The Farmer in the Optimal Dell

New Mexico Supercomputing Challenge
Final Report
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MULT - 61
nex+Gen Academy, Eldorado High School

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Executive Summary

In an ever information-filled world, up-and-coming farmers may have difficulty finding accurate measurements for the may requirements tomatoes have. This project has compiled many sources of information from studies, books, and growing guides[1, 2] into one program that provides quick knowledge of the success of one's crop based off of the plant's current surroundings. This resource has been narrowed down to focus solely on sungold tomatoes.

We used Python to access its more advanced commands and plugins. It has many avenues for simulations and data collection needed in the project.

The user will provide input when prompted by questions in the interface. Their answers will be stored, and a complex series of events will ensue.

First, based off of the size of the plot and the spacing between plants, the number of plants will be found. This number will be converted into ratios such as the ratio of water to plants, nutrients to plants, and light to plants. These ratios will give an initial indication of too much or too little of any variable, and influence the appearance of the plant.

Next, through compiling different video and databases[3] the team has graphed the average growth over time of cherry tomatoes, then modified the data points to show how a lack or an abundance of any nutrient is detrimental.

The raw inputs given by the farmer will then be plugged into the resulting graphs, and the y-variable will be the growth of the plant, measured by height.

Finally, the farmer will receive a graphical output showing in simple terms how their plants will turn out when fully grown.

Introduction

Problem Definition

This project's central goal is to provide an accessible utility for struggling sungold tomato farmers. This project will help them in that it will successfully predict how their plants will grow based off of the situation their plot is in. This takes into account water frequency and amount, spacing, amount of light, season, the amount of tobacco and nicotine in the air, and the nutrients commonly found in fertilizer: nitrogen, phosphorus, potassium (potash). Using the farmer's information regarding the aforementioned variables, the farmer will then see a projection of their crop, and then may choose to vary their treatment of the plants accordingly.

Background

Extensive research on the growth of sungold tomatoes[4] was needed to understand the relationships between the variables (light, water, etc.) and plant growth, how the growth of the tomatoes could be modeled. Some variable relationships were new to the team, such as that between tobacco and nicotine. Tomatoes exposed to those chemicals develop diseases and show stunted growth. Although the python code is not challenging technically, the execution and usage needed further looking into.

Some concerns that arose over the completion of the project included whether indoor or outdoor plots[5] affected growth. The team concluded that no significant difference was to be noted, especially so simplicity's sake. The complication also arose about the scale of planting, or what size of farm the program works for. The team has kept this in mind and made the program adaptable for all sizes.

[1]

Significance

A recent boom[6] in startup farmers and the production of greenhouse tomatoes has occurred, causing a new need for accurate, fast information unavailable to smaller-scale farmers with less experience.

In 2014, the Farm Act[6] was written, with special laws fixing the lack of support previously available to farmers. This included more acreage allowance, and special privileges for veteran or disabled farmers, highlighting the importance of recognizing smaller businesses. Although this law is at a national scale, the number of home or community gardeners is also worth mentioning.

[1] Photo of sungold tomato plant and vine
Source: BBC

The purpose of this project was started to aid these smaller farmers and gardeners in New Mexico, many of whom are untrained and under equipped, to deal with the dry conditions of the desert, and especially do not have the resources to spend experimenting. This project aims to connect farmers with a way to modernize their farm cheaply, accurately, and simply. Many programs exist such as those hosted by the New Mexico Department of Agriculture to serve this purpose of bettering the agriculture industry.

Problem Solution

Scope

When looking in to this project the team decided to limit the amount of variables we would be testing. We did this in order to have consis look into the project and limit the factor that could hinder the growth over time. The list of variables we are using and their optimums are as follows:

Water - 0.25 gallons/plant in summer, 0.2 gallons/plant in winter

Light - 14 hours in summer, 10 in winter

Spacing - 18 to 36 inches apart

Nitrogen-Phosphorus-Potassium Balance - difference between numbers no more than 3, none above 30

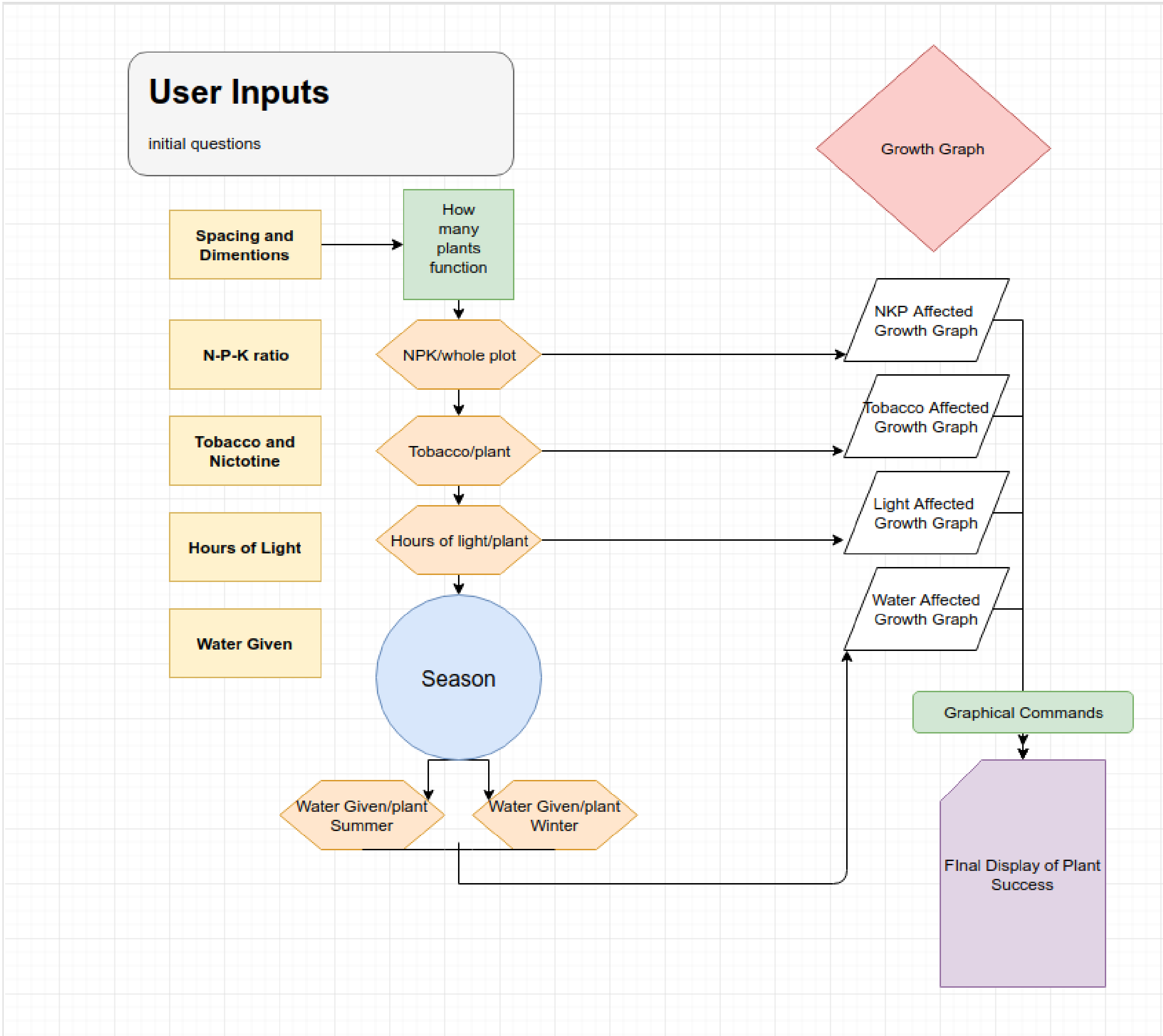
Tobacco - none

Nicotine - none

It is also important to note the setting of our project in New Mexico’s climate, which affects light and water variables. They have been adjusted as such.

Method

The project is structured in such as way as to ascertain the most crucial factors that affect tomato growth. Many other, smaller variables exist, but to stay within the range of completion, only a few were chosen. As seen in Fig 2, there is a slightly systematic approach, that allowed the team to more rapidly complete the computations for other variables after having completed at least one.



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Program

At the beginning of the year, the team discussed how this problem should be modeled. It was presented to structure the program in such a way as to provide an interactive tool that relies on user input, and compares it to optimum values. The code represents both the user's farm

[2] Project Flowchart

and the optimal farm in order to solve for how the user should improve their treatment and how their plants will end up in the current trajectory.

When evaluating the variables represented in this program the team turned to extensive research on the effects of their variables and how they affect the growth over time in the sungold tomatoes.

The program begins by asking for the user plot size and plant spacing, then continues with various questions based on the variables defined. This is shown, for example, when the program asks the user, "How much water do you give your plot?". When breaking down this question, the program will first, evaluate the size of the plot and the spacing between plants to find the amount of plants in this space.

This is found by adding the length of a sungold tomato plant (12 inches) to the given spacing. The value given for spacing had to be divided by two to account for the two plants that share the space between them. It is assumed that the area of the plot covered by the plant is roughly square, so the sum is squared. The total area of the plot is then divided by this exponent, finally exposing the total number of plants.

Next, this total number will be converted into a ratio of water per plant. Each variable will have such a ratio, with the variable to the plot area given.

This ratio will be inputted into a simple if then statement determining if too much or too little of each variable is being given, this based off of the growth optimums.

Lastly, our program plugs the ratio into the growth equations derived from growth over time, and floats that number. That number corresponds with a visual command, that, in tandem with the rough greater than or less than portion, displays a model of the tomato plant.

The team has used python to write the program. Initially, it was proposed that by using packages such as pyplot, a graph would be constructed by the program, but this was scrapped in place of an equation, where the x-value is the variable ratio, and the y-value is the height of the plant.

Challenges

The team encountered many struggles throughout the year. The first was to clearly define the problem and goals for the project. At the beginning of the year, the project was more set on finding optimums for plant growth. THis presented a simplicity issue, so the team then expanded horizons to more than a list, but an interactive comparing and compiling service.

Next the issue arose of how to connect the variable ratios to the optimums in an accurate way. Originally, the idea was to have a dictionary that simply assigned a graphical command for different ratio possibilities. This was discarded for a more accurate formula method.

Throughout the project, the team struggled with finding relevant information and receiving contact from our mentor, not to mention the difficulty of sparse meeting times and our ambitious goal. Often the idea was proposed of switching to NetLogo for a gentler approach, but the team decided to remain with python and explore the possibilities.

Conclusions

Results (In Progress)

In essence, this project should never be complete. It should always be becoming more detailed and accurate through the people that use it.

At the level outlined by the team in previous reports, the program is still in progress. Much headway has been made, and now a simple process of implementing the graphs and data collections must be completed. The expectation is that a functioning interactive machine will be procured and demonstrated at the expo in Los Alamos.

For a takeaway as this year winds down, the team has created the beginnings of a highly-functional tool, that can work to solve an important, though not highlighted, issue in New Mexico. It is believed that this project has purpose and potential, and has served the team members well in learning and growing in many fields.

Contributions:

This project, when developed to its full potential, could have a large impact on New Mexico's agricultural community. Farmers struggling to provide produce could drastically increase their production, gardeners could fine-tune their individual plants, and the statewide effort to foster technology, education, and success to its agricultural participants would receive a useful tool. The team hopes to promote widespread use of this program when fine-tuned, perhaps submitting to local leaders and active agricultural citizens.

Future Development:

When looking into the future of this project the team feels there is a surplus of potential. First steps would include going over places where this year may have called for simplification, such as in distinguishing light types, minute indoor and outdoor differences, altitude, and other nutrients in fertilizer. From there, the project would benefit from testing and fine tuning equations, then more hands-on data collection.

Acknowledgements:

The team would like to sincerely thank Suzanne Andrego for her expert advice and help with the research portion of this project and Karen Glennon for her constant support and willingness to provide contacts and outside help.

Thank you also to Patty Meyer and Neil Haagensen for helping improve the general quality and success of the project, and for always stepping in with problem-solving tips.

Team Information

Isabella Montoya, a junior at NexGen Academy, has participated in the challenge for many years, and has won numerous awards, including teamwork and technical poster awards. She participates in many organizations, including student counsel, in which she is a statewide leader. Isabella mainly programmed, having taken a Python course at CNM. She also helped in the final stages of the report and in data collection.

Savannah Phelps, a freshman at Eldorado High School, is wrapping up her third successful year of the challenge. She has been interested in STEM fields her whole life, and participates in a Robotics Club at her school, among several others. She focused mainly on report writing and presenting, although helped design the code theory and research.

Reyanna Fromme, also a freshman at Eldorado, participates in the Eldorado Band, and is an active member of the drama department as well. She has worked with Isabella for many years in the past. Reyanna served as the primary researcher, and assisted in report writing and code-proofreading.

Appendix

Code (Pending)

This code, although theorized completely, is still under the process of completion. This is what the team has completed so far. The final version will be displayed at the expo.

```
#Python Version 2.7
import math
import numpy as np
import matplotlib.pyplot as plt
import sys


#FUNCTIONS AND DICTIONARIES
#Determines how many plants in the plot given to us by the user, then returns that number.
def plant_lot(length, width):
        area = length * width
        plantspace = (12 + space) #The 12 is the amount of space needed to grow the plant
(12x12 pot)
        spaces = pow(plantspace, 2)
        howmanyplants = area/spaces
        return howmanyplants

#Determines the ratio of how much water is given to how many plants there are. We compare
this to the number Suzy's plot came out to after running this.
def water_perplant(howmanyplants, watergiven):
  waterRatio = float(watergiven/howmanyplants)
  return waterRatio



#MAIN CODE BODY
print('Hello, Welcome to our program')

#Ask questions to obtain values for use later
length = float(raw_input('What is the length of your plot(In inches): '))
```

```
width = float(raw_input('What is the width of your plot? (In inches): '))
space = float(raw_input('What is the space between each plant(In inches): '))
season = raw_input('Is it Winter or Summer?') #Winter is september to march, summer is april to
august
watergiven = float(input('How much water do you give to the whole plot per week? (Gallons): '))
nitro = float(raw_input('What percent of your usual fertilizer is nitrogen?'))
phos = float(raw_input('What percent of your usual fertilizer is phosphorus?'))
potash = float(raw_input('What percent of your usual fertilizer is potassium (potash)?'))


#Define variables
howmanyplants = plant_lot(length, width)
waterRatio = water_perplant(howmanyplants, watergiven)

#Two different code paths relating to seasons that affect water and light
if 'winter' in season.lower():
	if waterRatio > 0.2:
		print("Too Much Water")
	else:
		print("Too Little Water")

if 'summer' in season.lower():
	if waterRatio > 0.25:
		print("Too Much Water")
	else:
		print("Too Little Water")

#Spacing results
if space < 18:
	print("Too Close Together")
```

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