The effect of chitosan radiation of spinach plant based on agronomy characteristics on hydroponics floating system

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Abstract. Oligo chitosan is chitosan with a low molecular weight that derived from the extraction of shrimp shells which are irradiated using gamma radiation. The growth hormone content in oligo chitosan is able to increase the growth and production of crop cultivation on conventional agriculture. The oligo chitosan application is generally sprayed on plants, especially on the leaves and stems of plants. This research aims to find out the most influential method of oligo chitosan application if it’s applied to the cultivation of hydroponic floating raft systems, also to explain the effect of the application of oligo chitosan on the growth and production of spinach plants in the cultivation of the hydroponic system. There are three different ways of treatments in this study applying oligo chitosan to floating raft hydroponic system, which are sprayed out on plants (P1), dissolved in hydroponic nutrient solutions (P2), a combination of both (P3), and accompanied by controls. The oligo chitosan concentration given was 100 ppm in each treatment. The method used in this research is a descriptive comparative method, using primary data which is then analyzed quantitatively by using graphs and T-test. The results of this research were the application of oligo chitosan influences the growth and production of spinach plants to the hydroponic floating raft system. The treatment of oligo chitosan dissolution in the hydroponic nutrient solution (P2) was the treatment that gave the best influence to the height of the plant, number of leaves, and the amount of the yield of spinach compared to the other treatments. The width of the leaf does not have a significant effect on each treatment given.

1. Introduction

Indonesia is one of the countries that have a relatively large population growth rate. The amount of population in Indonesia increases each year, as an example in 2015 the population in Indonesia is 255,481,686 people, in 2016 the population becomes 258,704,986 people, and in the following year that is 2017, the population increased more to 261,890,872 people [1]. The increasing population will lead to higher food needs. However, the increasing population also causes agricultural land continues to decline due to land conversion, especially in urban areas as for industrial development, such as the construction of shopping centers, road construction, and residential areas. In 2014 there was a land conversion of agricultural land to non-agricultural from 50 thousand to 100 thousand hectares [2]. The massive development in urban areas has led to the displacement of green open spaces. The loss of green open space greatly affects the stability of the environmental ecosystem, while increasing pollution which can adversely affect the health of urban communities. Based on these problems, the need for a solution to be able to farm in narrow areas such as in urban areas in order to continue to producing food needs in the agriculture sector. One of these concepts is the concept of urban farming.

Urban farming is the concept of moving conventional agriculture to urban agriculture, the difference is on the people and the planting media. The concept of urban farming offers a solution by creating green
open land in the middle of city buildings. There are various types of urban farming planting systems, one of them is hydroponics. Hydroponics is a method of farming without using soil but by using nutritious water as its main element. The development of hydroponics in Indonesia is quite perspective because of the market demand for quality harvests continues to increase, does not depend on environmental and climatic conditions, competition for land use, and the absence of land degradation problems [5].

Another solution that can be done to fulfill the food needs along with increasing population, is to increase the crop production. One of the technology in order to increase the production is by adding growth regulators (ZPT) to crop cultivation. ZPT is an organic non-nutrient compound (nutrient) that is active in low concentrations to be able to stimulate, inhibit or change the plant growth and development quantitatively and qualitatively [9]. One of the ZPT products that can be utilized is chitosan irradiation.

Irradiated chitosan (oligo chitosan) is a low molecular weight chitosan derived from the extraction of shrimp shells that irradiated by using gamma-ray radiation. Oligo Chitosan contains several growth hormones including Indol Acetic Acid (IAA), kinetin, zeatin, gibberellins [4]. The content of the growth hormone is able to increase plant growth and production. The development and field towards the use of oligo chitosan as a promoter of plant growth have been carried out on several plants. For example on spinach plants which showed that the application of oligo chitosan by seed immersion and three times of leaf spraying significantly improved spinach yield compared to controls [6].

Based on the solutions described, it is necessary to develop information and technological innovations in the use of oligo chitosan for the hydroponic system by conducting research on the effects of chitosan application on the growth and production of plants grown through the floating raft hydroponic system.

2. Methodology
This research was conducted in February 2019 until May 2019. The place of this research was conducted at the Center for Isotope and Radiation Application of the National Nuclear Energy Agency (PAIR BATAN), Lebak Bulus, South Jakarta. The observed plant in this research were spinach plants with several parameters measuring plant growth such as plant height, leaf length, leaf width, number of leaves, and wet weight. The chitosan that used is oligo chitosan or irradiated chitosan called Fitosan that produced by the National Nuclear Energy Agency (Batam).

The research method used in this research is descriptive-analytical method through field observations. The treatments in this research consisted of 4 treatments including control (P0) no oligo chitosan is given, treatment 1 (P1) is spraying 100 ppm chitosan oligo on the leaves and the stem of spinach plants, treatment 2 (P2) is dissolving the 100 ppm oligo chitosan into the AB Mix nutrient solution, treatment 3 (P3) is a combination of spraying 100 ppm oligo chitosan on the leaves and the stem of spinach plants and dissolving 100 ppm oligo chitosan into the AB Mix nutrient solution. The given of oligo chitosan by dissolving the nutrient solution is only once, which is at the time of making the hydroponic nutrient solution, while the given of oligo chitosan by spraying is done once a week starting when the spinach plants begin transplanting to the floating hydroponic installation during the growth time until the harvest time.

3. Result and Discussion

| Treatment | Plant height (cm) | Number of Leaves | Leaf Length (cm) | Leaf Width (cm) | Wet Weight (g) |
|-----------|------------------|------------------|-----------------|----------------|----------------|
| P0        | 20,39            | 13               | 7,80            | 6,80           | 21,73          |
| P1        | 20,42            | 13               | 8,09            | 6,90           | 22,12          |
| P2        | 23,15            | 15               | 7,81            | 6,81           | 31,83          |
| P3        | 21,50            | 14               | 7,83            | 6,79           | 29,98          |
3.1 Plant height

Table 2. The Measurement of Plant Height

| Treatment | 3 HST | 6 HST | 9 HST | 12 HST | 15 HST | 18 HST | 21 HST | 24 HST | 27 HST |
|-----------|-------|-------|-------|--------|--------|--------|--------|--------|--------|
| P₀        | 1.73  | 1.84  | 1.96  | 2.25   | 2.63   | 3.55   | 5.56   | 8.83   | 14.09  |
| P₁        | 1.70  | 1.88  | 2.01  | 2.34   | 2.70   | 3.69   | 5.87   | 9.24   | 14.34  |
| P₂        | 1.70  | 1.94  | 2.08  | 2.37   | 2.88   | 3.93   | 6.96   | 10.71  | 15.90  |
| P₃        | 1.71  | 1.89  | 2.06  | 2.31   | 2.78   | 3.84   | 5.75   | 8.90   | 14.38  |

The lowest plant height in this research with an average of 20.39 cm was obtained from the P₀ treatment and the highest plants with an average of 23.15 cm obtained from the P₂ treatment. The height measurement at the time of growth spinach plants ranging from 15 HST to 27 HST also showed that P₂ has a superior plant height, then following by plant height at P₃.

![Figure 1. The Chart of Plant Height](image)

Indol Acetic Acid (IAA) and gibralin (GA) are growth hormones that contain on the oligo chitosan. IAA hormone can stimulate the growth of stem length and apical dominance also GA hormone which can stimulate plant height growth.

3.2 Number of Leaves

Table 3. The Measurement of Number of Leaves

| Treatment | 3 HST | 6 HST | 9 HST | 12 HST | 15 HST | 18 HST | 21 HST | 24 HST | 27 HST |
|-----------|-------|-------|-------|--------|--------|--------|--------|--------|--------|
| P₀        | 5     | 5     | 6     | 7      | 8      | 9      | 10     | 11     | 12     |
| P₁        | 4     | 5     | 6     | 7      | 8      | 9      | 10     | 11     | 12     |
| P₂        | 4     | 5     | 6     | 7      | 8      | 9      | 11     | 12     | 14     |
| P₃        | 4     | 5     | 6     | 7      | 8      | 9      | 10     | 12     | 13     |
The highest number of leaves at harvest (30 HST) was in the P2 treatment while the fewest number of leaves was in the P0 and P1 treatments. The average number of leaves at harvest in the P2 treatment is 15 strands, while in the treatments P0, P1, and P3 have an average number of leaves consecutively, 13, 13, and 14 leave strands.

![Figure 2. The Chart of Number of Leaves](image)

The difference in the number of leaves can be clearly seen at the age of 21 HST spinach plants until the harvest period. Cytokinin hormone will stimulate the cell division in plants and these cells will develop into buds, branches, and leaves [3].

### 3.3 Leaf Length

The measurement result of the leaf length in spinach plants showed that the P1 treatment had the highest average leaf length compared to other treatments. The average yield of leaves in the treatment P1 is 8.09 cm, while the treatments P0, P2, and P3 have an average number of leaves consecutively 7.80 cm, 7.81 cm and 7.83 cm.

![Figure 3. The Chart of Leaf Length](image)

### 3.4 Leaf Width

The measurement result of leaf width in spinach plants showed that the P1 treatment is the treatment with the highest average leaf width value compared to other treatments. The average leaf width in the
P1 treatment is 6.90 cm, whereas for treatments P0, P2 and P3 had an average number of leaves consecutively 6.80 cm, 6.81 cm and 6.79 cm.

![Leaf Width Chart](image)

**Figure 4.** The Chart of Leaf Width

Leaf length and width are influenced by the activity of the cytokinin hormone [7]. The increasing activity of cytokinin hormone will enlarge the leaf surface area or the length and width of the leaf.

### 3.5 Wet Weight

The measurement results of wet weight showed that P2 treatment is a treatment that shows the highest results than the other treatments. The average wet weight of spinach plants in P2 treatment is 31.8373 g. The wet weight of spinach plants after P2 treatment is in P3 treatment with the average of the wet weight of the spinach plants is 29.9 g. The next results for the P1 and P0 treatments consecutively 22.12 g and 21.73 g. These effects happened due to the giberalin hormone contained in oligo chitosan.

![Wet Weight Chart](image)

**Figure 5.** The Chart of Wet Weight

Giberalin in plants affects cell enlargement (increasing size) and cell division (an increasing number). The enlargement of these cells affects the new cells becoming larger than the main cell [8]. This increased of the cell size produce the increasing of the size of tissues, organs, and ultimately increases the plant parts as a whole as well as on the weight of the plant.

### 4. Conclusion
The conclusion that can be taken from this research is that the application of oligo chitosan has an effect on the growth of spinach plants that are cultivated with floating raft hydroponic systems in each treatment compared with control treatment. The P2 treatment or the dissolving oligo chitosan treatment into a hydroponic nutrient solution gives a higher effect based on the graph compared to other treatments and gives a significant statistical analysis of plant height, number of leaves, and wet weight of the plant. The P1 treatment or oligo chitosan spraying treatment on the leaves and stems of spinach plants gives a higher effect based on the graph on the length and width parameters of the leaves.

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