Effects of gibberellins on plant growth and development

Introduction

Gibberellic Acid, also called Gibberellin A3 or GA3 is a naturally occurring hormone found in plants with the chemical formula $C_{19}H_{22}O_6$. It is renowned for promoting cell elongation; this in turn stimulates overall plant growth and development, resulting in a taller, more mature plant.

The purpose of this experiment was to discover to what extent GA3 has on overall plant growth and development, if at all. Our plant of choice was the Pea Plant (Pisum sativum), for a multitude of reasons. The main reasoning behind the selection of the pea plant for this experiment was the fact they are already quick sprouting, meaning we can conduct this experiment in a short period of time, and if need be, run a secondary experiment afterwards to ensure experimental reliability, without impacting on time.

The Pea Plant has also been used by accredited scientists for various experiments, most notably in Gregor Mendels experiment, based on the Hybridization of Plants. It was discovered by researchers that the tall pea plants used by Mendel had GA3, and that the short plants were mutated to grow at 1/20 of normal speed, due to containing GA1, causing what we now know as dwarfism.

Even if no other discoveries were made from Mendels experiment, we can safely conclude that pea plants are very susceptible to Gibberellic Acid, which makes them perfect plants to conduct this experiment.

This experiment will be run using four subject plants. Two will be left control plants, being feed a drop of distilled water, while the other two plants will be feed a drop of GA3 each, these being the experimental plants.

In all, based on prior evidence, we hypothesis that Gibberellic Acid, or GA3 will stimulate plant growth resulting in the experimental plants being taller than the control set.

Materials and Methods:

We originally started with 6 already mature pea plants in a pot full of soil. The pots were identified with the group names, date and lab class. Next we carefully selected four of our potted plants to be our subjects for the experiment. We looked for the four most similar plants to be our subjects in order to keep the experiment as accurate as possible, so any plants that were unhealthy or considerably different in size were cut out of the pot using scissors at the base of the stem so as not to damage the root systems of the other plants.

We then tagged each plant with a number, 1 & 2 were the control plants and 3 & 4 were the experimental plants. We placed tags with strings around the base of each plant, ensuring we didn’t damage the plants in anyway.

For a reference point for height we marked a small line with a marker on the stem of each plant, just above the first node. This allowed us to have a constant point to measure the plant from.

Once our plants were labelled and marked we discussed the ways GA3 may alter the growth of your plants and identify what plant attributes we needed to measure in order to detect these changes and correctly quantify them. The measurements that were decided on were as follows:

- Plant Height
- Internode Length
- Width of Stem
- Number of Nodes
- Cell Length (No initial readings were taken)
- Cells/Internode (No initial readings were taken)
- Internode 6 Length (No initial readings were taken)
- Plant Colour
- Overall Plant Health

We then set out, recording initial readings for the above plant characteristics, excluding cell length, cells/internode and internode 6 lengths as they can only be recorded after we have finished taking the final results for the other attributes so we don't damage the plant and cause incorrect results.

We tabulated our results for easier comparison with the results which we took 7 days later.

After we finished recording our results we began applying our control solution of distilled water and our GA3 to our plants. One drop of control solution was placed in the shoot apex of our control plants, plants 1 & 2. We did this carefully using a dropper bottle and employing fine tweezers to open the leafy stipules enclosing the shoot apex. The drop is required to stay in place in the apex so if the drop ran off we simply repeated the application until we had a drop sitting in each apex.

The same process was repeated with the Gibberellic Acid on our experimental plants, plants 3 & 4. Ensure that during this process not to damage or move the plants, as well as washing the tweezers between the application of GA3 and Control Solution.

Our plants were then taken to the greenhouse, where they were left for seven days before we took our final readings.

After the week we began to record any major differences in morphology between the control plants and our experimental GA3 plants. We then again, took our second and final readings of each plant, tabulating them in the same fashion as the first data set. This time however we took readings for Cell Length, Cells/Internode and the Length of Internode 6.

To measure the cell length and cells/internode we were required to take an epidermal strip of each plants sixth internode. This was done using a sharp razor blade, making a small incision in the epidermis of each plant and with fine forceps, pulling the incision out away from the plant, getting a long, very thin strip of epidermis from the sixth internode. This was then cut into a small piece approximately 1cm long and placed on a microscope slide with a drop of distilled water and a cover slip placed on top. This process was repeated for each plant, ensuring to label each microscope slide with the corresponding plant number.

Placing the slides under a microscope we observed the plants at a microscopic level, which is how we recorded the data for cell length (Î¼m), (using an ocular micrometer), and the cell number.

We then computed all of our results to a percentage of change in order to appropriately analyse and compare the results between the control and experimental plants. Dividing the length of internode six (Î¼m), by the cell length (Î¼m), we determined the ratio of cells: internode.

Gibberellic Acid Experimental Method

Select and ‘ prune’ the four most similar plants

Label each plant and record the data required for the experiment:

Plant Height, Internode Length, Width of Stem, # Nodes, Colour, and Health

Place a drop of control solution to the shoot apex/terminal bud of the two control plants and place a drop of GA3to the shoot apex/terminal but of the two experimental plants

After 7 days observe the plants and record any changes in morphology between experimental plants and control plants

Take an epidermal strip from the sixth internode of each plant and place on a microscope slide with distilled water. Record cell length.

Compute all data to a change in percentage for comparison.

This experiment was designed to test the effects of Gibberellic Acid on plant growth and development. We did this by applying a small amount of GA3 to the apical meristem of pea plants and taking recordings of overall plant height, internode length, stem width, number of nodes, colour, health, length of internode 6 and cell length. These measurements were taken before the application of GA3 and then 7 days after application. This is shown as a class set, tabulated in overall percentage change in insert figure below.

It can be seen here that Gibberellic Acid had a very obvious effect on plant growth as almost all plant characteristics were mutated to a much larger figure in the experimental plants than the control plants. The averages in almost all are remarkably higher in the plants treated with Gibberellic Acid than those that went un-treated.

The most obvious change in plant morphology between the GA3 plants and the controls is the overall plant height. On average the control plants grew by 40%, where the plants treated with GA3 grew by 119%. The largest growth of the control plants was ~ 86%, where in turn the max GA3 plant growth was nearly 300% (290%). The minimums have a similar trend, with the control plants and the treated plants having minimums of 8% and 24% respectively.

As well there was a considerable increase in the length of the internodes. We measured both a standard Internode at the beginning of the experiment as well as internode 6, one which would have clearly been affected by Gibberellic Acid in order to get a nice broad range of data to give a good display of internode growth.

Internode 1 was rather dramatically affected by the GA3, as the average growth for the control plants was 11%, where the experimental plants were increased by on average, 38%. As shown in figure. As well the maximums followed the same trend, with the plants affected with GA3 being considerably higher at 289% in comparison to the control at 106%.

The measured sixth internode showed remarkable increase as well, even more so than the first internode. As shown in the figure below.

In the results there are a few data points which appear to be incorrect. They were included in the calculation of the mean but for accuracy sake the maximum and minimum do not include the strange results. That leaves the mean at 45% average growth for the control plants and 189% for the experimental plants, and the maximums, as expected following a similar trend even when omitting the unusually high results; 40% control max and 67% experimental max.

The final aspect of plant morphology to be drastically affected by the Gibberellic Acid treatment is the Cell Length. It is shown in the figure as well as figure below that overall GA3 had a substantial affect on elongating the plant cells. On average each control plant cell grew to 155Î¼m where in comparison the experimental plant cells grew by 347Î¼m on average. The maximum cell lengths followed a similar tendency, that the GA3 treated plants were higher than that of the control plants, 268Î¼m and 547Î¼m respectively.

From the data in figures it is difficult to see any dramatic change in stem width, number of nodes and cell: internode ratio.

You can see that there is a slight increase in average number of nodes between the treated and non-treated plants, with the treated plants having on average 44% increase in nodes after treatment and the control plants having on average 38% increase in the number of nodes. There is a difference between the control group and the experimental group but it pales in comparison to the differences already explained by the other results. See figure below.

The overall plant stem width was measured between the treated and non-treated plants. There is actually a 2% drop in average stem width when the GA3 was added. It shows there was minimal change between the control and the experimental group. The average stem width of non-treated plants was 15% while the treated plant was 13%. This can be seen below in figure.

This data is believed to have some inaccuracies as shown in the table there are groups who recorded negative stem growth which seems unlikely. The majority of results show either no change in stem width or a slight increase.

The ratio of cells to internode, or the average cells per internode was recorded at 173 for the control plants and 161 for the Gibberellic Acid treated plants. This in fact shows a drop in the ratio of cells to internode length. The maximum ratio for the control plants was 333 and 295 for the experimental plants. This shows a slight drop, however this difference is not as dramatic as the differences between the plants regarding other aspects of plant morphology such as height and cell length. See figure below

Discussion:

The results above show all the recorded data for this experiment, and in turn highlight many aspects where the application of Gibberellic Acid has greatly influenced the growth and development of the pea plants.

The three main characteristics of the pea plants that displayed the greatest change in morphology between the experimental plants and the control plants were, plant height, internode length and cell length. The most obvious of these was the overall height of the plants. With the experimental plants showing such a tremendous increase in size over such a small period of time it is safe to assume that yes, Gibberellic Acid, a plant hormone is somewhat responsible for plant growth.

The experimental plants also showed a large increase in the length of the internodes. This is another contributing factor to the overall height of the GA3 treated plants. Measuring two different internodes also helped to ensure accuracy among the internodes, showing two types of internodes, ones that were only slightly affected by GA3 and others that were dramatically affected by GA3. This answers the question posed wether the overall growth of the pea plants was due to internode growth or an increase in the number of nodes. As there was a slight increase in the number of nodes but wasn’t counted as being statistically relevant we concluded that the height increase was due to the elongation on the internodes.

There was little to no increase in Stem width and an slight decrease in the ratio of cells: internode. This came as a surprise as we had predicted that as a plant growth hormone, Gibberellic Acid would increase all aspects of the plants size, including stem width. After some research it was found that these results were correct, Gibberellic acid has little affect on stem width. " Surprises which we had not prepared for include the lack of variation between the diameters of the stems."

From the data on cell: internode ratio we begin to get an idea on how Gibberellic Acid works to expedite plant growth. We can clearly see from our results, in conjunction with other reports structured and performed in a similar fashion, that Gibberellic Acid promotes plant growth by elongating the individual cells in the plant. This is confirmed in the However, as we discovered, GA3 does not promote cell division as a method of lengthening the internode length and the overall height of the plant. This is further confirmed

However even with this data I was curious about the required energy required to sustain such an expedited growth. We should have, after all the data had been recorded, uprooted the plants very carefully by digging them out individually so we could inspect the root systems. We know that the root system is the main way plants collect the required nutrients, so in theory, an increase in size would require an increase in the root system, or in the root systems ability to harvest nutrients from the soil around it. After doing some research I found this to be correct. That in fact one of the major growths of the pea plant when treated with GA3 was the root system. " The final major variation noticed in the results was the incredible difference in root length between the two groups…. no doubt that the roots of the experimental group reached a length at least three-fold longer than that of the control group."

In general, our original hypothesis that GA3 would positively increase overall plant growth and development was supported. This is mostly due to the dramatic increase in cell length, internode length and the obvious height increase, as well as the data found regarding the lengthening of the root systems in the plants treated with Gibberellic Acid.

However I still felt that even with this data we can't rule out the possibility that there are adverse side effects to the application on Gibberellic Acid. Repeated experiments with more accurate data recording, over a longer period of time would be required to correctly reject the idea of a negative response to GA3.