Response of kale (Brassica alboglabra L.) to various planting media and application of liquid inorganic nutrition in DWC (deep water culture) hydroponic systems

C W B Yanti¹, R Dermawan¹, N S Nafsi¹, Rafiuddin¹, A H Bahrun¹, A Mollah¹ and A Arafat²

¹Department of Agronomy, Faculty of Agriculture, Universitas Hasanuddin, Jl. Perintis Kemerdekaan KM 10, Makassar 90245, Indonesia
²Universitas Sulawesi Barat, Indonesia

E-mail: radesya09@gmail.com

Abstract. Kale is one type of leaf vegetables that has a high nutritional content and is in demand by the community, hence has a high selling value. The purpose of this study was to investigate and determine the effect of liquid inorganic nutrients and various planting media in the hydroponic system on the growth and production of kale (Brassica alboglabra L.) plants. The research was conducted from May to July 2017 in Manggala District, Makassar. The trial was set based on split plot design with two factors, liquid inorganic nutrition and various planting media. The main plot was nutrition which consisted of two types, namely AB-Mix nutrition and R-Mix nutrition. Subplot was planting medium with seven treatment combinations namely sand, burnt husk, cocopeat, combination of sand + burnt husk, sand + cocopeat, burnt husk + cocopeat, and sand + burnt husk + cocopeat. The results show that there was a significant interaction between the sand planting media and the R-Mix nutrition which produced the highest average of chlorophyll content (6.57 mg/g). The combination of burnt husk and cocopeat growing media gave yields that tended to be higher compared to other planting media. The R-Mix nutrient treatment gave a higher yield compared to other nutrients in the total chlorophyll observation (6.03 mg/g).

1. Introduction

One of the horticultural commodities that are classified as quite premium and has good prospects to become an export commodity is kale. Kale, Brassica alboglabra L., is a vegetable plant that comes from the cabbage family. In Indonesia, kale is also known as kailan. Kale plant is one type of vegetables that has a high nutritional content needed by the human body, such as protein, minerals, and vitamins. The nutritional content of kale with its delicious taste makes kale one of the agricultural products that are in demand by the community, therefore it has high potential and selling value.

Kale is a food that is rich in sources of dietary fiber with a high content of vitamins A, K, and C, and important minerals potassium (K), calcium (Ca), and magnesium (Mg). In addition, kale has significant amounts of carotene and folate [1]. A previous study showed that kale grown in South America has the potential to provide a number of important minerals and an adequate amount of LMWC, also known as "prebiotic carbohydrates", with low to moderate protein and energy levels [2].
Market demand for kale exports is quite large at 72 tons per year while Indonesia is unable to provide it. The low kale product is caused by several obstacles, among others, the lack of application of the five farming businesses, namely the use of superior varieties, fertilization, irrigation, pest and disease control, and available land. In addition, vegetable production has not been optimally developed in Indonesia due to the lack of application of good cultivation techniques, especially among farmers [3].

To overcome the constraints of the conventional cultivation, hydroponic techniques as a way for plant production with efficient resources management and quality food production [4]. Hydroponic techniques for kale can be done using the DWC (Deep Water Culture) system. The advantages that can be obtained from the cultivation technique of vegetables with hydroponics include controlled plant growth, production does not depend on the season, and the selling price of the commodity is higher than the price of the commodity traditionally cultivated on open land. In addition, vegetable cultivation techniques using a hydroponic system are an alternative to increase production on increasingly narrow land conditions as a result of the conversion of agricultural land into industrial and residential areas.

The hydroponic system is a very effective method of crop production [5]. This system was developed based on the reason that if plants are given optimal growth conditions, then the maximum potential for production can be achieved. This is related to the growth of plant root systems, where optimum plant root growth will produce shoot growth or very high tops. In hydroponic systems, nutrient solutions are things that really need attention. Providing nutrition to plants is very important because nutrition plays an important role in providing energy to plants to grow and develop properly.

In the DWC hydroponic system, the application of liquid inorganic nutrients and the right growing media in hydroponic plants is very important in influencing plant growth, especially kale plants. Different types of growing media with the content they have will certainly have different impacts on plants. In addition, nutrition is also needed by plants so that the type of nutrition given to plants must be considered as well. Each plant has nutritional needs with different doses, as well as the metal content found in nutrients given to plants known as ppm. For successful fertilization efforts it is necessary to pay attention to the dosage, method, and timing of fertilization so that the fertilization effort becomes effective [6]. This is certainly becoming a reference for conducting research in examining the effect of planting media and liquid inorganic nutrition on kale plants. Based on this, the study was conducted to examine the growth and production of kale on various types of inorganic nutrients with a hydroponic system. The purpose of this study was to investigate and determine the effect of planting media and types of liquid inorganic nutrients on the growth and production of kale (Brassica alboglabra L.) with a hydroponic system. The benefits that can be obtained from this research are reference materials for the development of hydroponic kale cultivation in South Sulawesi so that it is easily known and carried out by the community.

2. Methodology
This research was conducted from May to July 2017 in Antang, Manggala District, Makassar City. The tools and materials used in this study were tarpaulins, ropes, polybags, trays, plastics, sprayers, drums, scales, and stationery. The materials used in this study were kale variety Nero di Toscana, water, AB-Mix nutrition, R-Mix nutrition, sand, burnt husk, and cocopeat.

A split-plot design was employed with two factors namely liquid inorganic nutrition and planting media. The main plot was the liquid inorganic nutrition consisted of two types of nutrients, namely: Nutrition AB-Mix (N1), and Nutrition R-Mix (N2). The subplot was the planting medium consisted of seven levels namely sand (M1), burnt husk (M2), Cocopeat (M3), sand + burnt husk (ratio 1: 1) (M4), sand + cocopeat (1: 1 ratio) (M5), Baked husk + Cocopeat (1: 1 ratio) (M6), Sand + Baked husk + Cocopeat (1: 1: 1 ratio) (M7). This experiment was repeated in 3 replications and each repetition consisted of 14 polybags so that there were 84 experimental units. The DWC hydroponic installation series in this study was set by making a planting tub from tarpaulin to put polybags for plants (Figure 1).
AB-Mix nutrition solution was made by diluting both nutrient stock solutions A and B using water. To make a nutrient solution with a concentration of 500 ppm required 2.3 ml of stock solutions A and B which are added to 1 liter of water. This ready-made solution is also ready to be applied to plants. R-Mix nutrition was prepared by mixing urea fertilizer, KCL fertilizer, NPK fertilizer, and Growmore leaf fertilizer in a 5-liter volume bucket. 5 liters of water were poured into the bucket partially while stirring. The solution was stirred until there are no more fertilizers that still crystallize and no sediment. The R-Mix nutrient solution is ready to be applied to plants.

Data were analyzed using analysis of variance to test the significance of the treatment given. If there is a significant effect then proceed with further tests using Least Significance Different (LSD) test at a level of confidence of 0.05.

3. Results

3.1. Effect of types of nutrition and planting medium on growth of Kale.
Analysis of variance shows that there was no significant effect of the type of nutrition and composition of planting medium on several growth parameters. Average of growth parameter of Kale plants are shown in Table 1.

**Table 1. Effect of two types of hydroponic nutrition solution and composition of planting medium on growth parameter of Kale grown hydroponically.**

| Nutrition   | Planting Medium | Plant height (cm) | Number of leaves | Leaf length (cm) | Leaf area (cm²) | Root Length (cm) | Fresh Weight (g) |
|-------------|-----------------|-------------------|------------------|------------------|-----------------|------------------|------------------|
| AB Mix      | Sand            | 25.2              | 14.0             | 5.9              | 14.0            | 8.2              | 10.2             |
|             | Burnt rice husk (BRH) | 23.3           | 14.0             | 6.5              | **20.3**        | **10.2**         | 11.0             |
|             | Cocopeat        | 19.0              | 13.8             | 6.0              | 18.0            | **10.2**         | 11.0             |
|             | Sand + BRH (1:1) | **27.0**          | **17.0**         | 6.6              | 17.0            | 9.8              | **11.8**         |
|             | Sand + Cocopeat (1:1) | 25.9           | 14.3             | **6.8**          | 16.3            | 8.2              | 9.0              |
|             | BRH + Cocopeat (1:1) | 19.2           | 12.0             | 5.7              | 15.0            | 8.2              | 10.3             |
|             | Sand + BRH + Cocopeat (1:1:1) | 21.4           | 12.3             | 6.5              | 14.0            | 8.5              | 8.7              |
| Mean AB-Mix |                 | **23.0**          | 13.9             | 6.3              | 16.4            | 9.0              | 10.3             |
| R-Mix       | Sand            | **29.8**          | **17.7**         | 9.6              | **44.5**        | **17.2**         | **24.7**         |
|             | Burnt rice husk (BRH) | 19.2           | 12.3             | 7.0              | 30.8            | 11.9             | 16.0             |
|             | Cocopeat        | 18.9              | 11.3             | 6.8              | 22.8            | 10.8             | 12.3             |
|             | Sand + BRH (1:1) | 28.3              | 15.6             | 9.7              | 37.0            | 14.9             | 20.2             |
|             | Sand + Cocopeat (1:1) | 27.4           | 15.7             | **10.7**         | 43.2            | 13.9             | 17.7             |
|             | BRH + Cocopeat (1:1) | 19.3           | 9.3              | 6.2              | 22.7            | 10.4             | 10.5             |
|             | Sand + BRH + Cocopeat (1:1:1) | 22.1           | 12.5             | 6.7              | 21.8            | 10.6             | 12.0             |
| Mean R-Mix  |                 | **23.6**          | 13.5             | 8.1              | 31.8            | 12.8             | 16.2             |

3.2. Effect of types of nutrition and planting medium on chlorophyll content of Kale plant
The results of variance showed that the nutrition treatment significantly affected the total chlorophyll of the kale plant, while the treatment of planting media and the interaction between the two treatments had a very significant effect on the total chlorophyll of the kale plant. Average of total chlorophyll of Kale plants as affected by the planting media and nutrition solution are shown in Table 2.

The 5% LSD test results in Table 2 show that the interaction between nutrition with various planting media affects the chlorophyll content of kale plants. The interaction of sand planting media
(M1) with R-Mix (N2) nutrition produced the highest average chlorophyll content (6.57 mg/g) and was not significantly different from the interaction of the treatment of fuel husk and cocopeat (M6) with AB-Mix nutrition (N1), but significantly different from other treatments. While the lowest average total chlorophyll (5.60 mg/g) is found in the interaction of cocopeat (M3) growing media with the nutrient AB-Mix (N1).

Table 2. Average total chlorophyll (mg/g) of kale in various planting media and nutrition

| Planting Medium                      | Nutrition    | LSD<sub>0.05</sub> | LSD<sub>0.05</sub>   |
|--------------------------------------|--------------|---------------------|----------------------|
|                                      | AB Mix       | R-Mix               | Planting medium      |
| Sand                                 | 5.88<sub>b</sub> | 6.57<sub>a</sub>  |                       |
| Burnt rice husk (BRH)                | 5.98<sub>b</sub> | 5.90<sub>b</sub>   |                       |
| Cocopeat                             | 5.60<sub>b</sub> | 5.81<sub>b</sub>   |                       |
| Sand + Burnt rice husk (1:1)         | 5.92<sub>b</sub> | 5.89<sub>b</sub>   | 0.13                 |
| Sand + Cocopeat (1:1)                | 5.66<sub>b</sub> | 6.01<sub>b</sub>   |                       |
| Burnt rice husk + Cocopeat (1:1)     | 6.51<sub>a</sub> | 6.07<sub>b</sub>   |                       |
| Sand + Burnt rice husk + Cocopeat (1:1) | 5.64<sub>b</sub>   | 5.97<sub>b</sub>   |                       |

LSD<sub>0.05</sub> Nutrition 0.16

The numbers followed by difference letters in the same rows (a, b) and columns (x, y) are significantly different at the LSD<sub>0.05</sub>.

4. Discussion
This study shows that there are different responses in kale plants to the treatment of different planting media and nutrients. Despite the insignificance results of the treatments on the observed parameters, R-Mix generally shows a better average value of the parameter. This is indicated by the parameters of leaf and root length, leaf area and total fresh weight of the Kale plant.

In a study conducted by Haile and Ayalew [7] showed that fresh kale biomass was strongly influenced by the application of liquid bio-slurry and inorganic N nutrients. The increase in kale fresh biomass due to the application of liquid bio-slurry and inorganic N nutrients can be associated with increased vegetative growth and increased assimilate production associated with an increase in leaf area. This shows that kale needs a high N to produce good fresh biomass. According to Brady and Well [8], increased yield of fresh biomass from kale due to the application of bio-slurry (a component of several important macro and micronutrients) may be caused by this nutritional effect, which is an integral component of many important plant compounds such as chlorophyll, protein, and amino acid. These plant compounds can increase vegetative growth and produce a good quality canopy which will increase the synthesis of carbohydrates through photosynthesis and ultimately increase crop yields, one of which is the total chlorophyll of kale plants.

Leaves are the site of photosynthesis, which will produce photosynthates and are transplanted to all plant organs through phloem vessels [9]. In the process of photosynthesis, the important thing is the absorption of solar radiation by the leaf surface, but not all incoming solar radiation can be absorbed by the leaf surface. Factors that influence the absorption of solar radiation, namely variations in leaf shape, thinness (emitted light), inclination and vertical distribution. Of course, this will affect the total amount of chlorophyll in plants, especially leafy plants such as kale.

Based on the results of the study it can be seen that there are interactions in the treatment of nutrition and planting media which have a very significant effect on the total chlorophyll of Kale plants. The treatment of sand growing media (M1) and R-Mix (N2) nutrition gave the highest yield in total chlorophyll. This is because the sand planting media has the capacity to store water better than
other planting media. In addition, the macronutrient content contained in the R-Mix nutrition is higher than that contained in the AB-Mix nutrient.

Based on the analysis conducted in this study, the macronutrient content contained in the R-Mix nutrition are N (190 g), P (50 g), and K (200 g) while the macronutrient content contained in the AB-Mix nutrition Goodplants is N (123 g), P (37 g), and K (174.5 g) as shown in Table 3. The stage of plant growth requires nitrogen to form new cells. Apart from being a major nutrient for growth, nitrogen plays an important role in the formation of leaf green matter (chlorophyll) which is very useful in photosynthesis [10]. In addition, micronutrients also affect the formation of chlorophyll even though the amount needed by plants is only small. In addition, according to Harjoko [11], the chlorophyll content is strongly influenced by light, oxygen, nitrogen, magnesium and iron, water, and environmental temperature.

| Unsur  | AB-Mix *goodplant* (N1) | R-Mix (N2) |
|--------|------------------------|-----------|
| N      | 123 g                  | 190 g     |
| P      | 37 g                   | 50 g      |
| K      | 174.5 g                | 200 g     |

Table 3. Comparison of macro nutrient content on R-Mix and AB-mix goodplant

The nutrient content is thought to be more easily absorbed by plants through the planting media of sand because sand has a higher water holding capacity compared to other planting media so that there is an interaction between the treatment of R-Mix nutrition and the sand planting media. The porous sand planting media is able to absorb nutrients better so that they can be more easily absorbed by plants. The texture and aeration of the planting media affect the rooting process when compared to its chemical properties such as acidity and others [12]. Sufficient oxygen can also speed up the rooting process.

In this study, it can be seen that the nutritional treatment of R-Mix (N2) and sand growing media (M1) has the highest total amount of chlorophyll. This is presumably because the R-Mix nutrition contains nutrients that are very suitable for plant growth coupled with sand planting media which have porous properties so it is suitable for plant growth. In addition, the lighting factor in the greenhouse is also at optimal conditions for kale. This is in accordance with previous studies that found the treatment of sand media gives the best results on the parameters of plant height, the number of leaves, leaf area, fresh weight, and dry weight of pakchoy compared to with burnt husk planting media [13,14].

Based on the results of this study it can be seen that the combined treatment of burning husk and cocopeat (M6) planting media has the highest value and has a very significant effect on the total chlorophyll parameters. This is because the combination of burning husk and cocopeat growing media gives good results on the total chlorophyll of kale plants. Cocopeat is considered a good growing media component with a pH that is acceptable to plants, with electrical conductivity and various other chemicals [15]. In addition, cocopeat has been recognized to have a high water-holding capacity and low aeration, thus affecting oxygen diffusion to the roots [16]. Variation on cocopeat for air capacity was 11-53% while water capacity was 50-81% [15].

According to Sambo et al. [17], the incorporation of coarse material into cocopeat can improve media aeration status. In addition, burnt husk is one of the growing media that can be used to improve the relationship of air and water on cocopeat [18]. The low water holding capacity and high pore space of the burnt husk making this material used as a substitute for organic or inorganic components to replace vermiculite and perlite and is effective in increasing drainage or aeration of planting media [19]. Burnt husk as a component for growing media, is like fine sand, except it is lighter and contains several nutritional and sterile elements. This shows that the combination of burnt husk and cocopeat growing media is a combination that is suitable for kale plant growth, especially to obtain high total chlorophyll.
In addition, the treatment of sand growing media (M1) also showed the same results with the planting media of rice husk and cocopeat (M6). This shows that the sand planting media can also give the best results and have a very significant effect on the total chlorophyll value in kale plants. This is due to the nature of the sand which has high porous properties.

5. Conclusions
From the research results obtained, conclusions can be drawn as follows:

a) Interaction of nutrition of sand growing media with R-Mix gives the highest yield in total chlorophyll of kale plant.

b) The combination treatment of burnt husk and cocopeat growing media gives a total chlorophyll tend to be higher than other planting media.

c) The nutritional treatment of R-Mix gives results that tend to be higher in total chlorophyll.

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