CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Chloe Brandon

Project Number
S1901

Project Title
Carbon Dioxide Uptake in California Native vs. Non-Native Plants

Abstract

Objectives/Goals
This project was designed to observe the differences in carbon dioxide consumption between varieties of California native drought-resistant (Salvia species, commonly known as sage) and the non-native landscaping plant Ligustrum recurvifolium. The two secondary objectives were a) measuring oxygen production rates and b) investigating leaf anatomy images in these plants.

Methods/Materials
Carbon dioxide and oxygen sensors were used to measure uptake and production levels. In addition, a plastic chamber, digital data logging system, Salvia mellifera plant, Salvia leucophylla plant, Ligustrum recurvifolium plant, spinach clippings, and a glass thermometer were used.

Results
The carbon dioxide data collected were compared to microscopic images of each plant's leaf structures and stomata, as well as data on the rates of oxygen generation in each species. The observed differences between Salvia mellifera and Salvia leucophylla were statistically significant. The Salvia mellifera was more efficient at removing carbon dioxide levels than Salvia leucophylla, although they were both more efficient than the Ligustrum. Anatomical differences in stomata and drought-resistant features were observed.

Conclusions/Discussion
Although the carbon dioxide uptake data were statistically very similar, the approximately 16-fold difference in water use makes the drought-resistant California natives a good option for water conservation without reducing carbon dioxide uptake.

Summary Statement
I devised a project which found that California native and non-native plants have similar carbon dioxide uptake rates.

Help Received
Dr. Karen Jain for her guidance in microscopic viewing and statistical analysis and Ms. Mary Hines for coordinating use of the sensors and equipment.

Name(s)
Ishaan S. Brar

Project Number
S1902

Project Title
Effect of X-ray, Ultraviolet, and Microwave Radiation on the Seed Germination and Growth of Phaseolus vulgaris

Abstract

Objectives/Goals
We are exposed to a large number of electromagnetic waves such as Ultraviolet (UV), Microwaves, and X-ray radiations. This experiment is testing the effect of these radiations on seed germination and plant growth.

Methods/Materials
Materials: 4 bags Miracle-Gro potting soil, 84 containers, water, X-ray machine, UV emitter, Microwave emitter, Phaseolus vulgaris seeds.To perform my experiment, I used kidney bean (Phaseolus vulgaris) seeds. I divided the seeds into several groups. First group was marked as Control. Second group of beans was irradiated with the X-rays. Third group of seeds received UV radiation exposure. Fourth group received microwaves radiation exposure. The seeds were planted in potting soil and watered on alternate days. The day of germination and the length of the plants were recorded for 30 days.

Results
During the first few days, the x-ray plants grew the fastest. Most of the X-ray exposed plants were taller than the control. Finally, in microwave group, few seeds germinated only in 10 seconds (s) and 20s exposure group and growth was stunted. The results of the experiment show the X-rays actually simulated the initial plant growth, especially in low intensity X-ray exposure group. Also, the UV radiation, delayed the plant seed growth, and then stimulated it to go faster. The only form of radiation that inhibited the growth was the microwaves.

Conclusions/Discussion
The results of the experiment show Microwave radiation has deleterious effect on seed germination and plant growth. UV and low-intensity X-ray stimulated seed germination and enhanced plant growth.

Summary Statement
The project showed X-ray and UV radiations enhance plant growth and microwaves inhibit plant growth compared to control.

Help Received
I set up and performed the experiment myself. X-ray irradiation was performed by licensed professional at Premier Valley medical Group, Bakersfield, CA.

Name(s)
David Campos; Camryn Macias; Michael Paz

Project Number
S1903

Project Title
The Effects of Silver Nanoparticles on Radishes

Abstract

Objectives/Goals
Test the silver nanoparticles found in silver nitrate to see if their antibacterial properties will have good and/or bad effects on radishes.

Methods/Materials
Silver nitrate, water, two clay containers with five radish seeds in each, water. One pot was watered with silver nitrate, the other was given water. Growth of radishes was analyzed.

Results
Each radish was harvested and analyzed after four weeks. The radishes with added silver nitrate had healthier coloration, did not attract pests, and longer leaves. The plants that were given water had longer roots.

Conclusions/Discussion
After analyzing each radish and comparing them, it can be determined that adding silver nitrate to the soil of growing radishes can increase the quality of produce.

Summary Statement
By watering some radishes with silver nitrate and some with water, we determined the positive and negative effects of silver nitrate on radishes.

Help Received
My chemistry teacher explained some uses of silver nitrate and helped create copious amounts of silver nitrate that was needed. My group and I designed, conducted, and analyzed the experiment ourselves.

Name(s)
Anthony J. Castillo

Project Number
S1904

Project Title
The Effect of Plant-Derived Aerosol Smoke Priming on Gene Expression and Seedling Vigor of Traditional Yemeni Watermelon

Abstract

Objectives/Goals
Current research on plant-derived smoke shows that it functions similar to plant growth hormones. The objective was to test the response of traditional Yemeni watermelon to plant-derived aerosol smoke and measure its effect on seedling vigor and gene expression.

Methods/Materials
Watermelon seeds were separated into replicates of 25 per treatment and control for six replications. Seeds were placed on screens in a smoke chamber and primed with aerosol smoke for 16, 32, 48, and 64 minutes. Smoke generated in a homemade smoker filled with straw briquettes was funneled through a heater hose into the smoke chamber. Seeds were sown in cups filled with peat moss and grown in an artificial green house. After six weeks, four randomly selected control and treatment seedlings from each replication were used for gene expression analysis using qPCR with three replicates per seedling per gene. Remaining seedlings were dried and metrics recorded to calculate seedling vigor.

Results
Seedling Vigor tests showed 32 minute treatment rendered the most viable seedlings while control and 16 minutes of treatment rendered the most non-viable. Gene expression was measured as a fold change compared to control gene cla004472. The expression of growth genes cla018893 and cla014050 were measured; an overall decrease in the expression of cla018893 was observed. The expression pattern for cla014050 showed that the 32 minute treatment had the highest expression, and the lowest expression in 64 minutes and the control group. Stress genes cla011165 and cla007751 demonstrated a significant decrease in all treatment groups compared to control.

Conclusions/Discussion
Results showed aerosol smoke treatment leads to vigorous and more viable plants. There is a clear trend that the longer treatment promoted growth. Effective treatment time ranged from 32-64 minutes. Gene expression data favored 32 minutes for some genes as an optimal treatment time compared to longer treatment times, while others appeared to have a negative response to any smoke treatment.

Summary Statement
I found that priming seeds with aerosol smoke could provide traditional farmers a low cost alternative to fertilizers, which many farmers need to sustain their living.

Help Received
I designed this experiment by myself. Seeds were provided by Mohamed A. Al Jumai. Dr. KC Vavra supervised work done at The Lab and taught me how to analyze gene expression data.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Sofia Contreras; Jayna Landeros; Gisele Ortega

Project Number
S1905

Project Title
Effects of Artificial Light on Solanum lycopersicum var. cerasiforme

Abstract

Objectives/Goals
The objectives were to test the negative effects of artificial light on cherry tomato plants, by the means of the artificial light being turned on during the night compared to the plants having no artificial light at night in order to simulate how light pollution affects plants in densely populated urban areas. A resulting goal was to figure out if inadequate plant growth led to a worsening of air pollution.

Methods/Materials
Three small, open greenhouses were built for the purpose of sheltering plants from heavy rain and wind, and to protect them from potential frosts, but they did not block natural sunlight in the daytime. Two tomato plants were housed in each greenhouse, for a total of six potted plants, along with bright lights in the first greenhouse, dim lights in the second greenhouse, and no additional lights in the third greenhouse. These solar powered outdoor lights easily turned on at the onset of darkness, simulating a city lighting up at night.

Results
Solanum lycopersicum var. cerasiforme thrived when grown in optimal conditions (natural sunlight during daytime and darkness at night) in comparison to less favorable conditions, which included the presence of artificial halogen lights on the plants at night. The control group grew an average of 19.25 cm, the group with dim artificial light grew an average of 6.25 cm, and the group with bright artificial light grew to an average of 11.25 cm.

Conclusions/Discussion
The results prove how plants in bustling cities never get to "sleep," because they are always exposed to bright light, interfering with the circadian rhythms of plants. This may show correlation to an increase in air pollution, since plants that are never removed from bright environments cannot photosynthesize as well as plants grown in optimal conditions, and will produce less oxygen. This discovery may aid environmentalists in reducing air pollution and light pollution by developing better, more "sleep-friendly" lights for cities.

Summary Statement
We discovered that the presence of unwanted artificial light affects the growth and oxygen production of Solanum lycopersicum var. cerasiforme (cherry tomato) plants, contributing to the problem of air pollution in dense urban areas.

Help Received
Pauline Riendeau, Gisele's grandmother, for allowing us to grow the plants in her backyard, our parents for purchasing the materials to construct the greenhouses, and our Chemistry Honors teacher, Mrs. Valle.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Mariah G. Cox

Project Number
S1906

Project Title
A Plentiful and Inexpensive Fertilizer Alternative: Human Urine

Abstract

Objectives/Goals
I would like to replace chemical and organic fertilizers with an inexpensive and readily available fertilizer by using healthy human urine. In the poverty-stricken countries, farmers may not be able to afford the costly fertilizers but everyone produces human urine, so you will never run low.

Methods/Materials
I used 4 different types of plants (Beans, Peas, Zucchini, and Spinach)
For the control I planted 12 of each type of plant and used only bottled spring water.
For the fertilizer I planted 12 of each type of plant and used Dr. Earth 4-4-4 fertilizer every 12th day and watered with bottle spring water every 4th and 8th day, so the plants weren't over fertilized.
For beans, peas, zucchini, and spinach I planted 12 of each type for every urine dilution: undiluted, 1 part urine: 1 part bottled spring water, 1 part urine: 5 parts bottled spring water, and 1 part urine: 10 parts bottled spring water. Gave designated dilution every 12th day and watered with bottled spring water every 4th and 8th day, so the plants weren't over fertilized.
I measured and recorded growth weekly and made note of any observations.

Results
After two weeks I put my plants out for a day in the sun to kill the mold that was present on the soil. The temperature outside was only 70°F (21.1°C). Not even a week later my spinach were all dead including the ones in my control and fertilizer. My zucchinis and other plants that were still alive were getting top heavy and tipping over, so I tied them up. Not even a week after tying them up my zucchini almost all died in my urine dilutions because I may have strangled them by tying them to tightly around the stems. My peas were spindly and did not grow very tall but the 1:10 dilution did just as well as the fertilizer, but the control did a little bit better than both. My beans grew very tall and were a little spindly. The 1:10 did just as well as the fertilizer.

Conclusions/Discussion
I found that healthy human urine can be used as an effective fertilizer if it is diluted to at least 1:10. After the spinach and zucchini were dead I performed soil tests to see the levels of nitrogen, potassium, and phosphorus. In most of the soil samples the nitrogen levels were medium to high. Potassium and phosphorus were medium to depleted. I am currently gathering data on 1:15 and 1:20 dilutions. My results for 1:15 and 1:20 dilutions will be finished by the state competition.

Summary Statement
I am trying to replace expensive chemical and organic fertilizers with an inexpensive, readily available alternative: healthy human urine.

Help Received
I went to Frank R. Howard Memorial Hospital in Willits, Ca and got in contact with their lab director, Arpad Peter. He taught me basic laboratory safety, gave me access to their urinalysis machine, and taught me how to use it. I performed a urinalysis, testing the levels of NPP in each dilution

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Alex R. Desbans

Project Number
S1907

Project Title
The Effects of Chicken Manure and Miracle-Gro Fertilizer on the Speed of Development of Pea Plants

Abstract

Objectives/Goals
The objective of this study is to determine which amendment to soil, chicken manure or Miracle-Gro fertilizer, would help a snow pea plant develop quickest.

Methods/Materials
Grew 8 snow pea plants in each of 3 soil beds for 40 days. The first control bed had just garden soil, the second bed had soil amended with chicken manure, and the third bed had soil amended with Miracle-Gro Fertilizer. Measured the pH, nitrogen, phosphorus, and potash levels every 5 days using 3 HoldAll soil test kits. Each plant received the same amount of water and sunlight each day, so the soil and the amendments were the only variable in this experiment.

Results
The Miracle-Gro plants sprouted in an average of 6.67 days, with a final average height of 5.5 cm and 17.8 leaves. The chicken manure plants sprouted in an average of 9.38 days, with a final height of 10.56cm and 27 leaves. The control plants sprouted in an average of 7.88 days, with a final height of 6.01 cm and 16.5 leaves. Both chicken manure and Miracle-Gro plants had similar levels of pH, nitrogen, and potash, higher than the control. The chicken manure plants had the highest levels of phosphorus. Finally, the chicken manure plants grew approximately 0.345 cm per day, while the Miracle-Gro plants grew only 0.165 cm per day and the control plants grew about 0.187 cm per day.

Conclusions/Discussion
The plants grown with chicken manure developed the quickest in terms of height and amount of leaves due to the soils high level of phosphorus. With further background research, I learned that phosphorus plays an important role in root development. So, the plants grown with the chicken manure took the longest to sprout since it logically took longer for the plants stronger roots to develop, but grew quicker vertically because of the strong foundation that the roots provided. The importance of these results is that they demonstrate that chicken manure is a viable natural alternative to potentially hazardous artificial fertilizers like Miracle-Gro.

Summary Statement
My project determined that the addition of natural chicken manure to soil helps snow pea plants develop quicker than the addition of artificial Miracle-Gro Fertilizer to soil due to the manures naturally occurring high levels of phosphorus.

Help Received
After consulting my science teacher at school about what materials I would need, my parents assisted me in purchasing and obtaining these materials. I completed the rest of the experiment independently.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Anita Garg

Project Number
S1908

Project Title
The Role of Physiological Traits in the Restoration of the Coastal Sage Scrub Community

Abstract

Objectives/Goals
The goal of this project was to understand how native coastal sage scrub species' individual physiological traits impact their health and growth in various environments.

Methods/Materials
Methods: Species with differing environmental traits were observed in environments that induced various stresses and responses. The first variable altered was seeding style, in which the stomatal conductance and height of 48 Salvia apiana plants were observed in a mixed and shrubs-only seeding style. The second variable altered was seeding method, in which the chlorophyll content and height of six coastal sage scrub species were observed in seeded and planted plots. The third variable altered was slope aspect, in which the SLAs of roughly 50 samples each of Sonchus oleraceus, Eriogonum fasciculatum, Encelia californica, and Artemesia californica were measured on north-facing and south-facing slopes. The drought tolerance of Isocoma menziesii and Encelia californica was quantified through the observation of weight of water consumed and number of live and dead leaves throughout the course of the experiment.
Materials:
Instruments: Scientific oven, plant pots, wax paper, meterstick, scientific scale, decagon leaf porometer, SPADmeter.
Plants: 10 Isocoma menziesii plants, 10 Encelia californica plants; 48 Salvia apiana plants at the Loma Ridge Restoration Site; roughly 50 samples each of Sonchus oleraceus, Eriogonum fasciculatum, and Encelia californica from the Loma Ridge Restoration Site; Encelia californica, Salvia mellifera, Artemesia californica, Eriogonum fasciculatum, Baccharis emoryi, and Acmispon glaber plants at the Back Bay Science Center.

Results
It was observed that in a mixed seeding style, Salvia apiana had a higher stomatal conductance and lower height. Only Eriogonum fasciculatum had higher specific leaf areas on south-facing slopes. Encelia californica consumed more water and had more live leaves than did Isocoma menziesii throughout the experiment. Five of six species displayed greater height through planting than seeding.

Conclusions/Discussion
Extensive root systems lead to nutrient deficiency. Planted seeding methods encourage pre-developed root systems, which allow for greater plant growth; an exception to the pattern are pioneer species. Trichomes and small leaves lend species greater ability to conserve water. Mesophytic leaves encourage rapid water loss.

Summary Statement
I observed which physiological traits allowed certain coastal sage scrub species to respond uniquely to various environmental stressors.

Help Received
My science teacher Mr. Smay guided me through the steps of the scientific process.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Francis Geng

Project Number
S1909

Project Title
Prolong Life of Roses: Cut Stem into Different Angles

Abstract

Objectives/Goals
This project is to test which angle of rose stem cut can increase the longevity of roses the most.

Methods/Materials
18 fresh uncut roses of same conditions harvested on the same day, 18 200 mL test tubes, an exacto knife, a protractor and distilled water.

Results
The angles of the cut stem influenced the longevity of roses. Roses with 45-degree angle cuts preserved their freshness for a longer time compared to the roses with other degrees of angle cuts. The roses cut at a 45-degree angle lasted over 7 days while the next longest was 6 days for 60-degree angle group.

Conclusions/Discussion
In the experiment, the three roses with 45-degree angle cut stems showed an average lifespan of 7.3 days, which is longer than the average longevity of all other groups in the experiment. My project is the first research about the relation between stem angle cut and rose longevity. My result will benefit florists who want to increase the longevity of roses. This method will bring immense economical profit to the ornamental flower market.

Summary Statement
I discovered that 45-degree angle cuts benefit the longevity of roses the most.

Help Received
I used the test tubes, exacto knife and distilled water in the York School Biology Laboratory.

Name(s)
Sagar Gupta

Project Number
S1910

Project Title
The Effect of Mutating Cellobiose Transporters on Thaxtomin Production in the Plant Pathogen Streptomyces scabies

Abstract

Objectives/Goals
Pathogenicity by the plant pathogenic Streptomyces scabies, the causative agent of common scab disease on various economically important root and tuber crops, is triggered by cellobiose, a subunit of the plant cell wall polymer cellulose. Cellobiose induces the production of thaxtomin A, the main virulence factor of this species. This phytotoxin affects the plant cell wall leading to stunted growth, cell hypertrophy and tissue necrosis. Previous research found that the deletion of the primary cellobiose transporter resulted in a significant decrease in thaxtomin production. However, bacteria missing this transporter were still viable on minimal medium with cellobiose as the only carbon source (TDMc). Hence, the presence of another cellobiose transporter was suspected. Indeed, homology searches revealed there to be two other transporter candidates.
The goal of this project is to study the role of these additional transporters during the onset of plant pathogenicity of S. scabies.

Methods/Materials
Deletion mutants were created by replacing the gene coding for the solute-binding protein of the transporters by an antibiotic resistance cassette. Three assays were conducted. For each assay, cultures of bacteria were grown and the optical density was equalized. Three biological repeats were present in all assays. The liquid and plate assays had two technical repeats. These assays were conducted on thaxtomin dependent medium with cellobiose (TDMc) and oat bran medium liquid (OBB) and solid (OBA), both of which are complex mediums. The radish assay was conducted on 1.5% agar. Thaxtomin production was measured through an HPLC machine.

Results
The mutation of second and third transporters showed no difference in growth or thaxtomin production compared to the wild type when grown on TDMc. However, on OBA one of the mutants failed to produce toxin. In addition, radish seedlings infected with this mutant only showed an attenuated virulence phenotype.

Conclusions/Discussion
The results show that under complex conditions at least one other transporter is important in the sensing of environmental triggers inducing the production of thaxtomin. The loss of a second transporter could not be compensated for by the actual cellobiose transporter. This is shown by the results of plant bioassays and the inability of this mutant to produce toxin on plant-based media that are known to induce thaxtomin production.

Summary Statement
At least two transporters are involved in the sensing of environmental triggers that induce the production of the plant toxin thaxtomin A in the plant pathogenic bacterium Streptomyces scabies.

Help Received
Dr. Isolde Francis at CSU Bakersfield provided guidance and materials for this project.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Desiree Ho

Project Number
S1911

Project Title
Synergistic Combinations of Mutualistic Epiphytes as Biocontrol Agents against Pseudomonas syringae

Abstract

Objectives/Goals
The objective of this project is to design a more targeted and effective biocontrol agent to reduce the impact of bacterial brown spot disease on green beans. I hypothesized that a greater diversity of leaf bacteria would increase nutrient utilization and antibiotic production against the pathogen, Pseudomonas syringae, protecting the plant from disease.

Methods/Materials
Investigation consisted of inoculating bean leaves with different combinations of antagonists before infection with the pathogen, testing for antibiotic production on agar plates, nutrient utilization profiling, and quantification of naturally occurring bacteria on leaves. Mutant strains inhibited in antibiotic production were tested for confirmation.

Results
My hypothesis was conditionally supported; if the combined strains were compatible, inhibited P. syringae, and competed for similar nutrients, the plant was protected from the pathogen to a degree greater than either individual strain. The results of experimentation showed that the increased population density of epiphytic bacteria on wet control plants generally reduced disease severity by half. Cyclic antagonism of A505, A534, and P. syringae resulted in low lesion counts overall, and the passive combination of A501 and A530 likely reduced lesion numbers through competitive exclusion of the pathogen.

Conclusions/Discussion
The combination of A533 and A538 was most effective in reducing disease severity through their additive antibiotic production and nutrient competitive exclusion. The synergistic combinations of protective bacteria has the potential to employ the strengths of multiple antagonists to control pathogens on a flexible range of crops.

Summary Statement
I combined protective epiphytic bacteria based on their antibiotic production and nutrient utilization properties to effectively inhibit plant pathogens.

Help Received
Prof. Steven Lindow and Renee Koutsoukis at UC Berkeley provided laboratory access, bacterial strains, and advice on improving my idea.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Gavin C. Joyce

Project Number
S1912

Project Title
Surviving Drought IV: More for Less

Abstract

Objectives/Goals
The experiment aimed to identify what approximate amount of daily recycled water produced the highest ratio of fruit to water expended for squash plants in a tiered system.

Methods/Materials
Tiered watering structure, apparatus for obtaining recycled water, scale, liter-sized measuring cup. Watered plants daily with specified amounts of recycled water while recording amounts of fruit harvested and water expended while cycling water from the bottom tier back to the top tier.

Results
The results of my experiment show that approximately 1200 mL/day of water produces the highest ratio of fruit to water expended in a tiered watering system with squash plants.

Conclusions/Discussion
The results of my experiment revealed that 1200 mL/day of recycled water sufficiently supplied growing plants with enough nutrients to thrive while not over saturating them with nutrients, damaging them. This knowledge would help people conserve water while also producing more fruit with the lower amount of water being used.

Summary Statement
This experiment aimed to determine what approximate amount of daily recycled water is best for producing the highest ratio of fruit to water expended in squash plants. I found that 1200 mL/day of recycled water produces the highest ratio.

Help Received
I designed and conducted the experiment myself. I also built the structure for the experiment with my grandfather, who allowed me to use his garden infrastructure for the experiment. In addition, my mother and my biology teacher, Ms. Sainato, both advised me on my experiment.

Name(s)
Anne K. Miyadi

Project Number
S1913

Project Title
The Effectiveness of Agriculture Systems Comparing Traditional, Hydroponics, and Aquaponics on the Growth of Allium cepa

Abstract

Objectives/Goals
Three different agricultural systems for growing crops were tested for their effectiveness. The hypothesis for this experiment was that Allium cepa (green onion) specimens cultivated in an aquaponics system would yield the tallest plants, those in a hydroponics system would be of a slightly shorter height, while those grown in a traditional soil-based, hand-watered system would be the shortest.

Methods/Materials
Supplies included plastic bins, PVC pipes, bulkhead fittings, clay bead media, pumps, aquarium tubing, a fish tank, 25 tilapia, water, all-natural gardening soil, 36 Allium cepa. Three separate and unique agriculture systems were constructed. In the traditional system, specimens were placed in soil and watered by hand. The hydroponics and aquaponics system had specimens suspended in clay bead media with identical pumps circulating water to and from the growbeds. The hydroponics system circulated water only. The aquaponics system included a separate tank of tilapia whose effluent was circulated as fertilizer.

Results
The Allium cepa grown in the traditional system were significantly smaller than those specimens grown in the hydroponic system, and in turn, both were smaller than those grown in the aquaponics system, proving the hypothesis correct. The specimens in the traditional system grew to a mean of 1.8 centimeters tall. In contrast, the specimens in the hydroponic system grew to a mean of 6.4 centimeters tall, approximately 3.5 times taller than those in the traditional system. Significantly, the specimens in the aquaponics systems grew to a mean of 9.4 centimeters, approximately 5.2 times taller than those in the traditional system.

Conclusions/Discussion
Hydroponics and aquaponics are vastly more effective than traditional agricultural systems. But the modest difference between aquaponics and hydroponics leads to the conclusion that fish effluent is only moderately beneficial. Hydroponics and aquaponics both offer more efficient growth. Rather than switching from traditional systems merely to try to maximize growth, farmers should consider using either hydroponics or aquaponics to also conserve water and space while growing crops more efficiently and effectively.

Summary Statement
I tested the effectiveness of different agricultural systems and learned that aquaponics is the best.

Help Received
I was advised by a friend who had personal experience in constructing aquaponics systems.

Name(s)
Wynn Phaychanpheng; Audrey Sogata

Project Number
S1914

Project Title
The Effects of Abscisic Acid on Growth of Unstressed and Stressed Brassica rapa

Abstract

Objectives/Goals
To test possible effects of application of abscisic acid on unstressed and water stressed Brassica rapa, and see if ABA's role in stomata and water usage in a plant would help the plants better combat drought stimulation. Additionally, we wanted to find out what time in the Brassica rapa life cycle would be the optimal time for application to increase number of buds, leaves, flowers, height, and pods. We predicted days 15 and 17 would be the prime time for application because it is near the maturing stages of the Brassica rapa.

Methods/Materials
We provided a sustainable environment for the plants using an artificial lighting system and a self-watering deli cup system. We tested a total of 40 plants, in which 20 were unstressed and the other 20 were stressed by reduction of water intake. We also further separated them into groups based on what days we applied the hormone: Days 9,11, Days 15,17, and Days 21,23, in addition to a control and an ethanol(solvent) control. To apply the ABA, we created a solution using ethanol soluble ABA, ethanol, and distilled water; we sprayed each plant with approximately 3.2 ml of solution per application day.

Results
We found that ABA does not have as much as an effect in the areas of plant height and number of pods, but it does in the areas of number of leaves, buds, and flowers. In the unstressed group we noticed the plants treated with ABA had stunted growth; for example, the leaves had an average growth rate of -3.95% (Days 9, 11) group, 9.09% (Days 15,17) and 2.27%(Days 21,23). In comparison, the control groups had an average growth rate of 22% and 30%. For the stressed group, the effect was quite the opposite. There was an increase in average number of buds and flowers particularly. In both groups, the plants applied with ABA on Days 9,11 produced the most profound effects.

Conclusions/Discussion
Our hypothesis on the optimal time of application being Days 15,17 was not supported; application on Days 9,11 produced the most prominent effects. Furthermore, we found that when ABA is applied to unstressed Brassica rapa, growth is stunted, and when applied to water-stressed plants, growth is increased in buds and flowers. The life span of the stressed group with ABA application was also increased. This discovery can benefit agriculturalists by providing an innovative way to reduce the amount of water needed to sustain growth, or even improve it in plants.

Summary Statement
We tested the effects of abscisic acid on unstressed and water-stressed Brassica rapa and discovered a procedure to help reduce water intake of plants naturally.

Help Received
We bounced back ideas with Dr. Amy Litt, however we designed, performed, and analyzed data from our experiment ourselves. The statistics teacher at our high school, Mr. MacIntosh, aided us with learning valuable statistical tests.

Name(s)
Alina V. Pollner

Project Number
S1915

Project Title
Novel Strategy to Increase Fruit Production via CRISPR-Cas9 Genome Editing

Abstract

Objectives/Goals
Towards enhancing fruit production, the purpose of this experiment was to eliminate Mini Zinc Fingers 1 and 2 (MZF1/2) from Arabidopsis thaliana using the genome editing method CRISPR-Cas9. An additional purpose of this experiment was to locate the expression of MZF1 by discovering where its promoter is active.

Methods/Materials
The pJJJ2 plasmid was created to be a T-DNA vector that allows plant transformation. This vector contained a multitude of important regions, including antibiotic resistance genes, a UBQ Constitutive Promoter, Cas9, and guide RNAs. These plasmids were then transformed into multiple bacterias and ultimately transferred into the wild type model organism Arabidopsis thaliana. Later, seeds were harvested and grown. Three plants that had received the plasmid were transplanted into soil until samples were taken for genotyping.

MZF1 promoter was fused to the GUS gene reporter present in the pJJGUS T-DNA binary vector. The promoter of MZF1 was amplified by PCR and cloned into pJJGUS and transformed into plants. Transgenic plants were selected for on Hygromycin MS plates, and plants were grown for six to eight weeks until samples were taken.

Results
The gene expression studies indicated that MZF genes are active in fruit, primarily in early growth stages. The CRISPR-Cas9 mutant had an altered genome, with two early stop codons produced, due to a G insertion in MZF1 and a two nucleotide deletion in MZF2. Interestingly, this led to a chimera stem that had a 333+ % increase in fruit, a novel result that is a positive indication of future value of this work.

Conclusions/Discussion
This study uncovered a previously poorly-understood role for MZF genes as crucial components for regulating and modulating fruit development and growth. These CRISPR-Cas9 mutants could therefore produce significantly more fruit compared to wild types, and could also increase food production when applied to other organisms (such as wheat, tomatoes, etc.). This new gene editing strategy for plants is not limited to MZF genes but also applicable to investigate functions of other genes critical for plant growth, differentiation and additional development programs.

Summary Statement
Through CRISPR-Cas9 genome editing, this project demonstrated a 333% increase in fruit production, in addition to elucidating the expression pattern of Mini Zinc Finger 1.

Help Received
All work shown in this project was completed entirely by the student. I received guidance with the design of the guide RNAs. I worked at the Yanofsky Lab at the University of California at San Diego with Dr. Juan-Jose Ripoll and Prof. Martin Yanofsky.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Emily Tianshi

Project Number
S1916

Project Title
A Novel Water Source: Biomimicry Study of Torrey Pine Needles for Moisture Harvesting (A Second Year Study)

Abstract

Objectives/Goals
Torrey Pine (TP) trees are well known for their ability to efficiently harvest fog and survive under drought conditions. The mechanisms for moisture harvesting have not been revealed. This study is focused on learning its surface properties and structure in a microscopic level. The results of this study may be utilized with biomimicry to develop a material or device for water harvesting.

Methods/Materials
Most of my important findings were generated from inexpensive tools purchased from Amazon: Portable Digital Microscope 800x Magnification; Home Ultrasonic humidifier; Electronic Milligram scale; Spray bottle and dyes. I used unconventional testing methods such as time resolved video analysis to study water uptake. Using differential weight analysis, the noises in my experiments were filtered when collecting water harvesting data. An FEI SEM and Keyence 3D Digital Microscope were used to observe the microstructure.

Results
A TP needle surface has alternating ridges and valleys. Ridges on a needle are hydrophilic. Valleys contain rows of stomata, which is highly hydrophobic. A micro-pattern of alternating hydrophilic and hydrophobic stripes was identified for TP needles.With two rough surfaces and one smooth surface, I found out the water drops can be absorbed by both needle surfaces directly! This was captured in a video under a microscope. A water droplet absorbing time ranged from several seconds to 2 minutes. Needle tip orientation plays an important role in moisture harvesting. TP needles harvest 2x more water than Jeffrey Pine needles with the needle tip-up orientation.

Conclusions/Discussion
For the first time a micro-pattern of alternating hydrophilic and hydrophobic stripes on TP needle ridges and needle valleys was identified and plotted! It reminded me of the hydrophilic and hydrophobic pattern on the darkling beetle's shell, which hydrates the beetle with condensed dew collected in the dessert. A water uptake effect was observed on TP needle surfaces through video recordings. I also concluded that stomata don't contribute to moisture harvesting. The needles in the tip-up orientation harvest 50% more moisture than the tip-down orientation.

Summary Statement
I explored how the surface structures and surface properties contribute to the moisture harvesting ability of the Torrey Pine needles in order to biomimicry a material or device for efficient water collecting.

Help Received
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