Sustainable Food Production Education Internship

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Executive Summary

This water project explored the relationship between watering methods and sustainable food growth with the ultimate goal of making practical recommendations to the public based on our findings. Our investigation was divided into two experimental designs. The first, larger part of the experiment examined which type of irrigation systems performed the best – drip or mist. This was determined based on the amount of water used and produce yielded. In this experiment, drip and mist irrigation systems were compared. This larger scale experimental design was conducted twice, first with summer crops and then with winter crops; however, the winter crop run ended prematurely due to COVID-19 closures.

Data collection often took place during our volunteer workdays at the RCC Urban Farm. These workdays were held 3 times a week and allowed community members to learn how to grow edible crops. At the same time, volunteers learned about sustainable practices regarding water conservation and organic practices while in the farm. In addition, volunteers took home a share of the harvest. The leftover harvest was distributed for free on campus on a weekly basis.

In addition, we conducted a second experiment aimed at maximizing sustainable food growth on a smaller scale. With more people opting for apartment living and the local student population in mind, we turned our attention to growing food with limited space. Therefore, we compared watering systems for potted crop growth. For this experimental design, we constructed our own self-watering pots in an inexpensive manner that is easy to replicate. These self-watering pots were compared to the same potted crops that were watered by hand in terms of plant growth, water usage, and harvest yield.

After collecting and analyzing the data and drawing conclusions, we designed educational materials to be distributed to the public. First, we designed two brochures that were

distributed in free food bags that were distributed to Riverside City College students for free as a form of COVID-19 relief. The brochures explained the benefits of gardening and how to construct a self-watering pot. In addition to these written instructions, we posted a video detailing how to build a self-watering pot.

Project Objectives

The idea for this project was born out of the Riverside City College Urban Farm's mission to make nutritious food accessible to college students and community members while prioritizing sustainable education and practices. In order to achieve the educational goal, we committed to hosting volunteer workdays that were open to any faculty, staff, student, and community member at any gardening skill level. During these workdays, intern would model and assist volunteers with learning how to grow food in a sustainable manner appropriate to the Inland Empire's conditions. Furthermore, recent studies have shown that community college students are at an even greater risk for food insecurity than students at four-year institutions, particularly during times of economic recessions (Blagg 2017). Motivated by a desire to address this issue on our own campus, we set up weekly produce giveaways that provided nutritious food to the community for free.

Additionally, we were interested in optimizing our water usage as we worked to reduce food insecurity on our campus. Water conservation was a natural avenue for exploration in conjunction with food sustainability, especially in the Inland Empire region. For our research, we planned to examine the efficiency of water drip and mist systems by comparing the harvest yield. In order to do so, we planned to conduct two trials with summer and winter crops. We also considered how different amounts of water affected plant growth in an effort to determine watering practices that optimized harvest yield and water conservation. However, due to a change in management and the subsequent COVID-19 outbreak, we shifted our efforts to an at-home sustainability experiment. We were interested in investigating small-scale food production, as well as optimal water usage, through self-watering and hand-watered potted crops.

Project Approach

As interns, our weekly duties included helping conduct volunteer workdays three times a week. These workdays, which were held in two-hour intervals, gave us an opportunity to demonstrate how to grow food sustainably and organically. We taught volunteers how to plant appropriate crops for each growing season in the Inland Empire. Additionally, we modeled how to maintain these plants and recognize when crops are ready to harvest. We also provided information and showed volunteers how to use organic, sustainable solutions, such as Neem and Sluggo, as alternatives to other products that are harmful for the environment and pollinators. In addition, volunteers were welcome take a share of the harvest home; the remaining harvest would be distributed for free on a weekly basis to students and community members on campus. Interns and volunteers also supervised and answered questions during the produce distribution.

Figure 1. Weekly free produce distribution table.

Figure 2. A map of the experimental plots in the RCC Urban Farm.

In addition to the community educational component of our mission, we conducted and collected data on a water experiment in 4 plots designated as A, B, D, and E within the Urban Farm. First, we divided each experimental plot in half. One half of each plot was irrigated with a drip watering system while the other had a mist water system installed. Each drip treatment had a mist counterpart treatment. Furthermore, each lettered group had the same type and number of crops planted in each row for both its drip and mist treatments. For instance, if the summer A drip treatment of the experiment had five tomatoes planted in the first row, the corresponding A mist treatment also had five tomatoes planted in its first row. As Figure 2 illustrates, a drip treatment would have its mist counterpart in the adjacent plot.

Figure 3. Plot B mist in the foreground and Plot A drip adjacent.

For the first experimental run, we planted crops suited to the Inland Empire summer growing season. In plot A, we planted zucchini, tomatoes, radishes, and serrano peppers while cucumber, Swiss chard, eggplant, and tomatoes grew in plot B. Yellow squash, kale, watermelon, bell peppers, and zucchini were planted in plot D. The last plot, E, included okra, zucchini, Fresno chili, patty pan squash, and Swiss Chard.

Figure 4. Plot A drip and B mist during the summer experimental run.

In addition, we were interested in optimizing water usage in the RCC Urban Farm. We experimented with two different watering times to see if watering less – and saving more water –

made a significant difference in plant growth. In the A and B drip treatments, the crops were watered for 20 minutes each. Then, in the D and E drip treatments, the watering time was reduced to 15 minutes. Each treatment was outfitted with a water meter that allowed us to calculate how many gallons of water were used during the set watering times. After determining how much water was used, we used the meters attached to each mist system to track and use the same amount of water for its corresponding mist treatment. For example, if treatment A drip used 18 gallons during the 20-minute watering interval, we used the meter for A mist to ensure this plot also received 18 gallons. We also timed and noted how long it took for the mist systems to produce the same amount of water.

Once we entered the winter growing season, we replanted with crops tolerant to cooler temperatures. We followed the same process as the summer to the extent that each treatment had corresponding drip and mist treatments. We also followed the same plot layout as the summer trial that is illustrated in Figure 2. However, in for the winter trial, we planted bok choy, cauliflower, cabbage, cherry belle radish, and watermelon radish in plot A. Likewise, we planted broccoli, broccolini, and Romanesco in plot B. In plot D, we planted kale, dill, and cauliflower while we planted lettuce, kale, and cilantro in plot E.

Figure 5. Broccoli and cauliflower harvest from the winter experimental run.

In addition to planting, watering, and maintain these plots, our duties as interns included recording data for analysis. In addition to noting how much water was used and the duration of time it took to produce that water, we also considered plant growth and health. We measured individual plants' height, width, number of fruits, and overall health. Later, we also recorded how much fruit each plant produced and the weight of that harvest. This data was later analyzed with statistical t-tests.

Figure 6. Plots D drip and E mist during the winter experimental run.

Due to a change in management of the Urban Farm space, we lost some access to the internship site. Therefore, we decided to design an additional experimental design we could conduct at home. Eventually, due to pandemic closures, our experimental process shifted entirely to at-home experiments. As a result, we decided to explore smaller scale sustainable growing practices that would be useful to apartment dwellers and our local student population. Our new experimental design compared self-watering and hand-watered pots and ran from April through June 2020. In this experiment, each intern kept three self-watering pots and three hand-watered pots. With three interns and one supervisor participating in this experiment, our experiment included twelve pots in total. The self-watering pots were handmade and purposely inexpensive so they could easily be recreated by community members. These self-watering pots featured a water reservoir at the bottom of the bucket. This water reservoir was separated from the soil by a planting saucer. To add water to this treatment, we poured water down a short PVC pipe which ran through a hole in the saucer directly to the water reservoir. In contrast, the hand-watered pots were simply filled with soil and watered from above by hand.

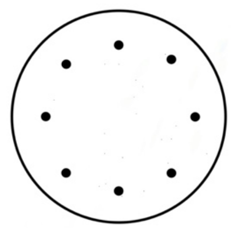


Figure 7. Planting pattern for basil and swiss chard in the at-home potted crop experiments.

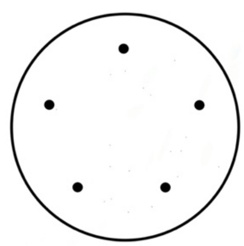


Figure 8. Planting pattern for peas and cucumbers in the at-home potted crop experiment.

We planted basil, cucumbers, and peas separately and compared their growth and harvest yield in each pot. For example, we planted basil in one self-watering pot and followed the same circular planting pattern in a corresponding hand-watered pot. However, our basil did not sprout as well as we predicted, and we replanted swiss chard instead. We filled all of our pots with moisture retaining potting soil and fed both cucumbers treatments fertilizer once. Moreover, we determined when our potted crops required watering based on soil moisture meters and recorded the amount of water added and meter reading as needed. Additionally, we measured how tall and wide each individual plant was on a weekly basis. When it was time to harvest, we also measured the harvest weight from each pot type and individual crop to determine which pot type performed best. Similar to the large-scale experiment, we compiled our harvest and watering data and used t-tests for statistical analysis.

Naturally, we remained committed to engaging with our community but were challenged by the new social distancing requirements. Instead of having direct contact as we formerly enjoyed during volunteer workdays, we encouraged our fellow students and community members to garden from a safe distance. Furthermore, we reasoned that healthy outdoor activities, especially those that would easily accommodate social distancing, such as gardening, would be particularly beneficial during this mentally-taxing crisis that has abruptly confined most of the population to their homes. For this reason, we designed both physical and virtual educational materials that were made available to the public. We designed and printed two separate brochures to be distributed to RCC students. One brochure, "Reasons to Garden," explained the health, environmental, and financial benefits to gardening (Appendix A). The second brochure, titled "How to Make a Self-Watering Planter," provided directions and pictures regarding how to make a self-watering pot at home with inexpensive materials (Appendix B). The brochures were printed in English and Spanish. Both brochures were distributed in the RCC Hungry Tigers Grab and Go bags, a free food service to assist RCC students during the COVID-19 pandemic. Also, a video was produced as an additional resource to walk community members through the process of building a self-watering pot titled "How to Make a Self-Watering Planter for Small Space Gardening" (https://www.youtube.com/watch?v=7-1S097-7P4&feature=youtu.be&fbclid=IwAR2mEDmcFZlz0CEH9caibZRoDQluGlxJavvzvfG8aum8r9-jm6ZrrC7WOBo).

Project Outcomes

When comparing irrigation systems, we used the amount of produce yielded as the basis for determining whether one system was more productive than the other. As stated earlier, we analyzed all of our harvest data using statistical t-tests. As a result, we found that the summer drip treatment produced significantly more produce overall than the mist treatments. Combined, all four experimental plots produced 341 lbs of produce. The drip treatments produced an average of 50.18 lbs per month whereas the mist system produced an average of 34.56 lbs per month. On average, the drip treatments yielded 15.62 lbs more per month. According to our post-experimental analysis, this difference is statistically significant ($p = 0.03$). When comparing harvest yield of the same crop between irrigation systems, the tomatoes grown in plot A showed a great enough difference between the irrigation systems to warrant a recommendation. Indeed, during the summer run, the drip system in plot A produced more tomatoes than the plot A mist treatment ($p = 0.0136$). The serrano peppers similarly performed better in the drip treatment than the mist treatment ($p = 0.00$).

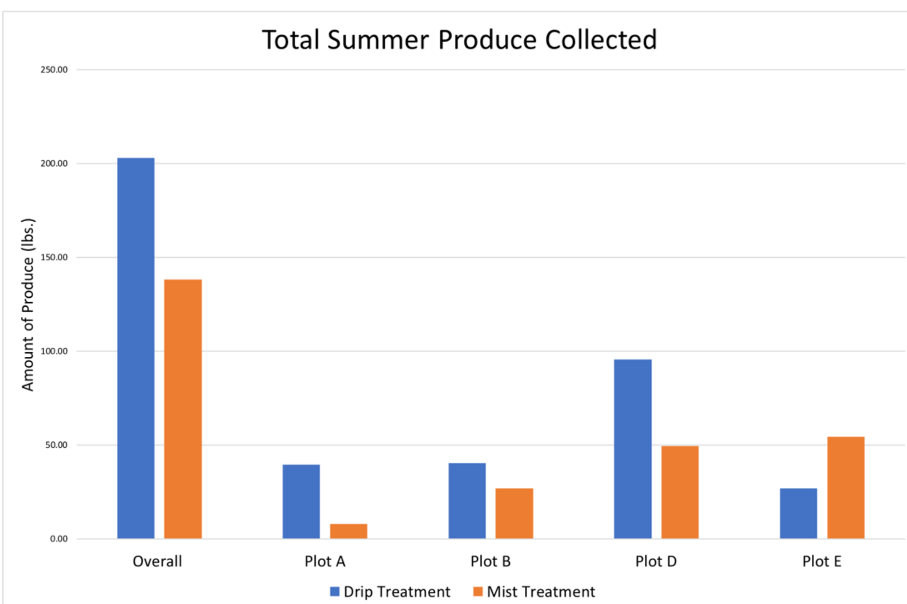


Figure 9. Total summer produce collected.

	Number of samples collected throughout experiment	Average weight of all samples collected (oz)	P-value	Statistically Significant? (Y/N)
A Mist Radish	3	0.00	0.1717	N
A Drip Radish	3	1.23		
B Mist Cucumbers	6	5.50	0.0366	Y
B Drip Cucumbers	6	32.50		
D Mist Watermelon	6	73.83	0.1947	N
D Drip Watermelon	4	103.88		
E Mist Okra	77	1.18	0.7420	N
E Drip Okra	61	1.25		
A Mist Zucchini	3	0.33	0.0714	N
A Drip Zucchini	3	15.50		
B Mist Swiss Chard	73	137.75	0.1165	N
B Drip Swiss Chard	84	225.70		
D Mist Bell Pepper	31	1.95	0.2715	N
D Drip Bell Pepper	31	2.48		
E Mist Swiss Chard	84	2.02	0.0007	Y
E Drip Swiss Chard	84	0.71		
A Mist Serrano Peppers	29	0.11	0.0000	Y
A Drip Serrano Peppers	29	2.83		
B Mist Eggplant	20	32.00	0.0015	Y
B Drip Eggplant	20	84.50		
D Mist Zucchini	19	2.74	0.0002	Y
D Drip Zucchini	19	19.61		
E Mist Patty Pan Squash	10	18.87	0.1775	N
E Drip Patty Pan Squash	15	12.70		
A Mist Tomato	29	4.66	0.0136	Y
A Drip Tomato	22	16.69		
B Mist Tomato	35	82.56	0.1814	N
B Drip Tomato	54	298.60		
D Mist Jalapeno	42	1.95	0.1924	N
D Drip Jalapeno	50	1.37		
E Mist Fresno Chili	50	1.21	0.2125	N
E Drip Fresno Chili	15	1.68		

Table 1. Summer harvest statistical analysis.

Unfortunately, our winter trial of the large-scale experiment was cut short to COVID-19 closures which barred our access to the RCC Urban Farm. The data we collected was not enough to make further recommendations regarding one irrigation system over the other; however, the drip treatment was slightly outperforming the mist treatment in terms of harvest produced at the time of the site closure. With the drip treatment yielding 14.4 lbs of harvest per month and the mist system producing slightly less with 13.1 lbs per month, it is not possible to draw statistical conclusions based on overall performance. However, we were able to conduct the experiment long enough to note that the water mist treatment's seeds germinated at a noticeably faster rate than their drip counterparts.

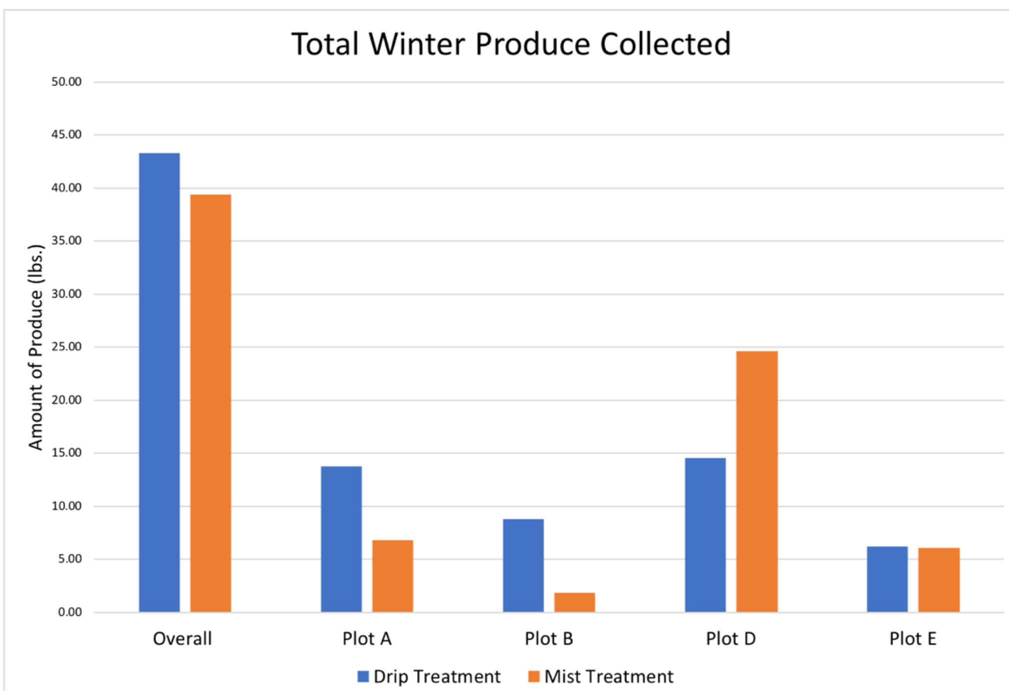


Figure 10. Total winter produce collected.

Similarly, we used statistical t-tests to analyze our data for the potted crop experiment. We measured and compared weekly growth data for individual pea, cucumber, and Swiss chard plants. We concluded that the cucumbers' growth data demonstrated a significant difference.

Indeed, the cucumbers grown in the hand-watered averaged 7.47 cm per week while cucumbers in the self-watered pots grew 2.29 cm on average per week ($p = 0.02$).

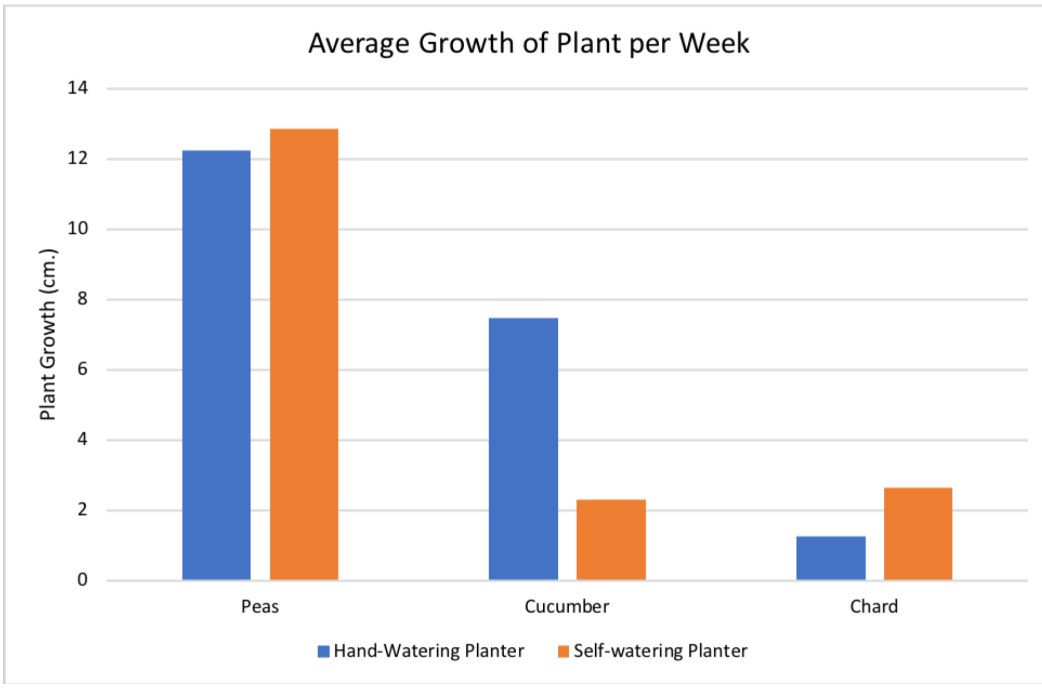


Figure 11. Average growth of potted plant per week.

In addition, we compared the amount of edible produce yielded by each type of self-watering potted plant versus its hand-watered counterpart. We did not find any significant differences in harvest yield between the potted crops. Furthermore, we did not have the opportunity to collect enough data on the Swiss chard's harvest due to time restrictions. Additionally, our data reflected that self-watering pots retained water better; therefore, they required less water overall. On average, all of the self-watering pots required 337 liters of water per day while the hand-watered pots received 440 liters of water per day. Despite this difference, their water usage was not found to be statistically significant ($p = 0.24$).

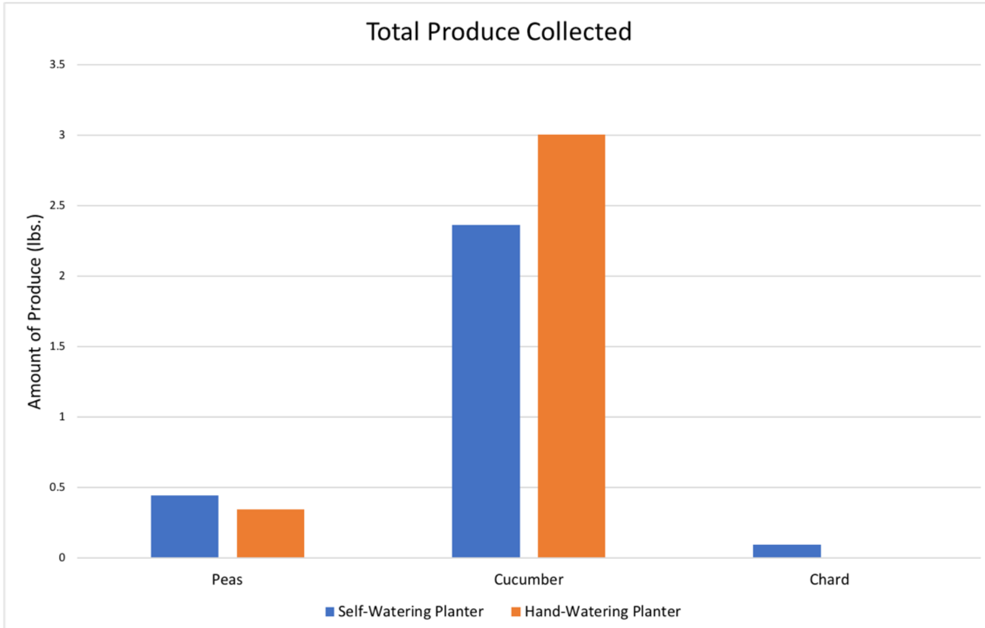


Figure 12. Total produce collected from potted crops.

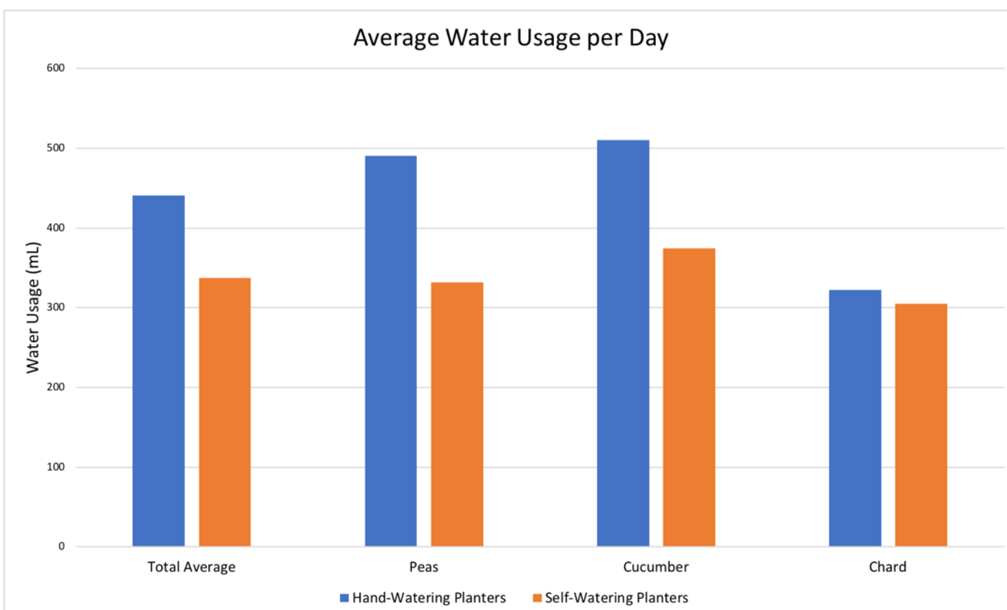


Figure 13. Average water usage per day for potted crops.

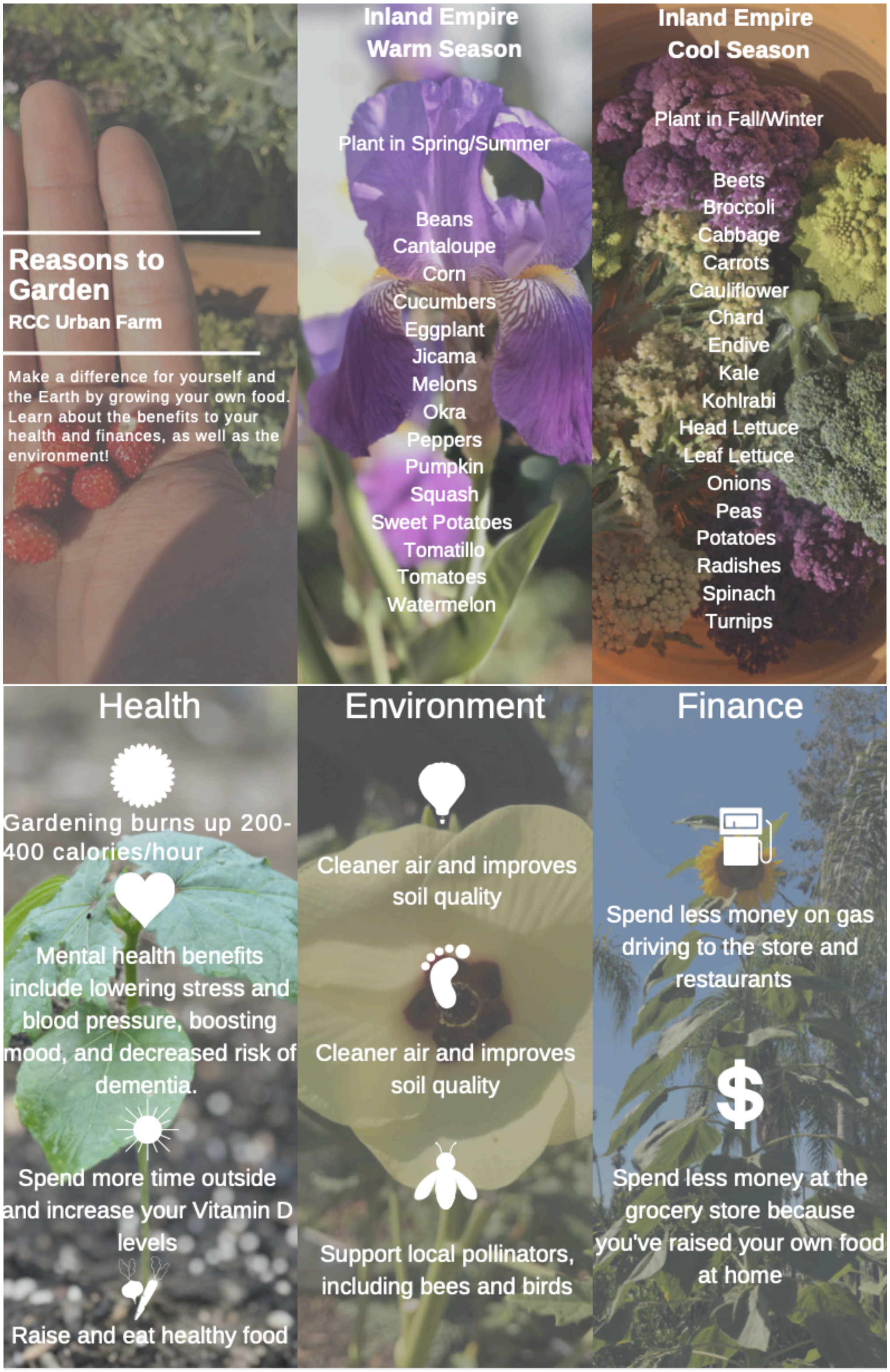
Conclusion

Our mission and its outcome have demonstrated the importance and effectiveness of community-level engagement. For instance, during the summer experimental trial, the experimental plots produced nearly 86 lbs per month of free, nutritious food to the community. This does not take the non-experimental plots into account which were open to volunteers to hone their gardening skills; the entire farm space combined yielded an even greater harvest for free distribution to the community. Our original efforts benefitted our community in multiple ways. First, we provided a welcoming space for gardeners of all levels to gain experience in a hobby that promotes exercise, mental wellness, and healthy eating habits. Second, we simultaneously provided sustainability education to volunteers through our farming practices. While teaching how to grow edible crops, we emphasized the importance of water conservation and pollinator-friendly practices. Third, we reliably provided nutrient-dense food to our community through our produce giveaways. As a response to challenges faced by students in accessing healthy food options, we provided free produce on a weekly basis on campus. In this manner, we ensured ease of access and removed the burden of cost in order to provide a healthy food resource for our local community.

Our large-scale irrigation experiment found that a drip water system is more efficient than a mist water system. Although drip systems required more time to produce the same amount of water as their mist system counterparts, the system yielded a significantly larger harvest. Indeed, a mist system may require an even greater amount of water to produce a harvest yield comparable to the drip system. In this manner, the drip system is advantageous for maximizing harvest yield while minimizing water usage.

In contrast, our potted crop experiment did not show any significant difference in water usage and harvest between self-watering and hand-watered pots. However, more research is needed into how to best serve a population that is increasingly opting for apartment dwelling and smaller spaces. Future researchers may be interested in investigating how the introduction of small-scale gardening, whether through free classes or designated sites on campuses, impacts college students' dietary habits and overall health. After this experience, the positive effect the RCC Urban Farm and our internship are clear to me and warrant future research. Both community and personal gardens can similarly be beneficial at other campuses and in other neighborhoods. Indeed, student hunger, as well as the need for physical and mental wellness, is universal and gardening can be a community-based component of a greater solution on college campuses everywhere.

Appendices



Appendix A

Looking for a low maintenance planter? Trying to reduce plant water usage? Going on vacation and abandoning plants? Try a self-watering planter!

ABOUT THE RCC URBAN FARM

The mission of the RCC Urban Farm is to provide space, guidance, and support for making healthy, sustainable food available to our community through practice and education. Using a sustainability approach and methods, current interns are working on an experiment to compare the efficacy and produce yield between a self-watering planter and a hand watered planter. So far, with the data recorded, we suggest that self-watering planters may require less water than hand-watering planters due to an accessible water reservoir. Details of this experiment will be published at the end of July.

HOW TO MAKE A SELF-WATERING PLANTER

RCC URBAN FARM

MATERIALS

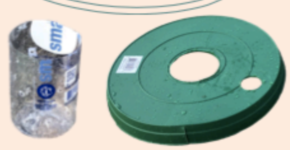
- -A planter with no holes on the bottom
- -Plastic planter saucer
- -An empty 1 or 2 liter bottle
- -About 2ft of PVC
- -A drill
- -A hand saw
- -Potting soil & plants/seeds
- -Marker

STEP 1

Drill many holes (about 5/8 in) in the bottom half of the water bottle. This is the wicking device. Next, trace the bottle in the middle of the saucer and cut around the outline. The bottle will sit in this hole.

STEP 2

Press the saucer into the bucket as far as it can go. You may need to cut down the saucer to fit. Place the bottle into the hole so it sits flush with the saucer. Mark the bottle just above the top of the saucer. Then remove and cut the bottle along that line with a hand saw.



STEP 3

Remove the saucer. To make the PVC pipe into a water tube, place the PVC pipe anywhere between the bottle hole & the edge of the saucer. Trace the outline of the PVC pipe and cut a hole for it to fit through.

STEP 4

Now place the PVC pipe in the planter. Cut the pipe so only 2-3 in of pipe sticks out above the soil line. Once you have the pipe at your desired height, put the saucer, bottle, and PVC pipe back in the pot. You should have a reservoir for water at the bottom.

STEP 5

Add a drain hole by drilling into the side of the planter just under where the saucer rests. This prevents overfilling of water. To finish, fill the pot with soil. Rest the PVC watering tube so that it sits at an angle to make adding water easier. Fill with water by pouring it into the PVC tube until you begin to see water flowing out of the drain hole. Add seeds of seedling of your choice. You're done!

Appendix B

Bibliography

Blagg, Kristin, Diane Whitmore-Schanzenbach, Craig Gunderson, and James Ziliak. 2017. "Assessing Food Insecurity on Campus." *Urban Institute.* https://www.urban.org/research/publication/assessing-food-insecurity-campus