Effect of Temperature on Mung Bean Growth Rate

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Abstract

With the rise of average global temperatures, its effects on plant growth should be further examined as plants are an integral part of life by providing oxygen, nutrients as food, and even shelter, to name a few (World of Change: Global Temperatures). Temperature is one of the primary factors in plant development, and as such we aimed to examine the effect of temperature on the growth rate of mung beans as they are a common food in diets throughout Asia. Previous research has shown that increasing mean temperatures increased the rate of growth in mung beans, given that the temperatures were not greatly exceeding 28° C (Aggarwal et al., 1977). Thus, we hypothesized that there would be a difference in mung bean growth dependent on temperature, with the warmer environment yielding the fastest rate due to hotter temperatures, allowing the seed coating to tear and embryos within to plump out. Using three different environments (cold ~3° Celsius, room temperature ~25° C , and warmer ~30° C), we placed mung beans in plastic ziploc bags and observed their growth over the span of 10 days. Each day, a ruler and string were used to measure the mung beans from the different environments and the data was recorded into three tables, one for each environment (see Appendix A). Growth of the sprouts ranged from 0cm - 20cm, and average growth for the warmer environment was 17.33cm, 14.67cm for the room temperature environment, and 0.067 for the cold environment. Taking the averages of growth in each environment, a one way ANOVA test was used and the variation between the three groups were deemed to be statistically significant (p-value=0.0001, α=0.05). Our findings agreed with previous research and we rejected the null hypothesis. The growth rate of mung beans was fastest in the warmer environment, with the optimal temperature ranging from 26 - 33 ° C for our particular experiment. Limitations may have included uneven distribution of water per mung bean, nonuniform temperature per bean as some beans may have been <1cm farther from the heat source than others, and space limitations for each mung bean to properly grow.

Introduction

Investigating crop growth is vital as it provides us with information about climate change which has become a prevalent issue in our society due to its long-lasting and inevitable effects. Alongside climate change comes the more specific issue of global rising temperatures, also known as global warming. In an ongoing study, scientists from NASA found that the average global temperature rose by 1° Celsius since 1880. Further, more than two thirds of this temperature increase can be attributed to the last 4 decades (*World of Change: Global Temperatures*). It takes a vast amount of energy from the sun to heat the ocean and land, and thus a 1° C increase is quite significant (*World of Change: Global Temperatures*). Temperature is one of the most primary factors in plant development. As such, global warming is an issue that extends not only to humans but also to vegetation and animal life around us. More specifically, the increase in average global temperature has the ability to significantly affect germination rates as well as plant productivity (Zhao et al., 2017).

Mung beans (*Vigna radiata*) are traditionally grown in various parts of Asia and have been accepted as a part of the local diet for many people (Zhou et al., 2017). The beans contain a balanced source of protein, dietary fiber, and significant amounts of bioactive phytochemicals. Considering the beans are rich in protein, amino acids, and antioxidants there are many health benefits associated with the beans as they have detoxifying, anti-inflammatory and diuretic properties. Typically, mung beans have a slightly sweet taste to them and are sold as sprouts or in dried form. As they are not popular in Western culture, they can still be found in most grocery stores. Generally mung beans benefit in warmer climates where the optimal temperature is 27-30° C and they are known for germinating and sprouting at quick rates in these conditions (Zhou et al., 2017).

In one study conducted by researchers, mung beans were exposed to high temperature stress (42°C) and the seedlings tolerance was understood through modulating the antioxidant defense and detoxification systems (Nahar et al., 2015). The results concluded that mung beans are able to tolerate short-term high temperature due to exogenous glutathione (GSH). GSH is an antioxidant property capable of preventing damage to important cellular components caused by reactive oxygen species such as free-radicals, peroxide and heavy metals. Biochemical reactions in plants are sensitive to high temperatures, which can lead to potential cellular damage or even death with long-term exposure. Another study provides evidence that increasing mean temperature increased the flowering in the beans. However a temperature too high delayed the flowering. The amount delayed also was dependent on the mung bean strain as 40 different ones were tested (Aggarwal et al., 1977). Ultimately, we rely on crops to sustain our diets and survive, therefore it is critical to understand the specific properties exhibited by plants when placed in extreme conditions such as significantly higher/ lower temperatures.

Our study further investigates the impact of temperature and how long mung beans can grow when placed into different conditions. We hypothesize that there would be a difference in mung bean growth if the beans are placed into a warmer environment, because the seed coating would rip faster allowing for embryos to emerge and beginning the growth process of stems/leaves quicker.

Methods

To begin the experiment we took nine sheets of paper towel and dampened them with tap water. To minimize error we recorded the temperature of the tap water with a household thermometer, prior to dampening the paper towels. A standard temperature of 20°C was used. Next, we labelled three ziploc bags as room temperature, colder (temperature colder than room temperature), and warmer (temperature warmer than room temperature; this process was repeated three times so we would have 9 bags in total. Multiple samples were used because an increased number of replicates reduces error and will give better results overall. After the bags had been labelled and the paper towel was dampened, we scattered five mungs onto each of the paper towels, placing it into each of the bags. For the room temperature bags, we placed them on the kitchen counter. The room temperature bags acted as the control for the experiment. For the warmer temperature bags, we placed them above a heater, and for the colder temperature bags we placed them into the freezer. No additional water was added to the bags throughout the experiment.

The mung beans were monitored over a total of 10 days, checking their growth with a ruler in centimeters at the end of the night. The temperature was recorded during each measurement, to ensure consistency of the environment and to make sure no abrupt changes in the environment were occurring. After the data was collected, we compiled it into a data table, and performed a statistical analysis. To analyze the data we used a one-way ANOVA test to determine if the results were statistically significant or not.

Results

After being put into different environments and measured for 10 days, the mean length of the mung beans in each environment were 17.33 cm for the warm environment; 26°C- 33 °C, 14.67 cm for the room temperature environment ; 22 °C- 25°C., and 0.067 cm for the cold environment; 2°C- 3°C. We used a one-way ANOVA test to determine whether the variation in mean values between the groups was statistically significant. Each group had an n value of 3, totalling 9 values.The ANOVA test resulted in a P-value of 0.0001, which is smaller than the alpha (α) value 0.05. Therefore, we can conclude that the difference in mung bean length between the environments is statistically significant and we can reject the null hypothesis. See **Figure 1** and description for an in depth analysis.

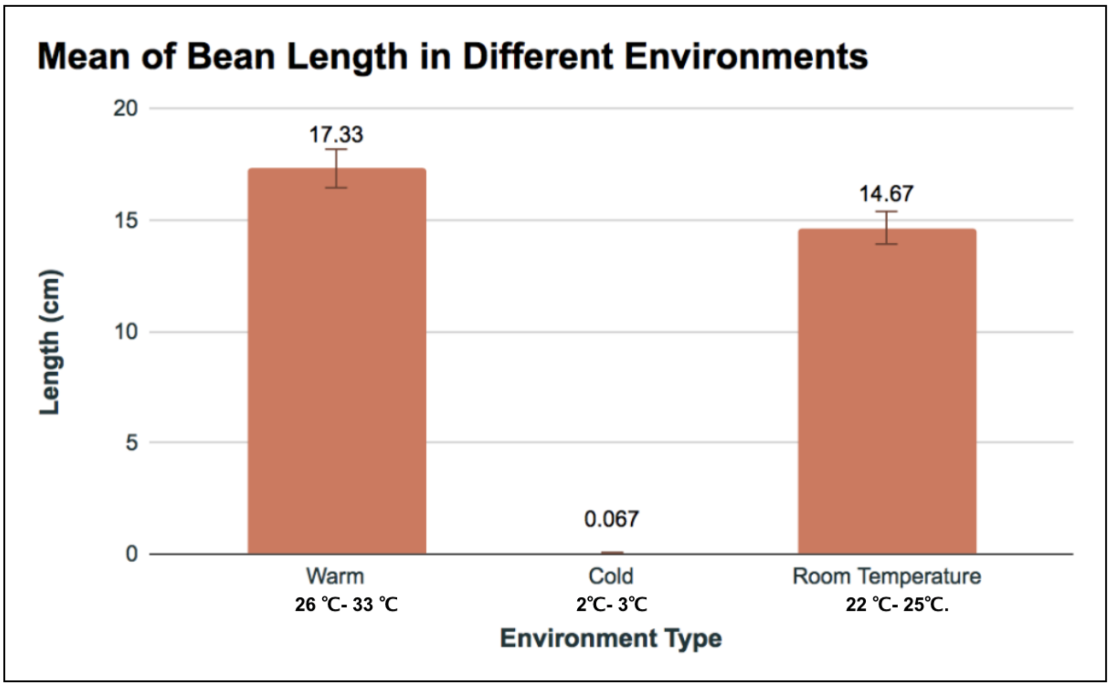

Figure 1: Bar graph of the mean mung bean lengths in different environments, based on temperature. The warm environment had a temperature range of 26°C- 33 °C. The cold environment had a temperature range of 2°C- 3°C. The room temperature environment had a temperature range of 22 °C- 25°C. The vertical error bars represent a 95% confidence interval. The one-way ANOVA test results showed that the difference in bean length between the environments is statistically significant (p-value: 0.0001).

Discussion:

The statistical analysis we conducted gave us a p-value less than the (α) value of 0.05, therefore we are able to reject the null hypothesis, and conclude that there is a significant difference in bean growth between the different temperatures. Our results lined up with the findings of previous research. As mentioned in the introduction the study conducted by Aggarwal in 1997 found that increasing temperatures can provide optimal growth for different types of mung beans. The researchers also found that extreme temperatures can delay the growth of the beans as well. This was also confirmed by Howarth in 2015, when he found that extreme high temperatures can lead to potential cellular damage or death if exposed to extremely high temperatures for a long period of time. The optimal temperature for mung bean growth is between 27 °C and 30 °C, which was supported by our results.

Sources of Error

Our results make sense scientifically when compared to previous findings, however we would like to account for some sources of error that we are aware of.

Water Distribution and Mung Beans

Since the mung seeds were randomly placed within the paper towels, the distribution of water was quite randomized. Some paper towels may have been more soaked than others, or if they were evenly soaked, the saturation of water may have been higher in specific areas of the towel. Mung beans have a significantly higher water absorption rate due to their larger pore size, therefore the water absorption may have differed between the beans due to the amount of water they were placed in (Ranawake, 2011). Having an insufficient amount of water decreases mung bean growth. Having an increased amount of water causes faster germination and growth of the mung bean. However, having too much water does not favour the optimum growth rate of the mung beans (Ranawake, 2011). The excessive water covers the roots and limits the amount of oxygen the roots can receive, which in turn destroys the roots (Oyama, 1975). Therefore having varying amounts of water through the paper towels may have significantly affected the growth rates of the mung beans, making the experiment less accurate.

Space and Germination

As mentioned previously the mung beans were randomly placed on the paper towels. Some beans were close together while others were more spread apart. Previous research has shown that to get optimal growth mung seeds should be spread out at least 2cm away from each other, otherwise growth is inhibited (Bekker et. al, 2002). Since the seeds were randomly placed and the 2 cm distance was not taken into consideration, some beans may have had an optimal environment to grow in, while others not. This may have caused disprecienies in the growth rate for the seeds and therefore our results.

Future Research

To reduce sources of error in future experiments, other variables which affect germination of mung seeds, specifically water content and distribution, should be taken into consideration. Water content can be managed by using a spray bottle to keep track of the amount of water going on to the paper towel and where the water is being sprayed. By doing this each of the mung seeds will have the same amount of water to germinate from. Distribution can be managed by placing the seeds exactly 2 cm away from each other rather than randomly placing them on the paper towel. This will allow each of the seeds to be in an optimal environment for growth.

To further this experiment and test the importance of a warm temperature on different crops, different types and strains of bean seeds can be used. From our experiment we were able to confirm that a warm temperature allows optimal growth for mung seeds. In future experiments and with more time, one could test if warm temperature has the same effect on other beans, such as kidney or garbanzo beans.

Conclusion

After conducting the experiment and running statistical analyses on the data, we found that the difference between the length of the mung beans in environments with different temperatures was statistically significant. From the one- way ANOVA test a p-value of 0.0001 was found. The p-value of 0.0001 is significantly smaller than the (α) value of 0.05, therefore the results are significant, supporting our hypothesis. In conclusion, it can be confirmed that mung bean length is dependent on the temperature of the environment, having the most growth in warmer temperatures, and little to no growth in colder temperatures.

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Citations:

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Appendix A

Colder Environment

Day/Date	Temperature (°C)	Bag 1 (bean length)	Bag 2 (bean length)	Bag 3 (bean length)	Comments/ Observations
Day 1: November 5th	3°C	0cm	0cm	0cm	Beans have not sprouted at all yet.
Day 2: November 6th	3°C	0cm	0cm	0cm	Beans have not sprouted at all yet.
Day 3: November 7th	3°C	0cm	0cm	0cm	Beans have not sprouted at all yet. They look a bit puffy, maybe because of the water.
Day 4: November 8th	3°C	0cm	0cm	0cm	Beans have not sprouted at all yet. Some look a bit puffy, maybe because of the water.
Day 5: November 9th	3°C	0cm	0cm	0cm	Same as previous day.
Day 6: November 10th	3°C	0cm	0cm	0cm	Same as previous day.
Day 7: November 11th	3°C	0cm	0cm	0cm	Same as previous day
Day 8: November 12th	3°C	0cm	0cm	0-0.1cm	Bag 3: 1 bean had very minimal growth
Day 9: November 13th	3°C	0cm	0cm	0-0.02 cm	Bag 3: 1 bean had very minimal growth
Day 10: November 14th	3°C	0cm	0cm	0-0.2cm	Bag 3: 1 bean had no further growth

Room Temperature

Day/Date	Temperature (°C)	Bag 1 (bean length)	Bag 2 (bean length)	Bag 3 (bean length)	Comments/ Observations
Day 1: November 5th	24°C	0cm	0cm	0cm	Beans have not sprouted at all yet.
Day 2: November 6th	25°C	0.1 - 0.3cm	0.1-0.3cm.	0.1-0.3 cm	⅘ beans have sprouted for Bag 1. All beans have sprouted for bag 2 ⅖ beans have sprouted for bag 3
Day 3: November 7th	25°C	0.3 - 0.5cm	0.1-0.9cm	0.7cm & 1.3 cm	⅘ beans have sprouted for Bag 1. All beans have sprouted for bag 2. ⅖ beans have sprouted for bag 3
Day 4: November 8th	25°C	0.6 - 2.7cm	0.5 - 3cm	0.5 - 5cm	Bag 1: All beans have sprouted. Fuzzy mold like growth on the stems. Bag 2: Also has fuzzy mold like growth on stems Bag 3: sprouts growing curved, not straight
Day 5: November 9th	24°C	1.5cm - 4cm	0.6-5 cm	1.5-6.5 cm	Bag 1: squiggly growth Bag 2: branching growth Bag 3: all squiggly branching growth with white fuzzy stuff on the stems
Day 6: November 10th	24°C	2-6.5cm	0.6 - 6cm	2-9cm	Bag 1: sprouting into the paper towel Bag 2: squiggly, branching growth Bag 3: leaves growing from the one with the longest shoot

Day 7: November 11th	23°C	5cm - 12cm	1- 8cm	4-10cm	Bag 1: continued growth Bag 2: continued growth. Bag 3: continued growth. No new leaves
Day 8: November 12th	23°C	6cm - 14cm	2.5 - 11cm	6-11cm	Bag 1: continued growth. Leaf on 1 sprout. Bag 2: continued growth. Bag 3: continued growth. No new leaves
Day 9: November 13th	23°C	6.5-15 cm	5-14cm	6-11.5 cm	Bag 1: continued growth. Leaves on 3 sprouts Bag 2: continued growth. Bag 3: continued growth. some mold.
Day 10: November 14th	22°C	6.5-16 cm	7-16cm	6-12cm	Bag 1: all have leaves Bag 2: squiggly branching growth. 4/5 have leaves Bag 3: lots of mold growth

Warmer Environment

Day/Date	Temperature (°C)	Bag 1 (bean length)	Bag 2 (bean length)	Bag 3 (bean length)	Comments/ Observations
Day 1: November 5th	33°C	0cm	0cm	0cm	Beans have not sprouted at all yet.
Day 2: November 6th	30°C	0.1-1cm	0.5-0.8cm	0.3-0.8 cm	Condensation present in the bags
Day 3: November 7th	30°C	0.5cm- 4.5cm	1.8-3.5cm	1.5-2.5 cm	The sprouts have emerged from the mung bean casing

Day 4: November 8th	29°C	2.5 - 8cm	3 - 6cm	2 - 5cm	Bag 1: 2 beans completed emerged from bean casing, ⅗ have additional 'branches' growing off them. ⅖ have small green leaves sprouting from the bean. Bag 2: all beans have long shoots with branching. Bag 3: all have long curved shoots. No branching.
Day 5: November 9th	29°C	4 - 10cm	5-7cm	2.5 - 5cm	Bag 1: all shoots have branching growth Bag 2: 2 shoots now have leaves Bag 3: 3 beans have leaves
Day 6: November 10th	29°C	4.5-14cm	7cm - 9cm	3cm-6cm	Bag 1: 4 of the shoots have leaves near the base Bag 2: lots of mini branches off the main shoot Bag 3: 4 beans have leaves
Day 7: November 11th	28°C	6cm - 12cm	7-12cm	7-13cm	Bag 2: all have leaves and branching Bag 3: all have leaves and branching
Day 8: November 12th	28°C	7cm - 14cm	7-13cm	7-15cm	All are longer and have more branching
Day 9: Nov 13th	26°C	10-15cm	9-18cm	10-15cm	Bag 1: One of the sprouts seems to be dying (turning brown) Bag 2: continued growth Bag 3: continued growth
Day 10: Nov 14th	27°C	11-16cm	10-20cm	14-16cm	Bag 1: seems like the 1 sprout is dead. Bag 2 + 3: continued growth