Learning Environmental Sustainability by Experiments: Using Chitosan in Plant Growth

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Abstract

Especially in recent years, due to climate change, the globally significant increase in the food demand, and particularly the dangerous consumption of farmlands, the wish for harmless as well as environmentally friendly food commodities have initiated the search for an alternative biological method that can meet this demand. Chitosan, obtained from chitin, is a natural biomaterial found to be effective in agricultural use in increasing the crop productivity and showing sufficient resistance against pathogens without the need for hazardous chemical substances. Chitin is found in various organisms, such as fungi, marine and freshwater sponges as well as in the exoskeleton of many invertebrates, and can be extracted easily from the waste shells of crabs and shrimps produced by the Seafood industry. Moreover, this natural polymer is the second largest renewable carbon source, making the production of chitosan an economic interest. Chitosan based materials are being investigated by researchers to be used in agricultural purposes. In the experiment, we tested effect of chitosan to germination period and growth rate of two different wheats, Triticum aestivum and Triticum monococcum. It was observed that seeds soaked in chitosan germinated earlier than the seeds soaked in water. As AP Biology students, we have been learning plant growth, organic molecules, and human impact on ecosystems. The scientific skills that we've gained through the year helped us expressing ourselves in different areas such as doing research and projects beyond the exams. Environmental sustainability and biodiversity protection are the biggest challenges for the future. With this project, we tried to see the effects of alternative methods in plant growth by using an organic waste derivative- chitosan and the importance of sustainable agricultural methods for the future of humanity.

Keywords: *chitin, chitosan, wheat.*

1. Introduction

Environmental issues around the world are getting the most important concerns of the twenty-first century. The main problems include global warming, climate change, shortage in water supplies, pollution, desertification, decrease in biodiversity and depletion of natural sources including soil. The increase in world population and people's lifestyles forces to reach the Earth's carrying capacity. For a sustainable future, people should learn to use world's sources efficiently and to peace with the nature by increasing their environmental awareness and changing their lifestyles. Especially in recent years, the food demand significantly increases globally with the increasing world population. Unfortunately, soil fertility decreases at the same time with intensive cultivation, insufficient replacement of nutrients, and deforestation. Besides wind and soil erosion cause to lose soil nutrients from ecosystems. In order to increase the crop yield to sustain the world population, more fertilizers are required. It is estimated that 70% of plant nutrients will be obtained from fertilizers by the year of 2020. So, fertilizers seem to be crucial for the future of food production although excessive use of fertilizers come across with variety of environmental concerns including groundwater contamination, eutrophication of fresh water sources, and algal blooms in coastal water that make the water unsafe. [8]

All the potential hazards of fertilizer use, the dangerous consumption of farmlands, the wish for harmless as well as environmentally friendly food commodities have initiated the search for an alternative biological method that can meet this demand. The alternatives which are being investigated to avoid chemical use to increase crop yield are bio-polymer materials. Chitosan, obtained from chitin, is a natural biomaterial found to be effective in agricultural use in increasing the crop productivity and showing sufficient resistance against pathogens without the need for hazardous chemical substances. Chitin is found in various organisms, such as fungi, marine and freshwater sponges as well as in the exoskeleton of many invertebrates, and can be extracted easily from the waste shells of crabs and shrimps produced by the Seafood industry. Moreover, this natural polymer is the second largest renewable carbon source, making the production of chitosan an economic interest. Chitosan based materials are being investigated by researchers to be used in agricultural purposes. [4]

In this context, the chitosan was used as an alternative bio-fertilizer in wheat growth to see the sustainable agricultural methods for the future of humanity.

2. Materials and Method

The material included two wheat types, *Triticum aestivum* and *Triticum monococcum.* Thirthy whaet seeds of each type were treated with three different set up. The seeds of Treatment 1 which is control group, were soaked with water for 24 hours. Then they were planted and applied with water only. Treatment 2 seeds were soaked with water for same duration and they were applied with 1% chitosan solution after planted. Seeds of Treatment 3 were soaked and applied with 1% chitosan solution. The numbers of the germinated plants were counted daily for three days. The wheat sprouts' average length was measured at the end of twentieth day.

Figure 1.

Seeds were soaked in water and chitosan solutions

Figure 2. Planted seeds and sprouts

1% chitosan solution was prepared as follows. 1 g of chitosan (Aldrich, Chitosan-high molecular weight) was poured by 100 mL of 1% acetic acid solution and stirred until dissolved. Solution's initial pH was 4.3. Then it's pH was adjusted to 6 by adding 1% NaOH solution. In order to obtain chitosan stock solution was diluted 500 times.

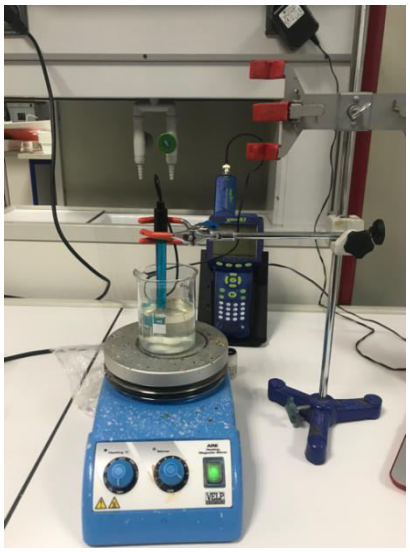

Figure 3. Chitosan solution preparation

The experiment was tested three times and average scores were counted.

3. Results and Discussion

Table 1: Percentage of germinated seeds

	DAY 1		DAY 2		DAY 3	
EXPERIMENT GROUP	*T. aestivum*	*T. monococcum*	*T. aestivum*	*T. monococcum*	*T. aestivum*	*T. monococcum*
1	56.7%	26.7%	76.7%	30%	80%	46.6%
2	26.7%	23.3%	60%	40%	83.3%	53.3%
3	50%	15%	86.7%	33.3%	93.3%	56.6%

Table 2: Average length of wheat sprouts by 20 days

EXPERIMENT GROUP	*T. aestivum*	*T.monococcum*
1	15.7 cm	15.1 cm
2	17.1 cm	15.9 cm
3	17.7 cm	16.3 cm

The research results indicated that soaking and watering the wheat seeds in 1% chitosan solution had a stimulating effect on the percentage of germinated seeds as well as the average height of the wheat sprouts. While both types of wheat were positively affected by the application of chitosan, it was observed that this natural fertilizer was significantly more beneficial for the cultivation *Triticum aestivum* in all of the different applications. On the basis of statistical analysis, it was found that the chitosan treated *Triticum aestivum* was recorded to have the tallest average height of 17.7cm and *Triticum monococcum* followed with 16.3cm which was 2 cm and 1.2 cm taller in comparison with the control group, respectively. Additionally, it was recorded that *Triticum aestivum* germinated 43.3% and *Triticum monococcum* sprouted 41.6% more than the control treatment.

A similar positive influence was observed in the second treatment when the seeds were soaked in water but were applied with 1% chitosan solution after they were planted. The sprouts of *Triticum aestivum* were recorded to have an average height that was 1.4cm taller than the control group while *Triticum monococcum* was only 0.7cm higher. Furthermore, at the end of the experiment, the results indicated that 83.3% of *Triticum aestivum* seeds had germinated, which was 3.3% more than the first experimental group. Similarly, it was observed *Triticum monococcum* germinated 6.7% more than the control group.

The results showed that the application of chitosan was most beneficial and effective when the seeds were both soaked in and watered with the 1% chitosan solution after they were planted. In the second treatment, the seeds were soaked in water which resulted in them to have a shorter average height and a less percentage of germination in comparison to the seeds in the third treatment group. *Triticum aestivum* was measured to be 17.1cm which was 0.6cm shorter than the average height of the same wheat when it received a complete application of the chitosan solution. In a like manner, *Triticum monococcum* was also recorded to have a shorter average length in the second treatment as it was 0.4 cm shorter than the third treatment. Moreover, *Triticum aestivum*, as well as *Triticum monococcum*, germinated 10% and 3.3% less in the second experimental group in comparison to the third, respectively.

In this study, the effect of chitosan on the seed germination and height was found to be significantly beneficial on both types of wheat that were tested. Both seeds showed a higher germination ratio and a taller average height when they were both soaked in and watered with the 1% chitosan solution in comparison with the other two experimental groups.

4. Conclusion

The results showed that chitosan affected positively the cultivation of *Triticum aestivum*, and *Triticum monococcum*. The seeds soaked in and watered with chitosan were observed to have the greatest germination percentage and the greatest length of wheat sprouts. In a world getting more and more crowded with increasing demand for food, biological compounds that enhance crop growth is an extensive area of interest. Chemical fertilizers that are used in agriculture for this purpose are not favored due to their unhealthy effects on the environment as well as to human beings. Polluting the waters, depleting essential minerals, acidifying the soils, and contributing to global warming, chemical fertilizers disrupt food chains and the balance of ecosystems leading to detrimental results that are hard to reverse. Chitosan, a unique biological compound, offers a possible solution to the increasing demand for food by promoting plant growth, managing plant diseases, and being environment-friendly. Easily obtained from wastes in large quantities at a low price, chitosan is a promising alternative for hazardous chemical fertilizers in agriculture by contributing to an eco-friendlier and more sustainable world.

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