments had mixed results. For average total N, red amaranth had higher variability over tatsoi, but for total NO_3- concentration, tatsoi had higher variability over red amaranth. For fresh end-of-season biomass, the control grew the largest tatsoi and the vermicompost grew the largest red amaranth. No treatment performed the best across all chosen metrics, indicating that this study can be improved upon or that these composting ideas do not work for VEGGI Farmers

Cooperative. The results of this study can increase VEGGI's knowledge of compost and sustainable agriculture, and also point towards areas of further research.

Background findings on compost treatments

Despite being out-performed by the control in some metrics, the three composts have unique nutrient profiles that can benefit particular crops. Nitrogen is a key component of synthetically made fertilizer, in addition to P and K as drivers of universal plant growth (Haug 1993). As expected, the vermicompost had the highest levels of total N (1.35%), which should be attributed to the additional worm casings. In comparison, BSFL compost had 75% less N (0.37%), and windrow compost had 0.98%. There were no hypotheses made for P and K concentration; however, the findings illustrated higher disparities between the composts. The P concentration for windrow and BSFL compost was comparable (893 and 816 mg/kg, respectively), but the vermicompost only had 517 mg/kg. The K concentration for windrow and vermicompost was comparable (6574 and 6387 mg/kg), but the BSFL compost only had 5494 mg/kg. The nutrient profiles of the composts should be robust and diversified, which this limited view of NPK supports. Based on this information, the windrow compost has a standard nutrient content, vermicompost specializes in N and K, and BSFL compost specializes in P.

Growth rate

Across tatsoi and red amaranth, the control grew the tallest plants at the quickest rate. However, height may be an inaccurate assessment of the treatments affecting plant growth because tatsoi grows radially and red amaranth grows vertically. Due to these results, the qualitative differences between compost treatments were acknowledged over their quantitative similarities.

For the tatsoi, the three composts had the same initial speed until the second week after seeding. After that point, the vermicompost had two periods of acceleration mid-season approximately two weeks and three weeks after seeding. After the third week, the growth rate decelerated, a pattern not observed elsewhere in the study. Two and a half weeks after seeding, the windrow compost accelerated for a brief period, and after that, windrow and BSFL compost had mimicking steady growth rates until the end-of-season. Based on this study, while the vermicompost had periods of acceleration, the deceleration at the end-of-season is not attractive to VEGGI growers to appeal to their customers. The steady success of the windrow compost is most appealing, in addition to the use of bedding soil control.

The composts performed differently for red amaranth, although the control still surpassed the treatments. Notably, the BSFL compost surpassed the vermicompost at the second week in the middle of the growing season, and even surpassed the control at the end of the season when it started to wane. The vermicompost and windrow compost grew indistinguishably, but the vermicompost created taller initial sprouts, which meant the vermicompost proved more successful.

The superior performance of the soil control over the compost treatments may be explained in latter metrics. Vermicompost's strong K and N content may suit *Brassicas* while BSFL's strong P content may suit *Amaranthus*. Due to the three composts' unclear general performance between tatsoi and red amaranth, VEGGI may chose to continue a compost based on costs, maintenance, biomass demands, or other variables instead of their performance.

Total nitrogen and nitrate concentration

The relationship of vermicompost to *Brassicas* and BSFL compost to *Amaranthus* does not hold true for total N and NO_3- content. For the total N content between tatsoi and red amaranth, windrow compost and the soil control showed the most divisive differences. Red amaranth contained higher levels of total nitrogen than tatsoi, but with more variability. Overall, the range across treatments and crops was just 3.79 - 4.54% of the plant biomass. The relationships between treatments and crops are more notable than the quantitative results. Red amaranth preferred windrow compost, and that relationship was also the least variable. Tatsoi preferred the control, while being most variable and least performance with windrow compost.

The relationships change when looking at NO_3- concentration. Vermicompost and BSFL compost was the most polarizing, with vermicompost best for red amaranth and BSFL compost best for tatsoi. Converse to total N, tatsoi demonstrated higher variability than red amaranth. Red amaranth demonstrated the largest range of total NO_3- (1943 – 3580 mg/kg), while the tatsoi's variability itself ranged from 509.9 – 1527.3 mg/kg. Nitrates are the portion of total N that is available to the plant (Kuo et al. 2012). The differences in NO_3- concentration between the treatments and crops may reflect the uptake ability of the plants rather than the treatments' capacity to be available for plant use.

Fresh biomass

The observations of fresh biomass between treatments and crops are valuable to VEGGI's supply to the market, as nearly all parts of tatsoi and red amaranth are edible. In addition, their prices are based on weight, so it is more advantageous to grow heavier plants. For tatsoi, the control and windrow compost generated the heaviest plants, and vermicompost produced the lightest plants. While BSFL had a mediocre performance, its variability was the highest and resulted in unreliable crop yields. For tatsoi, the vermicompost far surpassed all composts, but likewise, was the most variable. Windrow compost with red amaranth was the most consistent and least variable, but also generated the lightest plants. The relationships are not clearly defined between treatments and crops.

Limitations

The superior performance of the control over the compost treatments indicates areas of improvement for the study. This may relate to flaws in the experimental design or in the composts themselves. As the raised beds were made of compost-like material, additional compost treatments may not have contributed further benefits to the plants. The study aimed to contextualize the effects of compost in contaminated soil, but the use of raised beds on the farm nullified that goal. For the composts themselves, they were not finished "cooking" at the time of study implementation. In effect, the treatments were still decomposing into compost while the plants were seeded. This has the potential to leech nitrogen, rather than fix nitrogen, to the crops, preventing them from attaining the necessary elements to plant growth (Haug 1993). If replicated, better field design and quality composts would refine the data, lower variability, and generate clearer correlations between treatments and plant growth metrics.

The study's measurements could also be more accurate to test plant growth. For instance, with more funding and research capacity, the treatments could be tested across a broader nutrient profile rather than NPK. One of BSFL compost's advantages is a 20 fold increase in ammonium compared to typical compost due to the larvae leachate (Green and Popa 2012). Vermicompost and BSFL compost are also claimed to be more stable than typical compost due to their decomposition mechanisms. Increasing background knowledge of the treatment characteristics would place higher value on the relationships between treatments and plant growth.

In addition, the drip tape irrigation was defective in the intense summer heat. As a result, the biomorphology of the farm affected the distribution of viable plant samples to measure. The southwestern corner of the plot received the least amount of water due to their distance from the water source, both longitudinally and topographically. Scaling up this study would minimize these limitations, increasing the potential for successful samples and also stratifying the treatments to increase precision.

The potential of this study lies in its capacity to add replications and precision. More data points will build statistical significance, and more established differences between *Brassicas* and *Amaranthus* could be drawn. The results of this study are generally inconclusive, indicating the need to scale up the study to procure more precise results, or indicating an overall flaw in using compost as a plant growth supplement. This study can also be repeated across climates, plants, and composts to develop knowledge on the nuances of these relationships in agronomy.

Conclusions

Performing agriculture in a New Orleans summer is already a challenge due to the extreme weather and poor agriculture infrastructure. The spectrum and prevalence of soil contamination in the area, due to urban and non-urban point sources, indicate the need for a spectrum of soil amendments that may include compost (Horrigan et al. 2002). In a robust, agroecological system, the one-size-fits-all model of synthetic fertilizer would be eliminated to allow farmers to consider the needs of their crops and field conditions (Clark and Foster 2009). Different composts provide particular amounts of beneficial nutrients that can inhibit, modify, or neutralize contaminants. A particular composting method may be appropriate for VEGGI, but an entirely different method of soil remediation and plant growth supplements may work better as well.

This study develops the idea of compost use as a soil amendment and crop supplement. Increased use of compost can help close the loop of farm outputs and inputs by recycling biomass. The needs of the crops, conditions of the farm, and availability of compost biomass all form compelling arguments for one compost over another. The results of this study can help distinguish these needs, but more studies should be done to strengthen the correlation of the relationship. Whilst compost can recycle biomass and improve soil texture, the links for nutrient transfer and supplement were not supported by this study. Regionally appropriate agricultural methods will strengthen the dynamic systems of a farm, propelling them to higher yields and more efficient practices.

ACKNOWLEDGEMENTS

Thank you to Magnolia Project at the UC Berkeley Public Service Center for granting me the opportunity to spend a summer interning in New Orleans. The staff and growers at MQVN Community Development Corporation and VEGGI Farmers Cooperative, especially Daniel and Khải Nguyễn, were critical in evolving my non-profit internship into a community-based research project. Thank you to the lab technicians and services at Louisiana State AgCenter, Iowa State University Soil & Plant Analysis Lab, and Georgia State University Soil, Plant, and Water Laboratory. Tom McCann, Steven Chang, and Willy Lai from UC Berkeley’s Statistics Department were patient walking me through all of my statistics. Thank you to the crew from ESPM 100ES and ESPM 175 (Professor John Battles, Dr. Patina Mendez, Dr. Kurt Spreyer, Maya Hayden, Julie Hopper, and Anne Murray) for providing the environment and tools for intense scholastic engagement. Many thanks to Houston Wilson, my thesis mentor, for hooking me onto agroecology and being continuously available, responsive, and encouraging. Lastly, thank you to the funders who covered the costs of my travel, lodging, and research: Amy Adina Schulman Memorial Fund, CNR Travel Grant, and Professor Jeffrey Wickliffe of Tulane University School of Public Health and Tropical Medicine.

REFERENCES

Abdelaziz, M., R. Pokluda, and M. Abdelwahab. 2007. Influence of compost, microorganisms, and NPK fertilizer upon growth, chemical composition, and essential oil production of *Rosmarinus officinalis L.* Notulae Botanicae Horti Agrobotanici Cluj-Napoca 35:86-90.

Adams, J. D. W., and L. E. Frostick. 2009. Analysis of bacterial activity, biomass and diversity during windrow composting. Waste Management 29:598-605.

Brink, N. 1993. Composting of food waste and catching nitrogen. Acta Agriculturae Scandinavica, Section B – Soil & Plant Science 43:114-120.

Clark, B., and J. B. Foster. 2009. Ecological imperialism and the global metabolic rift: Unequal exchange and the guano/nitrates trade. International Journal of Comparative Sociology 50:311-334.

D'Emilio, M, R. Caggiano, M. Macchiato, M. Ragosta, and S. Sabia. 2013. Soil heavy metal contamination in an industrial area: access of the data collected during a decade. Environmental Monitoring Assessment 185:5951-5964.

Frederickson, J., K. R. Butt, R. M. Morris, and C. Daniel. 1997. Vermiculture with traditional green waste composting systems. Soil Biology and Biochemistry 29:725-736.

Ganeshamurthy, A. N., L. R. Varalakshmi, and H. P. Sumangala. 2008. Environmental risks associated with heavy metal contamination in soil, water and plants in urban and periurban agriculture. Journal of Horticultural Sciences 3:1-29.

Google Inc. 2013. Version 7.1. Google Earth, Mountain View, CA. www.earth.google.com

Green, T. R., and R. Popa. 2012. Enhanced ammonia content in compost leachate processed by black soldier fly larvae. Applied Biochemistry and Biotechnology 166(6):1381-1387.

Haug, R. 1993. The Practical Handbook of Compost Engineering. CRC Press.

Horrigan, L., R. S. Lawrence, and P. Walker. 2002. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental Health Perspectives 110(5):445-456.

Jugnia, L. B., Y. Mottiar, E. Djulkom, A. R. Cabral, and C. W. Greer. Effect of compost, nitrogen salts, and NPK fertilizers on methane oxidation potential at different temperatures. Applied Microbiology and Biotechnology 93:2633-2643.

Kuo, Y., S. Wang, C. Kao, C. Chen, and W. Sung. 2012. Using enhanced landfarming systems to remediate diesel oil-contaminated soils. Applied Mechanics and Materials 121-126:554-558.

McClintock, N. 2010. Why farm the city? Theorizing urban agriculture through a lens of metabolic rift. Cambridge Journal of Regions, Economy and Society 3:191-207.

R Development Core Team. 2006. R version 2.8.0. R Foundation for Statistical Computing, Vienna, Austria. http://www.r-project.org

United States Department of Agriculture. 2013. Food Access Research Atlas. Economic Research Service, United States Department of Agriculture.

Wortman, S. E., and S. T. Lovell. 2013. Environmental challenges threatening the growth of urban agriculture in the United States. Journal of Environmental Quality 42:1283-1294.

APPENDIX A: Lab tests for compost, soil, and plant analysis

1. Control Bedding Soil Sample Analysis – Louisiana State University AgCenter
   a. CHN and combustion analysis for total N, heavy metals, and water soluble P & K
2. Tatsoi Compost Sample Analysis – Louisiana State University AgCenter
   a. CHN and combustion analysis for total N and heavy metals
3. Red Amaranth Compost Sample Analysis – Georgia State University Soil, Plant, and Water Laboratory
   a. CHN and combustion analysis for total N and heavy metals
4. Tatsoi Plant Sample Analysis – Iowa State University Soil & Plant Analysis Lab
   a. Combustion analysis for total N
   b. Colorimetric analysis for inorganic nitrogen (NO_3^{-}N)
5. Red Amaranth Plant Sample Analysis – Iowa State University Soil & Plant Analysis Lab
   a. Combustion analysis for total N
   b. Colorimetric analysis for inorganic nitrogen (NO_3^{-}N)

APPENDIX B: R Studio script for permutation tests

```r
# permutation test
# HO: mu1 = mu2
# HA: mu1  =/= mu2

read.csv = "Tatsoi_1v2.csv"
datT = c(1:21)
datC = c(1:23)
permdiff = function(x, y, B) {
  k = abs(mean(datT) - mean(datC))
  P_Stat = numeric(B)
  for (b in 1:B) {
    m = length(x)
    z = c(x, y)
    Ind = sample(length(z))
    P_Stat[b] = abs(mean(z[Ind[1:m]]) - mean(z[Ind[-(1:m)]]))
  }
  R = sum(P_Stat >= k)
  p = R/(B + 1)
  p
}
permdiff(datT, datC, 1e+05)

# 1v2: 0.6266137
```