Study on Spinach Plant Growth

HTM 400; Wine Appreciation

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I. Introduction

Spinach Fundamentals

Planting Spinach

Spinach is cool-season vegetable that is primarily grown during the Spring and Fall seasons. This crinkly leafy green had origins in Iran around 400 AD where it began to be cultivated, it was then introduced to mainland Europe at the turn of the 11th century until finally making it to North America in the early 19th century. In California it can be virtually grown anytime of the year in coastal valleys due to the favorable climate conditions that help sustain its growth. The growing period for fresh market spinach is relatively short ranging between 21 to 60 days.

Understanding required growth conditions bolsters the production of spinach in large amounts without risking its growth to be stunted or for it begin bolting. Spinach requires soil that characteristically drains efficiently, has good soil-warming properties, possesses a well-balanced pH, and is nutrient-rich. Notably it finds better success with sandy loam soil, which provides efficient drainage and good soil warming. California's terroir provides sought after soil spinach conditions in four distinctive areas: the Central Valley, the Central & South coasts, and the Southern Desert valleys. It is most beneficial to grow Spinach in the moderate presence of Nitrogen, Phosphorus, and Potassium. Cultivating land helps prepare topsoil conditions for Spinach seeds to grow. The viability of Spinach seeds is highly sensitive requiring high seed densities when planting. These high densities overcome germination drop-off rates. Young seeds should be used over older ones as this also contributes to drop-off.

Growing Spinach: Abiotic Factors

The lifespan of Spinach is contingent upon the Climate, Temperature, Watering, and Light that it faces. Climatically, Spinach in its beginning development grows ideally between 7-24 degrees Celsius but can sustain temperature as low as 2 and as high as 30. During Maturation, its ideal temperature shifts toward that of 15-20 degrees Celsius. California Coastal valleys during Spring and Fall mimic these conditions precisely. The timing of spinach seeding should occur 6-8 weeks prior to or thereafter the anticipated frost date. This window capitalizes upon cool weather and sunlight conditions when it is most ideal for the plant. Day length is an important factor regarding the development of spinach. When excessive heat or dryness occurs the spinach is prone to *bolting* which causes it to uproot and cease production. Once temperatures begin to reach over 30 degrees Celsius spinach production begins to faulter. Thusly so, Greenhouse tactics such as plastic coverings help in regulating light content to moisture ratios. Moisture content is important to understand when irrigating spinach. Plants need not be oversaturated with water, but rather applied uniformly in small amounts. The total amount of times the plant is watered from emergence to harvest is only three.

Growing Spinach: Biotic Factors

The external forces it faces such as Pests and Infections also serve as limiting factors in development. Managing Pests and possible Infections is crucial in sustaining spinach. Weed management during planting and growth stages reduces the post-harvest work needed to remove it for marketability. This can be conducted Directly by hand or through chemical controls. Pest management sustains the quality of spinach against predation. Aphids, Leaf miners, Worms, Whiteflies, Thrips, and Mites all damage the Spinach plant. Using natural methods such as predators or implementing chemical controls help reduce the impact of these pests. Diseases are enhanced through moist environments and cool temperatures. These diseases can even be facilitated by pest themselves. Fungi, Viruses, and Downy Mildew all pose significant threats to spinach production. Usage of fungicides, irrigation-limiting practices, and disease-resistant species are controllable ways to manage these diseases. Awareness is keen to effectively manage adversities facing spinach.

Harvesting

When harvesting Spinach, cutting off leaves should take place during coolest part of the day, much like when harvesting grapes for wine. Cutting at the rosette optimizes the yield for what is marketable and allows for regrowing. This can be performed for another two to three rounds during the season until conditions favor otherwise.

Terroir: California's Competitive Advantage

California sustains a long growing season due to the favorable conditions certain areas of the state provide. The environment's Mediterranean climate paired with soil diversity and geographical layout serve important competitive advantages in agriculture.

Geographic Composition

The origin of the unique terroir traces itself back to the tectonic plates that formed the area. Key factors such as Sand, Dirt, and Clay all intermixed during the formation of California contributing to the land's lithology. Mountains Ranges of Mineral deposits eroded into soil occupying neighboring valleys. Volcanic eruptions from transitory boundaries such as the Pacific plate against the North American plate kicked up Ash and gurgled out molten sediment. Likewise as the coast began to recede, this exposed the base layer of soil that . The emergence of Alluvial Forces that transport sediment such as Rivers and Streams further enriched and recycled soil content.

Climate Composition

Rainy conditions manifest during Winter and Early Spring. This effect is powerfully influenced by the Pacific High, a system of High pressure that moves northward during the summer and returns southward during Winter. These rains accompanied with hot arid summers combine to provide ideal fruit ripening. This doesn't exempt California from experiencing Floods or

Droughts, but it does help in regulating the climate in a favorable way. The regulation of its climate is embellished by the way air and oceanic currents interact to provide land cooling. Warm Winds carry cool air over valleys that condenses to form fog banks. This regulates the temperature of these agricultural basins that otherwise would be exposed to too much excessive heat and dryness.

Overall, the diverse terroir that makes up the state makes it the ideal grounds for a wide variety of crops, including the spinach plant.

II. Literature Review

Sunlight Variable

The variable I chose for my spinach plant was to reduce the amount of sunlight that it received. Sunlight is a critical component to the development of a plant in three different aspects: Quality, Quantity, and Duration. Questions guiding research looked at how much does light impact the development of spinach, and what are its effects when taken away or reduced?

Quality

Quality refers to the *wavelength* of light absorbed by the plant. The sun emits different types of light that sit next to each other on the visible spectrum called *white light*. This range of light between 380 to 780 nanometers manifests as Red, Orange, Yellow, Blue, Indigo, and violet light. Only two wavelengths are crucial in developing spinach: Red and Blue. However, further analysis shows that Light Quality does not constitute a major implication on the growth of spinach.

Quantity

Quantity refers to the *concentration* of light particles being delivered to the plant. Think of this as measuring the energy density of light being emitted by the sun. Studies show using white light at higher concentrations yield more efficient crop production. Overall, a higher intensity of light yields stronger growth from Spinach. If one were to choose quality however, a lower intensity of light should be selected. During a project it was shown that a higher concentration of 800 PPFD light yields stronger growth responses from Spinach plants. In similar effect using concentrated amounts of Blue/Red Light at 100 to 150 PPFD, experiments using a quality index display results consistent with better quality in higher concentrations of 150. Even though the two types of light are different in each experiment, I believe it is important to note that both conclusions stipulate higher quality from higher concentrations of light.

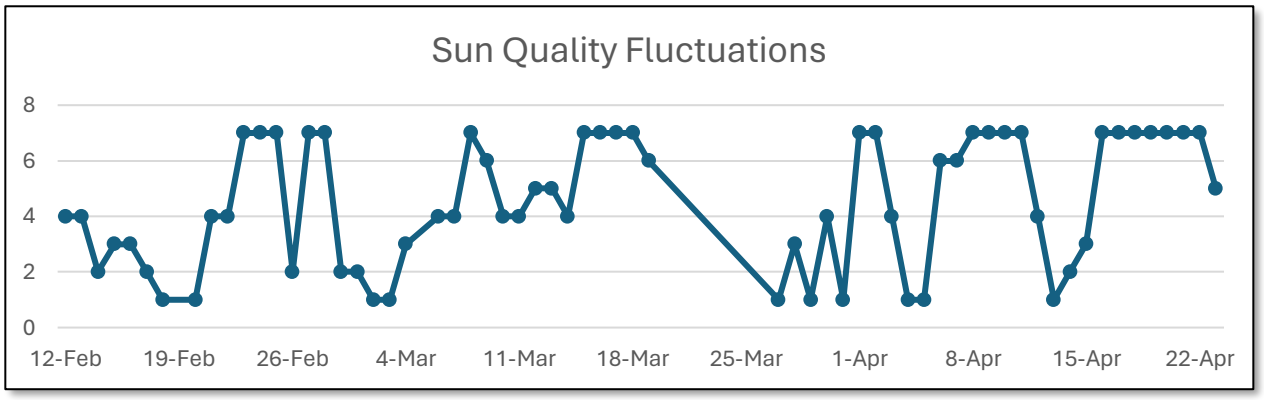
Duration

The *duration* of light is the amount of time the spinach plant sees, also known as its *photoperiod.* This is a fundamental perception in plant growing and situates in three categories*: Short-Day*, *Long-Day*, & *Day Neutral*. The optimal duration of spinach is just around 13 hours in controlled conditions making it a Long-Day Plant by these parameters. An important aspect of spinach growing compared to factors such as Quality and Quantity is the detail to photoperiod. It is important to note that this is view from the standard Growth Index as opposed to a Quality index The Quality index suggests a lower amount of light duration around 9 hours contributes to better quality spinach. This constitutes spinach to be a Short-Day plant This is a decision growers must consider when producing crops.

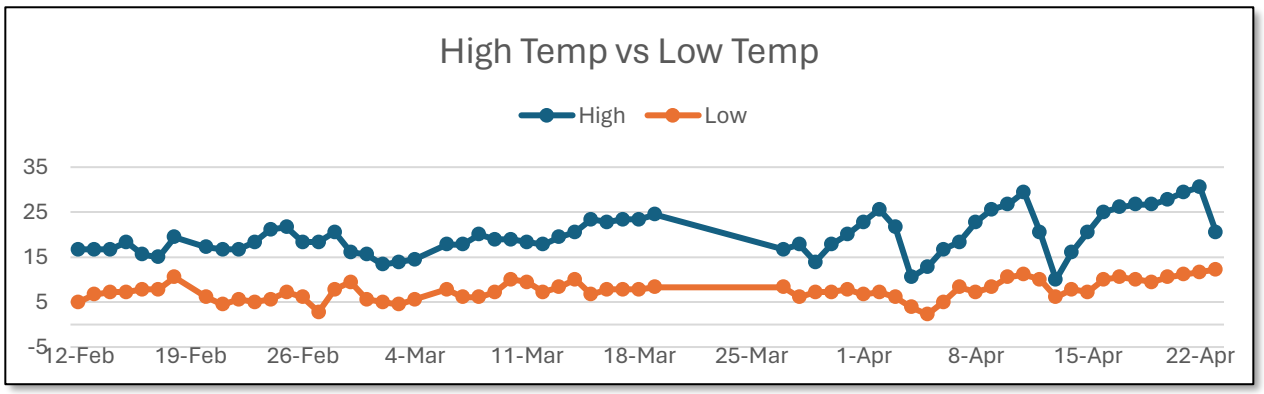
Overall, reducing the light variable will yield lower growth compared to full light intensity in the control plant. Studies display that lower concentrations and photoperiod of light contribute to lower documented growth rates exhibited in weight and Spinach leaf surface area.

Local Weather Implications

I reside over in the East Bay in a town called Discovery Bay. This town finds itself situated on the outskirts of Contra Costa and near San Joaquin County. Weather can be described as influenced by the Continental Valley it borders. The area is prone to Hot summers and cool winters, with the only bodies of water to help regulate its temperature being the delta that the bay feeds off into. However, it still is subject to the same climatic themes of rainy springs & winters, and warm winds carrying over cool water to generate fog banks. This year has provided for quite the variation in weather patterns according to the following figures.



The scale of the y-axis ranges from 0 to 7 and measures the quality of sunlight based on Cloudiness and Sun exposure. A 7 would mean no cloudiness and high sun exposure, while a 0 would be cloudy conditions such as rain and/or no sunlight exposure.



The scale of the y-axis ranges between -5 and 35 degrees Celsius. Two temperature functions were monitored, one being that of High temperature and the other Low. This helps identify trends that can overall impact spinach growth due to abnormal temperature fluctuations.

The sunlight variable and local weather implications will be further elaborated upon in the Discussion to help explain results found in the experiment. These factors are crucial in the analysis of the experiment and help draw accurate conclusions using reliable measurements.

Hypothesis

If the light quantity and duration is reduced on a spinach plant, then the spinach plant's ability to grow will also be reduced.

III. Methodology

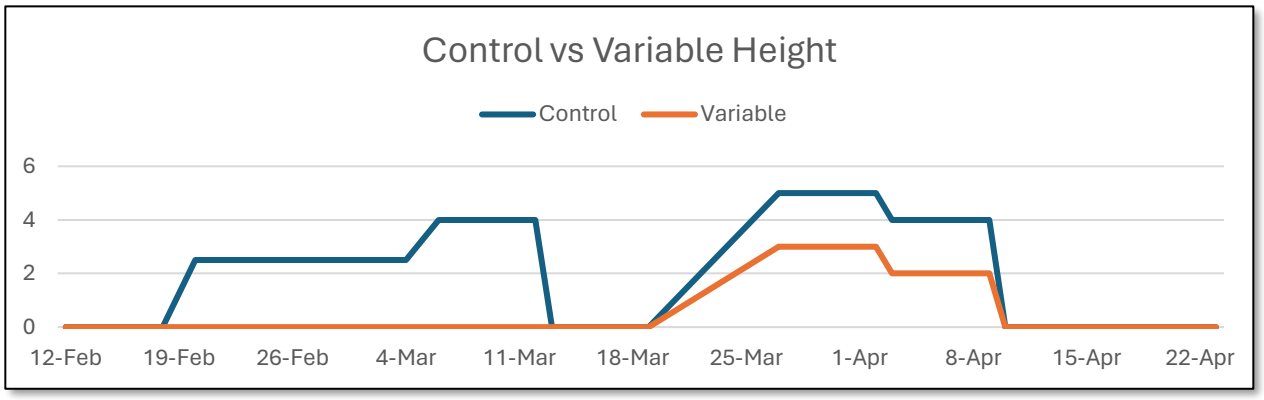
In designing the experiment, spinach seeds were planted in 4.5x5.5-inch pots giving enough space for the seed to develop. The water schedule was maintained every other day in amounts of 5 ounces. This was chosen to give a well-balanced cycle for the plant to absorb and dry quickly, making sure not to oversaturate. Extra watering was deemed necessary if plant showed signs of bolting due to dryness. The type of soil that was used consisted of All-purpose potting mix. One seed was planted per pot at a depth of around 2cm. If seed showed no signs of life another one would be planted in place to ensure consistency of the experiment.

The plants remained outdoors the entire experiment and faced southward in the front yard providing for optimal sun coverage. The control plant experienced max sunlight conditions, while the variable was taken under shade coverage in the later portion of the day to reduce the direct sunlight it could absorb. This variable effecting Light Quantity and Quality serves to prove my hypothesis that reduced light will yield reduced growth.

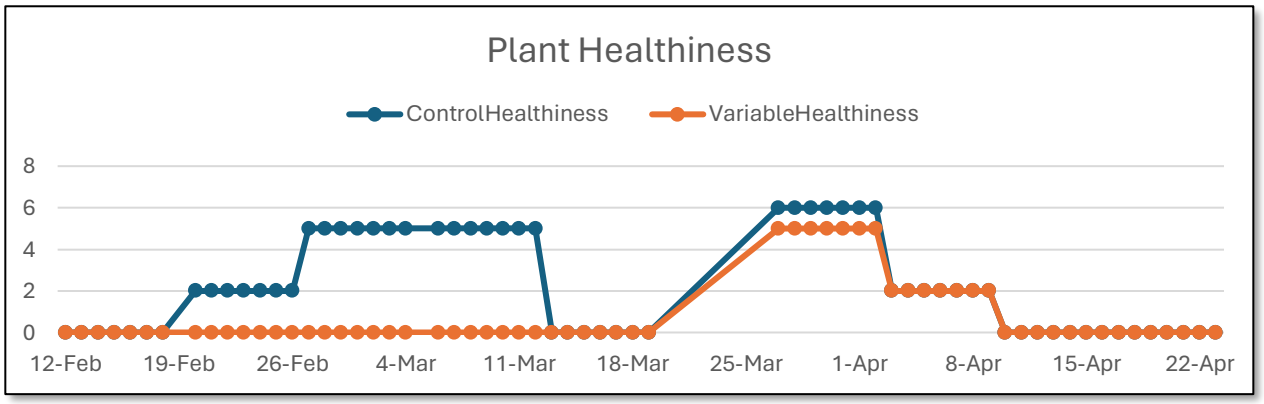
Every week statistics will be recorded based upon: Sun Quality on a 7-point scale, Highs/Lows of daily temperature in Celsius, Control/Variable Plant lengths in centimeters, and Plant Healthiness on a 7-point scale. These stats are then recorded and compiled into a data set which will visualize climate and plant characteristics. At the end, comparisons will be made about the results between the Control Plant and the Variable. The findings will formulate an argument that tests the Hypothesis for the Spinach experiment based on Light Manipulation.

IV. Results

The results of the experiment display greater growth rate and Leaf Length in the control. The following figure displays the documented length over time.



The Control spinach was able to experience a peak of 4cm while the variable did not grow at all during Weeks 1-6 of the experiment. Then a second round was initiated as both plants had died around the halfway point of the experiment from external disruption. During the second half of the experiment the control reached a peak of 5cm while the variable only reached a peak of 3cm. The plants then began to bolt towards the end of the experiment. Overall, the control spinach exemplified better seed germination capabilities and growth peaks compared to the variable. Plant Healthiness reflects the quality of the spinach plant in terms of how it looks. For instance, discoloration due to dryness would deduct from quality score while a lush green leaf would receive a higher score. Similar trends exhibited in Plant Healthiness correlate with the Spinach length measurements.



V. Discussion

Analysis of the results supports that greater light exposure improves germination success and growth response from a spinach plant. The germination success rate of the control was 2:1 compared to the variable plant. Leaf length also proved greater in the control plant compared to the variable. These results are supported by longer light quality and duration.

Local weather varied greatly in the East Bay impacting these results. Poorer Quality days due to fluctuations in both Temperature and Sun Quality detract from the ideal conditions experimental spinach require. This exemplifies the external hardships faced during the experiment contributing to overall results.

Climate Quality score was mainly reduced by rain, cloudiness, and extremely windy conditions. These factors are manifestant on the Quality Fluctuations figure. These fluctuations impact the viability of spinach development. It is noted within the sunlight breakdown that light intensity and duration is a key factor in growth. During early February and March prior to the halfway point of March 18th, the area was subject to more Low quality and less High quality as opposed to past the halfway point which had more high-quality days and less low-quality ones. This weather detrimentally affects the plant, with greater odds against the sunlight variable as the plant may not conduct photosynthesis as effectively as it possible could compared to the control. When it comes to rainy conditions as well, being oversaturated can pose a problem along with reduced temperature and greater moistness. These conditions paired with reduced sunlight overall detracts from effective development.

Temperature constitutes an important factor in the development of spinach. If temperatures are too low the spinach won't develop properly, and when it reaches to hot of temperatures the plant will bolt. The overall effect of temperature on the spinach resides in the massive fluctuations it experienced as opposed to the actual temperature, which remained quite favorable at peak daytime temperatures. The area was not subject to frequent extreme highs or lows in the area risking spinach growth failure which is around 2 degrees and 30 degrees. Temperature remained favorable through most of the experiment. It was not until past the halfway point where extreme temperature fluctuations appeared for a solid two weeks until trailing off in the mid to upper 20s. These fluctuations exceed spinach's range of optimal growth that hovers around 15-20 degrees Celsius. This effects the spinach plant by increasing its chances of bolting due to abnormal highs or lows.

VI. Conclusion

The experiment supports the hypothesis that if light quantity and duration are reduced, then spinach development is also reduced. This is important in relating Light's impact on plant growth. The sun provides a vital resource needed to successfully carry out photosynthesis and the control plant in relation to the variable in this experiment was able to achieve greater growth responses and healthiness. This is attributed to the fact that the control was able to capture more quality sun exposure compared to the Variable plant when other variables are held constant. This demonstrates the importance Light has in evaluating the success and quality of a crop yield.

This experiment relates to viticultural decision-making by determining questions regarding how much light to expose grapes to in vineyards, and knowing what types of grapes are most feasible in that environment. Light exposure allows for proper levels of plant growth development sustaining a larger canopy and shade coverage from improved growth. This variable also effects the efficiency in which sugars are produced in the plant effecting grape characteristics and quality. For instance, cooler environments provide for better White Wine growing conditions. This is reflective of Northern white wine-producing regions such as Northern France, or Germany. These cooler environments experience less light quality and lower temperatures, much like the variable plant in this experiment. Higher sun exposure yields more acidic grapes due to higher sugar development. This is characteristic of southern red wine growing regions such as Southern France, or Italy. Much like the Control plant in this experiment. Each variety comes with its own set of decisions in delivering a final product with complexity. This lack of light in the experiment shows how manipulating a variable can yield this complexity under viable conditions that won't kill the plant. This difference in experience from one seed to another adds depth to a plant by acclimation to certain conditions. Understanding what is wanted in the long-term helps make decisions in the present, and light exposure is one of the many factors affecting decisions regarding wine quality.

Overall, the unique terroir of an environment contributes to the characteristics of a product such as Spinach or Grapes. This experiment serves as a guide in understanding how climate variables and the ways they can be manipulated achieve particular results.

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