The combination of irradiation biofertilizer of rhizosphere microbes consortium inoculant (IMR) and inorganic fertilizer on the growth of kale in a floating raft hydroponic system

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Abstract. A hydroponic floating system is a working system where a plant is placed in a floating net pot on the surface of water. In hydroponic systems, the content of inorganic fertilizers contained in the media is the main source of nutrients for plants. The use of biological fertilizers is expected to reduce the dose of inorganic fertilizers applied to hydroponic systems. The main objective of this study was to obtain a combination of inorganic fertilizers with Inoculant of Rhizosphere Microbial Consortium (IMR) and biofertilizer which has the most influence on the N content, growth and production of kale plant. There are five different treatments on hydroponic floating system viz 100% inorganic fertilizer (control), 100% inorganic fertilizer + IMR (Pa), 75% inorganic fertilizer + IMR (Pb), 50% inorganic fertilizer + IMR (Pc), and 25% + IMR (Pd), where 100% inorganic fertilizer is equivalent to 10 mL / L and the amount of IMR given to each treatment was 10 ml/L. The method used in this research was descriptive comparative method, using primary data which is then analysed quantitatively such as using graphs, and T-test. The results of the research showed that giving a combination of 100% biological fertilizer and 50% inorganic fertilizer, can reduce the use of inorganic fertilizers by 50%, and gave the best and significant influence on plant height 34.41 cm, leaves as much as 30 strands, root length 24.27 cm, and the harvest weight 80.97 grams. The combination of 100% biological fertilizer and 50% inorganic fertilizer does not give a combination of N content of the kale plant.

1. Introduction

The need for food is increasing along with the increase in population, but this is not balanced with the availability of agricultural land which is actually narrowing. The increasing need for food crops is not only for carbohydrate-based food crops but also for horticultural crops, such as vegetables and fruits. Today, public awareness of the importance of health is increasing, thus encouraging an increase in demand for vegetable commodities.

One example of vegetables that are popular and widely consumed by Indonesian people is kale. According to Muchadi [1], kale contains 29.13% protein, 5.4% fat, and 6.71% carbohydrate. Based on the Central Statistics Agency (BPS) [2] the total consumption of kale in 2015 was 1132.77 kg and increased in 2016 by 1232.05 kg. Kale production at the farm level is still very low at an average of 8-10 tons/hectare when compared to the potential yield of water spinach plants which can reach approximately 20-35 tons/hectare [3]. This is because the cultivation technology applied is still
traditional. For this reason, it is necessary to use technology to increase kale production to meet market demand.

The existence of land is very important in supporting agricultural production activities [4]. The development of industry quickly and broadly can lead to the displacement of agricultural land, especially in urban areas. One alternative that can be done to overcome these conditions is hydroponic technology. Hydroponics is a method of farming without using soil as its main medium but instead uses water. Hydroponics can also be said as a cultivation technology where the need for nutrients is given together with water into the planting medium [5].

The hydroponic planting system that is often used is to use a floating raft system. Floating raft hydroponics is a way of cultivating plants in hydroponics that is quite easy to do, then when viewed from an economic point of view this floating raft method does not require a lot of costs.

The main component that becomes an important factor in the cultivation of a hydroponic system is the provision of nutrient solutions. Plant nutrient requirements for hydroponic systems are basically provided in the form of nutrient solutions. Nutrition in hydroponic plants that is commonly used is the AB mix nutrient solution. AB mix is an inorganic fertilizer made from chemicals that can be used as nutrients in hydroponic plants. The use of fertilizers made from chemicals always requires quite expensive costs and leaves chemical residues both on land and on agricultural products produced so that if consumed can endanger human health such as affecting liver function, kidneys, nervous system and the more severe is causing cancer [6]. The addition of biological fertilizers which are active ingredients can be a solution in reducing the use of inorganic fertilizers. The use of biological fertilizers cannot be applied 100% independently without the addition of inorganic fertilizers because the microbial content contained requires the supply of nutrients for life from the inorganic fertilizer (nutrient solution) supplied.

Biofertilizers are environmentally friendly fertilizers by providing nutrients to plants continuously and can play a dual role by producing phytohormone that is beneficial to plants. The addition of biological fertilizer is expected to substitute inorganic fertilizer so that the use of inorganic fertilizer can be reduced. Biofertilizers contain microbial inoculants (both single and consortium).

The primary objective of this study was to obtain a combination of inorganic fertilizers with Inoculant of Rhizosphere Microbial Consortium and biofertilizer which has the most influence on the N content, growth and production of kale plant.

2. Methodology
This research was conducted at the National Nuclear Energy Agency from February 1 to May 15, 2019. Plant seeds used were kale seeds LP-1. Inorganic fertilizers used are special formulations that are adapted to kale plants. The biofertilizer used is the Rhizosphere microbes consortium Inoculant (IMR) produced by the National Nuclear Energy Agency Environmental Laboratory, consisting of Azotobacter and Bacillus circullan isolates.

The research method was conducted analytically using a T-test consisting of 5 treatments namely 100% inorganic fertilizer control, 100% inorganic fertilizer + IMR, 75% inorganic fertilizer + IMR, 50% inorganic fertilizer + IMR, and 25% inorganic fertilizer + IMR. The dose of 100% of the AB mix nutrient given is to dissolve a concentrated solution of 5 ml A and 5 ml B in 1 L of water, where the EC value obtained is in accordance with the requirements for kale plants which is 2.0 - 2.1 mS/cm. The addition of biological fertilizer in the treatment is 10 ml / L.

Plant nurseries are carried out at the National Nuclear Energy Agency's Wire House using cocopeat. Kale plants that are 6 days after seedling are transferred to rockwool media to be incorporated into the floating raft hydroponic installation. The application of inorganic fertilizers and IMR is carried out once when the seeds are transferred to a hydroponic installation that already contains nutrients (inorganic fertilizers + IMR) as a growth medium. At the age of 2 weeks after planting, kale has begun to be harvested.

The main parameters studied and measured in this study were plant height, number of leaves, and weight of yields and N content in kale. Plant height was measured from the base of the stem on the
surface of the planting medium to the tip of the highest leaf. Measurement of plant height was carried out once every three days to see in detail the changes in the height of the kale in each treatment given. The number of leaves was measured at the time of harvest by counting the number of fully formed leaves. The weight of the harvest was weighed on all parts of the plant including roots, stems and leaves. Analysis of N content was carried out on each sample of treated plants using the Kjeldhal method. N analysis was carried out at the Soil Fertility and Plant Nutrition Laboratory of the Faculty of Agriculture, Padjadjaran University.

3. Results and discussion
The provision of nutrient solutions with different doses affects the physiological conditions of kale. Overall, the plants given the microbial consortium showed better performance on the appearance of leaves, stems and roots. Based on the analysis of the uniformity of growth and production of kale, which includes the height of the kale, the number of leaves, the length of the roots and the weight of the yield, the criteria are very good (Table 1).

| Treatment | Plant height (cm) | Coefficient uniformity (%) | Wet weight |
|-----------|-------------------|----------------------------|------------|
| Control   | 3.02              | 5.97                       | 11.18      | 18.96      | 25.50      | 31.33      |
| Pa        | 3.09              | 5.83                       | 10.00      | 15.51      | 22.15      | 28.41      |
| Pb        | 3.00              | 6.80                       | 12.09      | 18.73      | 25.82      | 31.97      |
| Pc        | 3.05              | 6.60                       | 11.55      | 19.38      | 27.11      | 34.41      |
| Pd        | 3.07              | 6.28                       | 9.98       | 15.03      | 21.65      | 28.32      |

3.1. Plant height
The results of observations on plant height with time intervals of 1 -16 days after planting (DAP) are shown in table 2.

| Treatment | 1 DAP | 4 DAP | 7 DAP | 10 DAP | 13 DAP | 16 DAP |
|-----------|-------|-------|-------|--------|--------|--------|
| Control   | 3.02  | 5.97  | 11.18 | 18.96  | 25.50  | 31.33  |
| Pa        | 3.09  | 5.83  | 10.00 | 15.51  | 22.15  | 28.41  |
| Pb        | 3.00  | 6.80  | 12.09 | 18.73  | 25.82  | 31.97  |
| Pc        | 3.05  | 6.60  | 11.55 | 19.38  | 27.11  | 34.41  |
| Pd        | 3.07  | 6.28  | 9.98  | 15.03  | 21.65  | 28.32  |

The lowest plant height with an average of 28.32 cm was obtained by Pd with a combination of 25% inorganic fertilizer + IMR and the highest plants with an average of 34.41 cm were obtained from Pc with a combination of 50% inorganic fertilizer + IMR. Data on plant height at 16 days after planting is shown in Figure 1.
The best combination of liquid inorganic fertilizer and biological fertilizer on plant height parameters is in the treatment of 50% inorganic fertilizer + IMR. The average height of the treatment plants at harvest (16 DAP) is 18.57 cm. In this experiment, the application of biological fertilizer can help increase plant growth. According to Wilujeng, et al. [7] states that the activities of various microorganisms in biological fertilizers produce growth hormones such as auxin, gibberellins, and cytokines that can stimulate plant growth. The combination of 50% inorganic fertilizer nutrient solution (AB mix) + biological fertilizer (IMR) gave significantly different results compared to the control treatment with the difference in plant height being 9.83%.

3.2. Number of leaves
The results of observations on leaves number with time intervals of 1 -16 days after planting (DAP) are shown in Table 3.

| Treatment | 1 DAP | 4 DAP | 7 DAP | 10 DAP | 13 DAP | 16 DAP |
|-----------|-------|-------|-------|--------|--------|--------|
| Control   | 12.54 | 14.43 | 16.56 | 20.79  | 24.39  | 28.30  |
| P_a       | 12.78 | 14.46 | 16.82 | 20.66  | 23.98  | 27.56  |
| P_b       | 12.92 | 16.22 | 18.60 | 21.58  | 25.01  | 28.52  |
| P_c       | 12.88 | 15.92 | 18.44 | 22.68  | 26.69  | 30     |
| P_d       | 12.88 | 15.10 | 16.49 | 20.16  | 23.22  | 27.32  |

The lowest number of leaves is seen in Figure 2 with an average of 27.32 obtained by Pd with a combination of 25% inorganic fertilizer + IMR, while the highest number of strands obtained by Pc with a combination of 50% inorganic fertilizer + biological fertilizer with average the average number of leaves is 30 strands. Giving a combination of biological fertilizer and nutrient solutions began to appear to provide the greatest number of leaf strands in 10 days after planting to harvest. The combination of 50% inorganic fertilizer nutrient solution (AB mix) + biological fertilizer (IMR) gave significantly different results compared to the control treatment with the difference in the number of leaves being 6%. 

![Figure 1. The chart of plant height.](image)
Microbial content contained in IMR biofertilizers, especially Azotobacter which is applied to plants can increase nitrogen from the air through the activity of N-fixing bacteria and stimulate the process of preparing cell protoplasm in the process of photosynthesis, resulting in the process of forming new cells [8].

3.3. Wet weight
The average result of the high wet weight of plants in the combination treatment of 50% inorganic fertilizer + IMR is influenced by plant growth parameters, namely plant height and the number of leaves. 50% combination treatment of inorganic fertilizer + IMR has optimal growth compared to other treatments, thus giving the highest crop wet weight results that is equal to 80.97 grams. This is in accordance with the opinion of Djunaedi [9] which states that the production of a plant is usually influenced by its vegetative growth. If vegetative growth is good, then production will be good too.

This study shows that the treatment with a combination of 50% inorganic fertilizer + IMR is the best treatment for plants to absorb nutrients by utilizing the activity of Azotobacter bacteria in biological fertilizer in providing N nutrients for kale plants. This is supported by the opinion of Jaya [10] which states that plants will experience optimal growth if they have favorable conditions such as the availability of nutrients, minerals, and water. The combination of 50% inorganic fertilizer nutrient solution (AB mix) + biological fertilizer (IMR) gave significantly different results compared to the control treatment with the difference in plant wet weight being 3.15%.

3.4. N content
Element N is needed by plants to support growth. Plants will grow well if nutrients can meet the needs of the plants themselves. Based on plant analysis [11], the N concentration of Kale plant is said to be sufficient if the value reaches 2.5% -4.5%, not sufficient if the value is less than 2.5%, and if the N content of plants shows a number that is greater than 4.5%, the N content is high.
Table 4. Analysis of N content.

| Treatment | I    | II   | III  | Average (%) |
|-----------|------|------|------|--------------|
| control   | 4.83 | 4.59 | 5.01 | 4.81         |
| P_a       | 4.71 | 4.71 | 4.13 | 4.51         |
| P_b       | 5.00 | 4.78 | 5.13 | 4.97         |
| P_c       | 4.49 | 5.28 | 5.54 | 5.10         |
| P_d       | 4.77 | 4.35 | 4.36 | 4.49         |

Pa and Pd treatments the results were classified as sufficient in the amount of 4.51% and 4.49%, while for the control treatment, Pb, and Pc had a relatively high absorption of N, amounting to 4.81%, 4.97% and 5.10%. 50% combination treatment of inorganic fertilizer + IMR (Pc) is a treatment that contains the highest N content of 5.10%, this is because the bacteria contained in the IMR can survive in an environment that supports its development so that it is able to carry out its activities optimally. His activities include fixing N so that it is available to plants and producing phytohormones [12].

The results of the analysis using the T-test showed insignificant results between control with Pa, Pb, Pc, and Pd. The results obtained for the N content did not show significant results due to differences in the numbers obtained by each treatment having a thin difference in value, and the number of samples tested was too small.

The value of N content in each treatment still shows that plants grow well because viewed from the morphological structure of the plant does not show symptoms of N deficiency such as dwarf and yellowing leaves, but instead plants grow tall and leaves remain green.

4. Conclusions
The conclusion that can be drawn from this study is that the combination of 50% inorganic fertilizer nutrient solution (AB mix) + biological fertilizer (IMR) gave significantly different results compared to the control treatment with differences in plant height, the number of leaves and plant wet weight with each value respectively were 9.83%, 6% and 3.15% but did not give significant results on the uptake of N.

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