Naturcycle, LLC. and Boston Medical Center Rooftop Farm

“Crop Cultivation and Urban Agriculture Media Efficiency – Year 2 Final Report”

Research Project 2024

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Introduction

Urban and rooftop farming has emerged as a sustainable solution to address the growing demand for local and fresh produce in rapidly growing, densely populated areas. A variety of green roof media is commercially available for the development of these urban and rooftop farms and can drastically effect crop cultivation, energy expenditures, water retention, and overall sustainability for urban agricultural practices. This report details a collaborative research study between Naturcycle, LLC and Boston Medical Center (BMC) Rooftop Farm. The BMC Rooftop Farm is a 2,658 square foot farm with more than 30 varieties of crops. The farm not only provides fresh, local produce to the hospitalized patients, cafeterias, Demonstration Kitchen, and Preventive Food Pantry, but is also part of BMC's commitment to sustainability. The farm reduces storm water runoff, increases green space, and reduces energy use, including the energy required to transport food. The farm was designed and installed by Somerville-based, Recover Green Roofs, and opened in 2017. Naturcycle, LLC is a firm focused on providing specialty compost, engineered soil, and green roof media needs. Their mission is to provide high-quality compost and engineered soils to users of all types. Their team is dedicated to enhancing the environment with local, sustainable materials for landscaping uses, green roof projects, and other applications.

This research project aims to examine the difference in crop cultivation and efficiency across different green roof media. The media included in the study includes a high organic potting soil used as the “standard”, the urban agriculture blend historically and currently in use at the BMC Rooftop Garden referred to as “BMC Blend”, the soilless media blend provided by Naturcycle referred to as “Naturcycle” or “NC”, and a third-party soilless media which is also in use in some areas on the BMC rooftop farm. Data was collected onsite at BMC’s rooftop farm from May 2024 to October 2024 in the experimental bed areas which was all of Bed 7 and the first half (Boxes 1-12, Rows A-D) of Bed 5. Parameters of the research study included information about soil characteristics and crop characteristics. Soil characteristics collected included relative temperature, relative soil moisture, and soil composition. Crop characteristics collected were mostly growth metrics that varied depending on the crop type which included turnips, collard greens, jalapeño peppers, and tomatoes. These growth characteristics included length of largest leaf, number of leaves, and plant height. The total pounds harvested of each crop by soil type was also computed and weekly harvests were tracked. Qualitative measurements were also taken by documenting growth pictures of the experimental beds to compare real-time growth and pictures taken of harvest to show similarities and differences between harvested crops. This is a Year 2 continuation of the experiment in which the baseline was set forth in the previous report “Crop Cultivation and Urban Agriculture Media Efficiency – Year 1 Final Report”. In addition to the Year 2 data collection across crop and soil types, comparisons are also drawn between the data presented in the Year 1 report and the data presented here in the Year 2 report. The goal of this report is to compare efficiency of crop cultivation and soil characteristics for engineered green roof media in real farm growing conditions.

Methods

Experimental Set Up

At the BMC rooftop farm, Bed 5 and Bed 7 were designated for the experimental area. There are four rows in each Bed (A, B, C, and D) labeled left to right, respectively. Boxes 1-12 in each row in Bed 5 and boxes 1-31 (only 1-29 in row B) were used for the experiment.

In Bed 5, the BMC blend was located in row A boxes 1-6 and row B boxes 1-6. The third-party soilless media was located in row A boxes 7-12 and row B boxes 7-12. The high organic potting soil (the "standard") was located in row C boxes 1-6 and row D boxes 1-6. The Naturcycle ag blend was located in row C boxes 7-12 and row D boxes 7-12.

In Bed 7, the high organic potting soil ("standard") was located in row A boxes 1-31. The third-party soilless media was located in row B boxes 1-29. The BMC Blend was located in row C boxes 1-31. The Naturcycle ag blend was located in row D boxes 1-31.

All boxes were filled previously (in Year 1) with their respective medias and then placed with a single irrigation emitter that was placed centrally in the box. Spray irrigation emitters were located in the middle (between rows B and C) every 4 boxes. All boxes in all rows in Bed 5 were irrigated the same and all boxes in all rows in Bed 7 were irrigated the same, however irrigation in Bed 5 and Bed 7 were different. After the growing season in Year 1, the boxes remained outside, uncovered, and were untouched until saplings or seeds were planted for the experiment in May/June of 2024. These conditions reflect true growing and treatment conditions on the farm.

All media were treated equally with fertilizers, additives, and pest treatment at the discretion of the farm manager during the Year 2 study. All seedlings that were transported were grown in the same greenhouse and grown in high organic potting soil before being transported to the soilless media boxes. The only major pest damage noticed was damage on the collard greens where they received the same organize pest repellant application which was even across all collards planted in the experimental area. It is important to note that the farm manager had changed from the Year 1 study to the Year 2 study. The research assistant performing data collection had also changed from Year 1 to Year 2. There was also a delay in the planting season this year so there is not the same quantity of data collected in Year 2 as compared to Year 1, however there was enough data collected to be significant and have a large enough of a sample size for comparisons. These variables were out of the control parameters of the study. Care and insurance were taken to ensure that the growing conditions of the Year 1 plants reflected the growing conditions of the Year 2 plants, and that training was given so data collection was the same across research assistants so comparisons could be made between years. However, these comparisons are made generally and are not absolute as complete control of the experiment could not be controlled.

Crop Location and Planting Schedule

Collard green seedlings were transported to respective media boxes (boxes 1-16) in Bed 7 in June 2024. They were first harvested on July 16th and all crops were finished being harvested by October 23rd.

Turnips were directly seeded and planted into the respective media in Bed 5 in June 2024. Six boxes were planted per soil type and only planted on the outside of each soil type so only rows A and D had turnips planted in them. They were first harvested on August 1st and all crops were finished being harvested by August 15th.

Jalapeño pepper seedlings were transported to the respective media boxes (boxes 17-31) in Bed 7 in June 2024. They were first harvested on July 16th and all crops were finished being harvested by September 25th.

Tomato seedlings were transported to the respective media boxes on June 14th. Six seedlings were planted per soil type and only planted on the inside of each soil type so only rows B and C had seedlings planted in them. They were first harvested on August 15th and all crops were finished being harvested by September 18th.

Harvesting

All crops were harvested on a "ready to harvest" basis, meaning that crops were harvested when they were ready to be harvested at the discretion of the farm manager. For example, this means that some weeks only crops in rows A and D were harvested while the other two rows were not harvested because the crops were not ready to harvest until the following week based on crop growth.

Weekly crop harvests were recorded by taking the total weight of crop harvested after rinsing and subtracting any weight from the container they were placed in for harvest. Crops from the same soil type were harvested and weighed together.

Soil Temperature Measurements

A backyard pro compost thermometer by Reotemp was used to take soil temperature measurements every week. Collection was taken from 14 randomly selected boxes per soil type where the average was then computed and reported. The bottom 1" of the probe was inserted into the soil and the probe was allowed to equilibrate for 1 minute before the number was read and reported. Collection always started with the standard and then moved to the BMC Blend and finally the Naturcycle ag blend. The third-party media was not included in these measurements due to the nature of the soilless media. For example, if boxes 3, 6, and 9 were those randomly selected for collection, collection was taken from Standard box 3, BMC box 3, and NC box 3. Then measurement moved on to Standard box 6, BMC box 6, and NC box 6. Same pattern was followed for box 9 and all other boxes.

Air temperature was also recorded during the timing of data collection on that day and included in the weekly measurements.

Relative Moisture Measurements

A garden and compost moisture meter from Reotemp was used to take relative soil moisture measurements every week. The same boxes selected for collection of temperature were also used to take moisture readings. The Standard was used as calibration and always reported as "5" which is "ideal" soil moisture. The same collection pattern for temperature was followed for moisture with the calibration of the Standard and then the measurement of BMC blend and NC and then the next set of boxes were used for collection repeating the same calibration process. The third-party media was also not included in moisture measurements due to the nature of the media.

Growth Measurements

Growth of collard greens from seedlings was tracked through biweekly (every 2 weeks) counts of unfurled leaves and length of largest leaf – measured from stem to tip with a tape measurer. Measurements taken from 8 plants (half of the boxes) and averaged together. The 8 plants selected were the odd numbered plants and they were always the ones included in the measurements. Baseline measurements were taken on day of transfer to the media boxes.

Growth of plants transplanted as seedlings (jalapenos and tomatoes) was tracked through biweekly (every 2 weeks) measurements of plant height from surface of soil to tallest part of the plant. Measurements taken from 8 plants (half of the boxes) and averaged together. The 8 plants selected were the odd numbered plants and they were always the ones included in the measurements. Baseline measurements were taken on day of transfer to the media boxes.

Green Roof Media – Saturated Media Extract Analysis: Soil Composite Reports

Soil composites were taken monthly from May (baseline) to October and sent to the Penn State Extension Laboratory for analysis. Composites were collected according to the soilless media sampling instructions included with the information sheet provided by Penn State. In summary, these instructions included to take the same at least 6 hours after watering and 5 days after a fertilizer treatment. The top ¼ of media was scrapped aside and small portions of media was sampled from several inches into the media from at least 10 or more boxes of the same media type. The boxes selected for composite samplings were selected using a random number generator and 14 boxes were selected. The composite was then spread out in a clean potting tray and left overnight to dry out. The following day it was placed in a labeled and securely sealed plastic zipper bag and then mailed with its appropriate information and chain of custody forms to the laboratory.

Results

The following Table 1 and Figure 1 reflect the average soil and air temperatures in degrees Fahrenheit.

*Table 1: Average Soil Temperature by Soil Type in degrees Fahrenheit. PS = potting soil ("standard"), BMC = BMC Blend, NC = Naturcycle ag blend, *air = relative air temperature*

Temperature (°F)										
Soil	*Date*									
	5/28	**6/4**	**6/13**	**6/20**	**6/27**	**7/2**	**7/9**	**7/16**	**7/25**	**8/1**
PS	71	71	67	80	75	64	75	74	68	73
BMC	72	76	67	82	75	70	81	80	73	79
NC	71	73	67	81	75	70	81	80	73	79
*air	76	76	75	85	85	70	78	80	76	77
Soil	*Date*									
	8/6	**8/13**	**8/20**	**8/27**	**9/3**	**9/10**	**9/18**	**9/25**	**10/3**	
PS	65	76	71	72	58	73	62	59	58	
BMC	64	78	72	71	62	74	66	63	61	
NC	66	77	71	72	62	73	65	62	60	
*air	68	81	72	73	65	75	64	63	50	

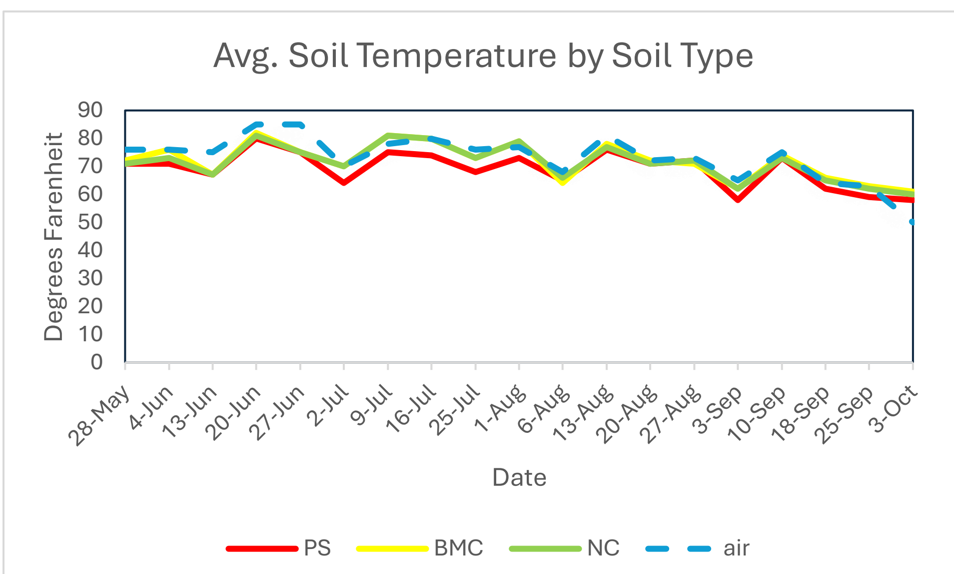

Figure 1: Soil Temperature by Soil Type in degrees Fahrenheit

As seen in Table 1 and further exemplified in Figure 1, there is no large difference on average between the average temperature of the soil based on soil type. Since the randomly selected boxes that measurements were taken from included a variety of crops and were taken throughout the experiment when crops were rotating, it can also be concluded that crop type does not affect temperature of the soil, and it remains consistent across all media types.

The following Table 2 and Figure 2 reflect the average relative moisture across media type.

Table 2: Relative Moisture by Soil Type.PS = potting soil ("standard"), BMC = BMC Blend, NC = Naturcycle ag blend

Relative Moisture										
Soil	*Date*									
	5/28	**6/4**	**6/13**	**6/20**	**6/27**	**7/2**	**7/9**	**7/16**	**7/25**	**8/1**
PS	5	5	5	5	5	5	5	5	5	5
BMC	1	1	1	1	1	2	1	1	1	1
NC	9	5	4	4	5	6	5	5	3	4
Soil	*Date*									
	8/6	**8/13**	**8/20**	**8/27**	**9/3**	**9/10**	**9/18**	**9/25**	**10/3**	
PS	5	5	5	5	5	5	5	5	5	
BMC	2	1	1	2	1	1	1	1	1	
NC	4	3	5	4	2	3	2	3	2	

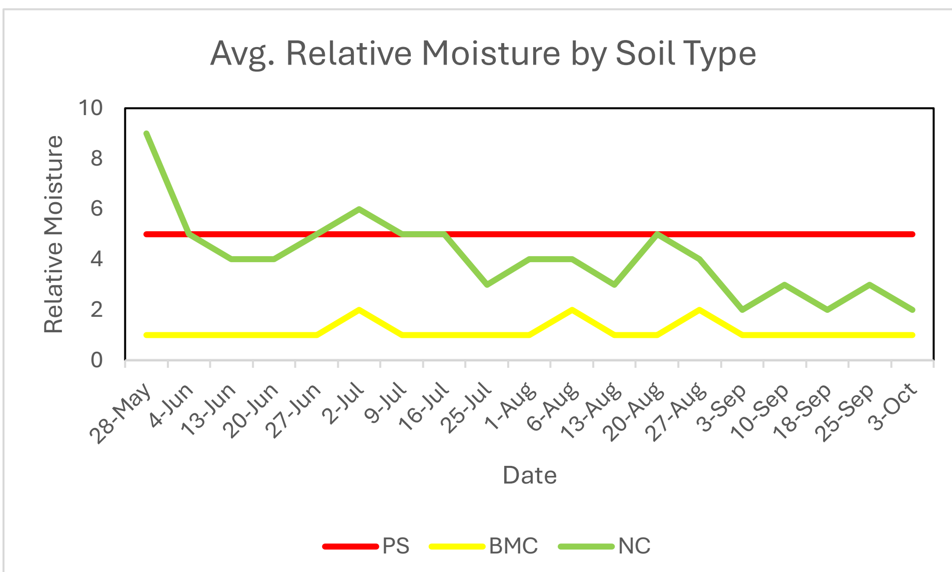

Figure 2: Relative Moisture by Soil Type

Table 2 shows the relative moisture measurements across media types. The way the probe reads relative moisture was on a reading of 1 to 10. The probe was inserted into the high organic potting soil and calibrated to a reading of 5 which indicated ideal soil moisture. The probe was then inserted into the BMC blend and finally the Naturcycle ag blend, ensuring that the probed was wiped between measurements. As seen in Figure 2, the high organic potting soil always read a 5 as it was calibrated to ideal conditions. The Naturcycle ag blend was reading above ideal conditions in the beginning of the study but after a large drought throughout the summer, it consistently read a little higher than ideal. The BMC blend almost always had a reading of 1 or 2. Based on how the probe reads this measurement by using conductivity and discussing how the media is made, these relative soil measurements should be used carefully when drawing conclusions about the soil moisture of the media over the course of the study. Comparing these measurements to the percent moisture that was obtained during the soil composites should give a better understanding of how the moisture of the soil changed throughout the study.

The following Table 3 and Figures 3 and 4 shows growth of collard greens from seedlings and is tracked through biweekly counts of unfurled leaves and length of largest leaf – measured from stem to tip. Measurements taken from 8 plants (half of the boxes) and averaged together. Baseline measurements for all seedlings taken on day of transplant were 5 unfurled leaves and 4.5 inches for the largest leaf length.

Table 3: Average number of leaves and average length of biggest leaf (inches) for collard greens in Bed 7

Collard Greens – Bed 7				
	Date			
	6/27		7/9	
Soil Type	*# of Leaves*	*Biggest Leaf (inches)*	*# of Leaves*	*Biggest Leaf (inches)*
Potting Soil	5*	4.5*	12	7.75
3rd Party	5*	4.5*	11	7
BMC Blend	5*	4.5*	9	6
Naturcycle	5*	4.5*	11	7
	Date			
	7/25		8/8	
Soil Type	*# of Leaves*	*Biggest Leaf (inches)*	*# of Leaves*	*Biggest Leaf (inches)*
Potting Soil	10	11.5	11	12
3rd Party	10	11.25	9	10
BMC Blend	7	9.75	8	10
Naturcycle	11	12.5	13	13
	Date			
	8/22		9/3	
Soil Type	*# of Leaves*	*Biggest Leaf (inches)*	*# of Leaves*	*Biggest Leaf (inches)*
Potting Soil	12	11	12	10
3rd Party	10	9	11	9

BMC Blend	10	8	12	9
Naturcycle	12	13	13	12

	Date			
	9/18		10/3	
Soil Type	*# of Leaves*	*Biggest Leaf (inches)*	*# of Leaves*	*Biggest Leaf (inches)*
Potting Soil	11	8	8	7
3rd Party	9	7	7	6
BMC Blend	10	6.5	7	6
Naturcycle	11	9.25	12	9

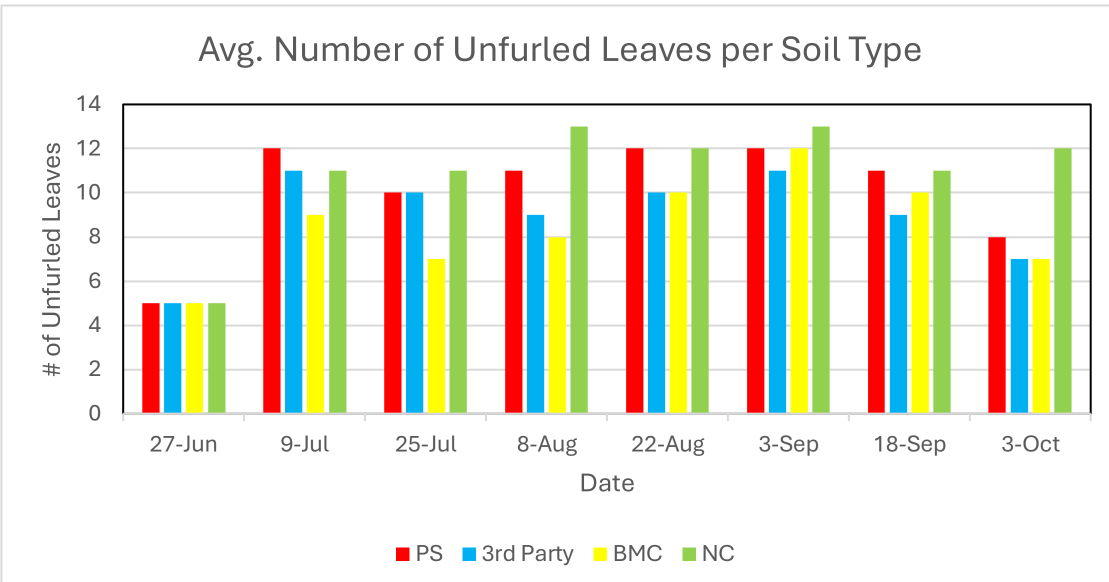

Figure 3: Clustered column bar graph of number of avg. unfurled leaves per soil type for collard greens

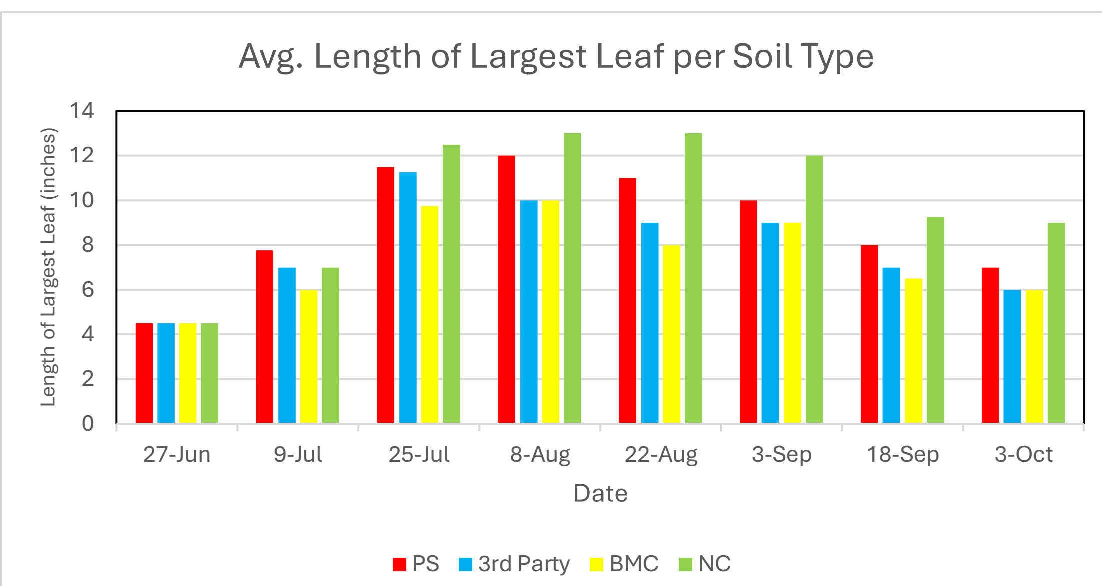

Figure 4: Clustered column bar graph of avg. length of largest leaf per soil type for collard greens

Table 3 and subsequent figures 3 and 4 show the growth characteristics for collard greens over the course of the growing season. The general trend of the number of unfurled leaves per soil type remained consistent throughout the season. Potting soil almost always had the greatest number of unfurled leaves with Naturcycle and BMC having consistently high numbers as well. It should be noted that Naturcycle and Potting Soil collard greens were harvested almost every week while BMC and the 3rd party collard greens sometimes had weeks skipped as they were deemed not harvest ready yet. In terms of size of leaf, all media types were relatively consistent throughout the season. Naturcycle collard greens had the most unfurled leaves and the largest leaves with Potting Soil have the second biggest leaves. The 3rd party Collard Greens and the BMC leaves were comparable, and smaller than the other two. The Naturcycle collard greens had consistent growth throughout the season and maintained their size until the end.

Table 4 and Figure 5 shows growth of tomato plants starting at transplant of seedlings. Growth is tracked through biweekly measurements of plant height from surface of soil to tallest part of the plant. Measurements taken from all available plants (due to small sample sizes) and averaged together. Baseline measurements for all seedlings taken on day of transplant were 12 inches.

Table 4: Avg. height of plant (inches) for tomatoes per soil type

Tomatoes – Bed 5 (Average Height – inches)								
Soil	*Date*							
	6/27	**7/9**	**7/25**	**8/8**	**8/22**	**9/3**	**9/18**	**10/3**
PS	12	21.5	35	34	34	33	33	25
3rd Party	12	17.5	31	32	32.5	33	34	22
BMC	12	20	31	31	31.5	32	32.5	23
NC	12	23	41	32	43.5	44	44.5	19

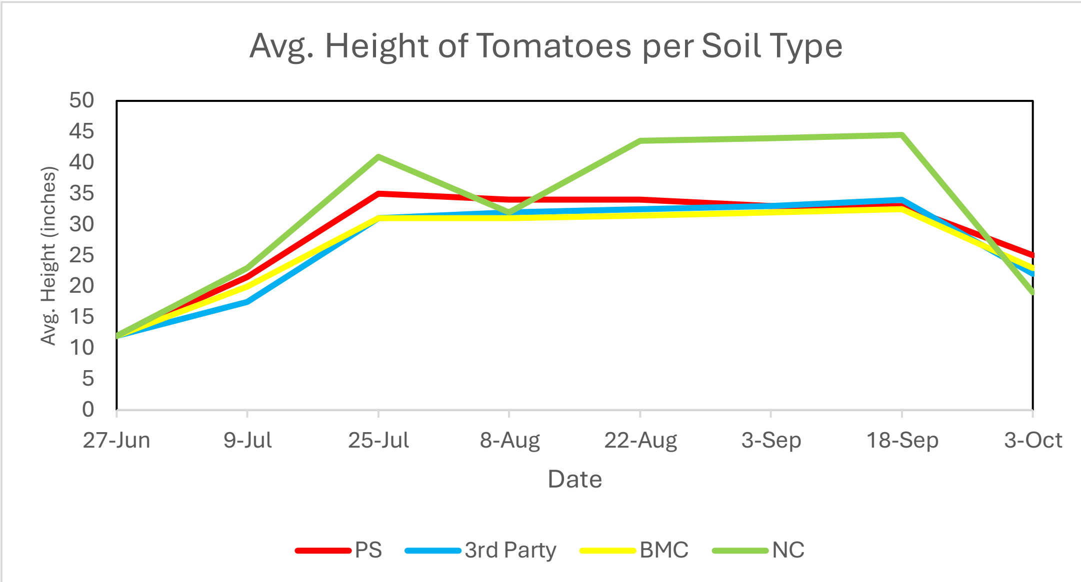

Figure 5: Avg. Height of Tomatoes (inches) per soil type

As seen in Table 4 and in Figure 5, all tomato seedlings were the same height when transplanted into their respective media on June 27th. The tomatoes grown in Naturcycle had increased growth patterns and the tomatoes grown in the Potting Soil, the BMC blend, and the 3rd party media had similar growth patterns. The large decrease in heigh from September to October, most noticeable in Naturcycle, but also present in the other measurements, is due to the fact that many of the plants used for measurements had broken or were removed from the media as the growing season was over.

Table 5 and Figure 6 shows growth of Jalapeño pepper plants starting measurements at transplant of seedlings. Growth is tracked through biweekly measurements of plant height from surface of soil to tallest part of the plant. Measurements taken from all available plants (due to small sample sizes) and averaged together. Measurements taken from 8 plants (half of the boxes) and averaged together. Baseline measurements for all seedlings taken on day of transplant were 11 inches.

Table 5: Avg. Height (inches) of Jalapeno Peppers per Soil Type

Jalapeño Peppers – Bed 7 (Average Height – inches)								
Soil	*Date*							
	6/27	**7/9**	**7/25**	**8/8**	**8/22**	**9/3**	**9/18**	**10/3**
PS	11	17	21	21	22	22.25	21	20
3rd Party	11	15.25	21	21	20	19	19	18
BMC	11	14	19.25	20	19	18	22	21
NC	11	18.5	22.5	22	20	21.5	24	22

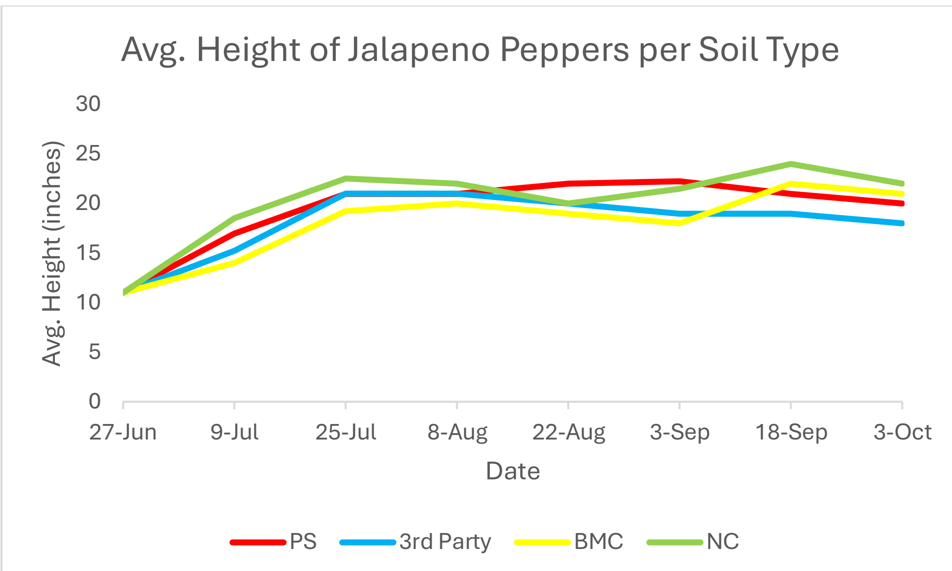

Figure 6: Avg. Height (inches) of Jalapeno Peppers per Soil Type

As seen in Table 5 and in Figure 6, all Jalapeño pepper seedlings were the same height when transplanted into their respective media in June. They all had similar growth patterns with Naturcycle producing the tallest plants.

Tables 6 – 9 show the total pounds harvested for each crop by soil type. Weekly crop harvests were recorded by taking the total weight of crop harvested after rinsing and subtracting any weight from the container they were placed in for harvest. Crops from the same soil type were harvested and weighed together.

Table 6: Total pounds harvested for collard greens per soil type

Collard Greens – Total Pounds Harvested	
Soil Type	*Total Pounds Harvested (lbs)*
Potting Soil	14.4
3rd Party Media	13
BMC Blend	8.1
Naturcycle	20.8

Table 7: Total pounds harvested for tomatoes per soil type

Tomatoes – Total Pounds Harvested	
Soil Type	*Total Pounds Harvested (lbs)*
Potting Soil	3.6
3rd Party Media	2.7
BMC Blend	3.4
Naturcycle	5

Table 8: Total pounds harvested for jalapeno per soil type

Jalapeño Peppers – Total Pounds Harvested	
Soil Type	*Total Pounds Harvested (lbs)*
Potting Soil	10.6
3rd Party Media	6.2
BMC Blend	6.6
Naturcycle	11

Table 9: Total pounds harvested for turnips per soil type

Turnips – Total Pounds Harvested	
Soil Type	*Total Pounds Harvested (lbs)*
Potting Soil	1
3rd Party Media	0
BMC Blend	0
Naturcycle	3.8

Tables 6-9 show that the total yield of produce for Naturcycle was extremely comparable, and often even higher, than the total yield of produce for the potting soil standard. These tables also show how significantly different the total pounds harvested for the potting soil standard and Naturcycle were when compared to the current BMC Blend and the 3rd party media. Pictures of plant growth and crop harvests are found in the picture appendix, but it is of note that most of the produce from plants grown in the potting soil standard and in the Naturcycle media were larger and more plentiful than produce from the current BMC blend and 3rd party media. Also, these crops were also more likely to be harvested on a weekly basis. The turnips grown in the 3rd party media and the BMC blend never reached a "ready to harvest" status before the growing season was over. The sprouting and development of them was minimal compared to the potting soil and Naturcycle. However, all the turnips struggled this growing season as they were planted very late into the growing season.

Tables 10-13 show the summary of analysis for the monthly soil composites taken and sent to Penn State. Composites were collected according to the soilless media sampling instructions included with the information sheet provided by Penn State.

Table 10: Summary of analysis for May soil composite

5/28/24 Soil Report			
	Soil Type		
Analysis (units)	Potting Soil	BMC Blend	Naturcycle
pH	7.4	7.6	7.2
Soluble Salts (mmhos/cm)	0.43	0.72	1.82
Nitrate-N (mg/L)	2.16	12.67	33.66
Ammonia-N (mg/L)	0.1	0.52	0.28
Nitrate-N + Ammonia-N (mg/L)	2.26	13.19	33.94
Phosphorus (P) (mg/L)	4.3	4.5	5.7
Potassium (K) (mg/L)	19	14	23
Calcium (Ca) (mg/L)	111	262	582
Magnesium (Mg) (mg/L)	15	32	48
Boron (B) (mg/L)	0.0012	0.055	0.069
Copper (Cu) (mg/L)	0.5	1.4	1.1
Iron (Fe) (mg/L)	33.1	32.9	29.6
Manganese (Mn) (mg/L)	1.73	3.62	3.09
Sodium (Na) (mg/L)	43	49	75

Zinc (Zn) (mg/L)	11.6	16.1	18.4
Moisture (%)	53.8	6.2	14.8
Organic Matter (% dry weight)	49.58	6.2	12.18
Cation Exchange Capacity (CEC) (cmol/kg)	45.47	9.66	19.45

Table 11: Summary of analysis for June soil composite

6/27/24 Soil Report			
	Soil Type		
Analysis (units)	Potting Soil	BMC Blend	Naturcycle
pH	6.9	7.2	7
Soluble Salts (mmhos/cm)	1.41	2.28	2.02
Nitrate-N (mg/L)	102.86	134.25	65.34
Ammonia-N (mg/L)	0.3	12.65	0.77
Nitrate-N + Ammonia-N (mg/L)	103.16	146.9	66.11
Phosphorus (P) (mg/L)	27.4	27.1	7.9
Potassium (K) (mg/L)	235	347	108
Calcium (Ca) (mg/L)	153	303	547
Magnesium (Mg) (mg/L)	30	62	52
Boron (B) (mg/L)	0.174	0.277	0.194
Copper (Cu) (mg/L)	0.8	1.5	1.3
Iron (Fe) (mg/L)	36.4	29.3	31.1
Manganese (Mn) (mg/L)	3.92	16.81	7.04
Sodium (Na) (mg/L)	92	113	98
Zinc (Zn) (mg/L)	17	18.7	21.7

Moisture (%)	48.5	6.6	11.5
Organic Matter (% dry weight)	49.82	5.98	10.61
Cation Exchange Capacity (CEC) (cmol/kg)	34.43	8.44	14.59

Table 12: Summary of analysis for August soil composite

8/15/24 Soil Report			
	Soil Type		
Analysis (units)	Potting Soil	BMC Blend	Naturcycle
pH	6.9	7.8	7
Soluble Salts (mmhos/cm)	0.69	0.78	1.95
Nitrate-N (mg/L)	7.64	9.39	15.78
Ammonia-N (mg/L)	0.2	0.24	0.23
Nitrate-N + Ammonia-N (mg/L)	7.84	9.63	16.01
Phosphorus (P) (mg/L)	14.1	6.8	4.5
Potassium (K) (mg/L)	42	16	25
Calcium (Ca) (mg/L)	159	273	600
Magnesium (Mg) (mg/L)	21	36	38
Boron (B) (mg/L)	0.104	0.133	0.14
Copper (Cu) (mg/L)	0.5	1.1	1
Iron (Fe) (mg/L)	32.6	18.3	29.9
Manganese (Mn) (mg/L)	1.62	2.54	2.42
Sodium (Na) (mg/L)	85	61	119
Zinc (Zn) (mg/L)	9.3	8.1	16.1
Moisture (%)	55.3	8.7	13.2

Organic Matter (% dry weight)	52.01	4	10.25
Cation Exchange Capacity (CEC) (cmol/kg)	42.07	5.96	14.21

Table 13: Summary of analysis for October soil composite

10/23/24 Soil Report			
	Soil Type		
Analysis (units)	Potting Soil	BMC Blend	Naturcycle
pH	7.1	7.8	7.2
Soluble Salts (mmhos/cm)	0.77	0.67	1.28
Nitrate-N (mg/L)	10.15	4.98	7.22
Ammonia-N (mg/L)	0.32	0.27	0.19
Nitrate-N + Ammonia-N (mg/L)	10.47	5.25	7.41
Phosphorus (P) (mg/L)	27.4	8.2	4.8
Potassium (K) (mg/L)	25	13	1
Calcium (Ca) (mg/L)	133	175	348
Magnesium (Mg) (mg/L)	24	24	22
Boron (B) (mg/L)	0.082	0.077	0.114
Copper (Cu) (mg/L)	0.4	1.2	0.9
Iron (Fe) (mg/L)	18.8	14	23.1
Manganese (Mn) (mg/L)	1.07	1.54	1.41
Sodium (Na) (mg/L)	86	53	91
Zinc (Zn) (mg/L)	12.9	10.1	15.1
Moisture (%)	65.1	10.6	22.7
Organic Matter (% dry weight)	50.36	3.79	10.94

Cation Exchange Capacity (CEC) (cmol/kg)	36.13	6.12	15.01

Based on tables 10-13, the monthly soil reports show general trends of decreasing nutrients as the months progress. This is to be expected as the season goes on that the nutrients are depleted from the soil. The percent moisture is an interesting measure as it has a general trend of potting soil being the wettest and BMC blend being the driest but there is no month-to-month trend, and the percentages tend to fluctuate. This tends to make sense with the fluctuations in the weather and precipitation that the Rooftop Farm received over the course of the season, but it is interesting to compare it to the relative moisture readings noted earlier in the report.

Discussion

In conclusion, this research project provided information about the difference in crop cultivation and efficiency across different green roof media. After examining the research parameters, soil characteristics, and growth characteristics, several conclusions and comparisons can be made for the Year 1 to Year 2 study. Potting soil was used as the standard in this study as it is considered the normal growing media for saplings and for container and normal gardening to be used in rotation during the growing season across a large variety of plants. However, it is not usual for it be used in an urban agriculture setting because of the quick depletion of its nutrient's portfolio. The goal of an urban agriculture media blend is to be a stable container of growing media over several growing seasons. It was previously hypothesized in the Year 1 Final Report that the yield of crops was expected to decrease in Year 2 and that hypothesis was true. Naturcycle had the highest yield of crops during the Year 2 growing season for the crops were planted in both years.

It was also hypothesized that this version of the Naturcycle agriculture media was expected to perform on the same caliber in the Year 2 study as it did in the Year 1 study, even with some slight decrease in crop and harvest yield. This hypothesis was supported, even with the difficult to draw absolute comparisons since the growing season was shorter in Year 2 than it was in Year 1. Another hypothesis would be that if the soil and farm conditions were left alone and the study was to be brought back for a Year 3 study, then the same trends would appear. After Year 3 though the experiment would need to end, and the beds would need to be refreshed due to the compaction and loss of soil due to the monthly soil samples. Based on the data and trends in the Year 1 and Year 2 study, the recommendation that Naturcycle is the long-term (multi-season) agricultural media for dark leafy greens, pepper plants, and tomatoes.

Something brought up in the Year 1 report was the relative moisture readings. As stated previously, the potting soil was used as the calibration soil and seen as the "ideal" soil moisture measurement. In turn, the other two medias had measurements taken "relative" to the ideal potting soil container it was calibrated to on a scale of 0-10 (0 being dry, 10 being wet, 5 being ideal conditions). We also learned last year that the Reotemp probe used for relative moisture uses conductivity for its readings and it was theorized that green roof media (Soilless media made with expanded aggregates sand and compost, like perlite or expanded shale) may not make as good of contact with the sheath and tip of the probe to provide an accurate relative moisture reading. The relative moisture readings for the Year 2 study were more consistent throughout the season, and the BMC soil (which was previously only reading as a 0 or 1) was reading as a 1 or 2. This growing season was much drier than the previous Year 1 study, and the probe is 1 year old. With the changing of the farm manager, there was different fertigation throughout the farm system, so this could have introduced more less salt content into the soil as well. Also, during the readings, some patches were dry while other patches were wetter in the same box, even the same distance from the emitter. There are many variables that can affect the relative moisture of the soil and Year 1, and Year 2 have brought forward interesting data which one could run an entire, more controlled study on. In general, it can be concluded that the potting soil retained the most moisture and was considered "ideal" conditions. Compared to these ideal conditions, the Naturcycle had similar water relation and relative moisture, while the BMC blend was considerably drier than ideal.

These documented characteristics help provide insight into the most effective practices for green roof media development to help support the ever-growing field of urban agriculture and farming.

Appendix

Growth Pictures

Collard Greens

Figure 7: Left to Right - Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken 6/27/25

Figure 8: Left to Right - Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken 7/16/25

Figure 9: Left to Right - Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken 8/15/25

Figure 10: Left to Right - Naturcycle, BMC Blend, 3rd party Media, Potting Soil. Picture taken 9/18/25

Jalapeño Peppers

Figure 11: Left to Right - Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken 6/27/25

Figure 12: Left to Right - Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken 7/9/25

Figure 13: Left to Right: Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken on 8/15/25

Figure 14: Left to Right: Naturcycle, BMC Blend, 3rd Party Media, Potting Soil. Picture taken on 9/18/25

Tomatoes

Figure 15: Top Left - 3rd Party Media, Top Right - Naturcycle, Bottom Left - BMC Blend, Bottom Right - Potting Soil. Picture taken 6/27/25

Figure 16: Top Left - 3rd Party Media, Top Right - Naturcycle, Bottom Left - BMC Blend, Bottom Right - Potting Soil. Picture taken 7/9/25

Figure 17: Top Left - 3rd Party Media, Top Right - Naturcycle, Bottom Left - BMC Blend, Bottom Right - Potting Soil. Picture taken 9/4/25

Figure 19: Top Left - 3rd Party Media, Top Right - Naturcycle, Bottom Left - BMC Blend, Bottom Right - Potting Soil. Picture taken 10/23/25

Turnips

Figure 20: Potting Soil Turnips. Picture taken 7/16/25

Figure 21: 3rd Party Media Turnips. Picture taken 7/16/25

Figure 22: BMC Blend Turnips. Picture taken 7/16/25

Figure 23: Naturcycle Turnips. Picture taken 7/16/25

Figure 24: Potting Soil Turnips. Picture taken 8/15/25

Figure 25: 3rd Party Media Turnips. Picture taken 8/15/25

Figure 26: BMC Blend Turnips. Picture taken 8/15/25

Figure 27: Naturcycle Turnips. Picture taken 8/15/25

Harvest Pictures

Figure 28: Left to Right: Potting Soil, 3rd Party Media, BMC Blend, Naturcycle. Harvested on 9/4/25

Figure 29: Left to Right: Potting Soil, 3rd Party Media, BMC Blend, and Naturcycle. Harvested on 8/15/25

Figure 30: Left to Right: Potting Soil, 3rd Party Media, BMC Blend, and Naturcycle. Harvested on 9/18/25

Figure 31: Left – Potting Soil, Right – Naturcycle. Harvested on 8/1/25