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Seedless fruit and methods of Parthenocarpy

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Abstract

The process of parthenocarpy involves the use of phytohormones to change the growth process of a plant's fruits and results in fruits that are generally seedless. In this project, three phytohormones commonly used in parthenocarpy were tested for their effects on the size and quantity of the produced fruits. The procedures were designed to study patterns of each hormone's effect at different amounts and the effects of cross-pollination on fruit size. *Brassica rapa* plants were grown in a uniform manner and the male organs were removed upon flowering. After the plants were emasculated, a number of pistils were exposed to phytohormone in varying amounts. It was predicted that if *Brassica rapa* are grown in a controlled environment, plants treated with a greater amount of natural and synthetic auxin phytohormones will produce larger fruits as compared to plants treated with less phytohormone. It was also hypothesized that plants that cross-fertilize will produce a greater quantity of fruits and more seeds as compared to plants treated with phytohormone. The data shows that greater exposure to hormones generally results in larger fruits, where as all of the hormone induced fruits are smaller than fruits produced by cross-pollination.

Introduction

Seedless fruits are produced through the processes of either stenospermocarpy or parthenocarpy, and they are a more commercially valuable product than fruits with seeds. Stenospermocarpy is the production of fruit by fertilization of the embryo followed by abortion of the embryo prior to fruit formation. The fruit will form with a slightly smaller size; this is due to the absence of hormones that are released from the seed after developing into a fruit. Parthenocarpy is different in that there is never fertilization of the ovule. The induction of fruit production in this experiment is caused by artificial parthenocarpy, which involves the stimulation of the growth of a fruit using both natural and artificial plant hormones. In this project, *Brassica rapa* are exposed to 3 different plant growth hormones to determine whether or not these hormones will yield virgin fruits, and how different hormones at different amounts will affect the production of parthenocarpic fruit.

Three types of auxin-like plant hormones, were used in the procedure to induce the production of fruit without fertilization. They are known as indoleacetic acid (IAA), indolebutyric acid (IBA), and naphthalene acetic acid (NAA). IAA is a natural phytohormone that is produced in very low amounts in plants. When this hormone is applied to plants, it may cause enhanced growth. This hormone has been proven to be the most important auxin in most plants. IBA is also a naturally occurring phytohormone, but has been shown to be less potent than IAA. The last hormone used in this experiment was NAA, which is different from the other two hormones being utilized, because it is synthetic. NAA is inexpensive, and was created as a convenient hormone for use by gardeners. NAA has a similar structure to that of IAA, but is less effective because it is not a naturally occurring hormone. All 3 types of hormones were used on the *Brassica rapa* in varying amounts and the effects were analyzed. A previous study, done by Dr. Schadler used a similar procedure; however, in their study, they did not vary the amount of hormone used. In the current study, we examined the effect of varying the amount of each hormone used in hormone induced parthenocarpy. Our work is more consistent with King's experiments in that they used phytohormone with a similar method of application and variable concentrations.

It is anticipated that if the *Brassica rapa* plants are all grown under uniform conditions throughout the length of the project, then the cross pollinated plants will produce fruits the fastest, and contain seeds, while IAA and IBA treated plants will produce fruits without seeds faster than NAA plants. Also, the plants that are treated with the greater amount of hormone will grow faster, and produce larger fruit. This hypothesis is derived from knowledge of natural reproduction. Since the plants are grown uniformly and without any genetic/chemical variations, the cross pollinated plants

will produce fruits as they would naturally. On the other hand, the auxins would not produce the same results. Since it is the hormone that triggers the fruit formation during the absence of the male gamete, sexual reproduction does not occur. Although the ovules form into fruit as usual, there is no fertilization of the ovules. The reason that IAA and IBA may develop fruit faster is because they are natural hormones, whereas NAA is a synthetic hormone.

Materials and Methods

Growing containers were prepared using potting soil with 1:2 Vermiculite and fertilizer pellets. Two *Brassica rapa* seeds were then added to each container. Containers were placed in continuous artificial light and organized into 5 rows of 3. Artificial light is created using fluorescent light bulbs, which remain on throughout the entire period of the experiment (Figure 1.). Using the Standard Stock *Brassica rapa*, the flowering of each plant took approximately two weeks from planting. Fifteen plants used in this experiment: 3 were cross-pollinated, 3 were exposed to IAA, 3 were exposed to IBA, 3 were exposed to NAA, and 3 were given no hormone for use as controls. Once all of the plants have flowered, and the buds have opened, the parthenocarpy procedure must be initiated: in the experimental hormone groups the male organs are removed, and the petals and sepals discarded (Figure 2). The emasculating of the reproductive organs ensures that there will be no pollination. The parthenocarpy procedure was not performed on the pollination group. A hormone/lanolin preparation was made in the following concentrations: IAA (5000 ppm), IBA (5000 ppm), and NAA (5000 ppm). A sterile wooden toothpick was used to dab the premixed hormone/lanolin onto the stigma. 0.5 mg of pre-prepared hormone/lanolin was applied onto every stigma of one container of the corresponding group of plants. 1.0 mg of hormone/lanolin was applied to the corresponding groups of plants. Pure lanolin, without hormone, was applied to the control group of plants. The purpose of the lanolin is to prevent hormones or pollen produced by the other plants from altering the results of the control group. The two pollination group plants were cross pollinated using a separate bee-stick for each. The growth of each group was observed over time, and any significant difference in the rate of fruit growth was recorded. When the fruits were large enough to examine for seeds, all fruits were removed from the plant and analyzed when dry.

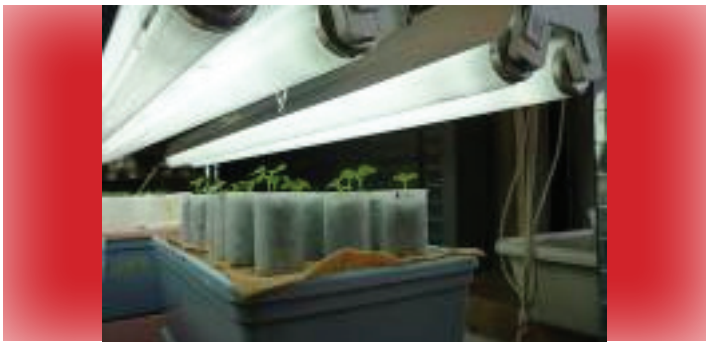

Figure 1. An ideal setup is shown. The light source is constantly on and the plants are setup in such a way that they receive light evenly.

Figure 2. *Brassica rapa* have been completely removed of anthers, filaments, petals, and sepals. The groups of plants are in the process of being treated with their corresponding hormones.

Results

The results of this experiment show a direct correlation between the use of each auxin, the rate of fruit growth, and length of resulting fruits. The results of all trials are shown in Tables 1 and 2. The statistical analysis of all treatments is shown in Table 3 (a value of 0 is not included, as this means no fruit was produced). Based on the data, cross-pollinated *Brassica rapa* produces the longest fruit and bears seeds within the seed pods. IBA produces the second longest fruit, NAA produces the third longest fruit, and IAA produces the shortest fruit (Table 3). No seeds were found in the IAA, IBA, or the NAA treated fruits. The control group produced no fruit whatsoever.

Table 1. Seed Pod Length of Cross Fertilization Group in Centimeters

Treatment	1	2	3	4	5	6	7	8	9	10
Fertilized	4.7	4.3	4.3	3.9	2.3	2.2	2.2	2.2	2.1	2.1

Table 2. Seed Pod Length (centimeters):

	0.5 mg Treatments						1.0 mg Treatments				
Treatment	1	2	3	4	5	Treatment	1	2	3	4	5
IBA	2.2	1.9	1.9	0	0	IBA	3.2	3.1	2.9	2.5	0
NAA	2.5	0	0	0	0	NAA	2.65	2.6	2.1	2.0	0
IAA	2.1	1.6	0	0	0	IAA	2.1	2.1	1.8	1.6	0

Table 3. Statistical Comparison:

	Quantity of Fruits on Average				Size of Fruits on Average		
Treatment	1.0mg	0.5mg	Total	Treatment	1.0mg	0.5mg	Total
IBA	4	3	7	IBA	2.925	2.0	2.529
NAA	4	1	5	NAA	2.338	2.5	2.37
IAA	4	2	6	IAA	1.9	1.85	1.88
Fertized	-	-	10	Fertized	-	-	3.03

Discussion

The results from the previous experiments by King and Schadler show both major consistencies and inconsistencies with our data. In Schadler's experiment, the data parallels that of this experiment in respect to the length and seed presence of cross-pollinated untreated *Brassica rapa* and phytohormone treated *Brassica rapa*. King's study used the tomato plant, *Lycopersicum esculentum* in his experiments and his data showed that hormone induced parthenocarpy tomato fruits were the same size as his cross-pollination fruit. In our study we have shown that treated *Brassica rapa* fruits are smaller; this data suggests that not all angiosperms show the same effects after being treated with IAA, IBA, or NAA. Our data on the growth of fruit and presence of seeds between treated and untreated plants is consistent with Schadler's data, who also used *Brassica rapa*, but inconsistent in terms of which hormones were more or less effective. In this study, the IBA treated plants produced the largest and fasting growing fruit, followed by NAA treated plants, which grew faster and larger than the IAA treatment group. This result differs from Schadler's results in that in his experiments, the IAA grew less than NAA, and more than IBA. However, the IAA group in Schadler's study was based on only a 0.5 mg treatment, not on a 1.0 mg treatment, as was tested in our experiment. As well as a lower production rate, our experiment seemed to have a much larger gap in terms of size comparisons between the cross-fertilized plants' fruit and the treated plants' fruit. Additionally, this experiment utilized a smaller number of plants, giving its results weaker statistical power. If our results are flawed it could be due to one of the following reasons: too few *Brassica rapa*, unstable testing environment, or human error. On the other hand, if the data collected in this study is in fact correct, this could mean that previous studies contain flawed results, or that there is some unknown variable which would render all three studies to be consistent with each other.

References

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