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The growth rate of hydroponic lettuce at various nutrient compositions from liquid synthetic, solid synthetic and liquid organic fertilizers

Nyayu Siti Khodijah*, Ratna Santi, Riwan Kusmiadi, and Euis Asriani

Department of Agrotechnology, Bangka Belitung University, Indonesia

**Corresponding author's e-mail: nyayukhodijah@yahoo.co.id*

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ABSTRACT

The hydroponic system of lettuce cultivation has become popular in the new normal era after the Covid 19 pandemic. So that the efficiency of input and the ease of supplying nutrients in hydroponic farming deserves to be a concern. Hydroponics commonly uses synthetic fertilizers that are completely available and sold commercially. Efforts are needed to make media choices by utilizing easier and cheaper resources, among others by making various alternative nutrient source compositions from widely available, cheap, and commonly used synthetic fertilizers such as NPK and Gandasil. Another option that also needs to be tested for the efficiency of its utilization is the use of liquid organic fertilizers from chicken feather waste. Calculation of the growth rate of lettuce grown on various nutrient compositions of liquid organic and synthetic fertilizers was carried out. The types of fertilizer composition tested were P1= AB-mix (control) 50 ml in 10 liters of water, P2= NPK 10 g + Gandasil 5 g in 10 liters of water, P3= AB-mix 25 ml + 5 g NPK + 2.5 g Gandasil in 10 liters of water, P4= AB-mix 25 ml + 400 ml chicken feather LOF in 10 liters of water, and P5= 5 g NPK + 2.5 g Gandasil + 400 ml chicken feather LOF in 10 liters of water. The results showed that the highest growth rate of lettuce was obtained in the P4 composition, with the best results for Net assimilation rate (NAR), total wet biomass production per plant, ratio of wet weight of shoot: wet weight roots, relative plant height growth rate, relative leaf number growth rate, and relative plant growth rate.

Keywords:
Nutrient composition, Growth rate, Liquid organic fertilizers, Synthetic fertilizers, Hydroponic lettuce

1. Introduction

Increasing scarcity of land and water, especially in densely populated settlements, makes hydroponic systems that save more land and water more attractive to young and lay farmers [1]. In addition, social restrictions in the current Covid 19 era have made hydroponic farming more popular than before, including hydroponic lettuce cultivation. Lettuce is a vegetable rich in fiber, contains useful vitamins and nutrients and minerals, lettuce also contains bioactive compounds that are beneficial to health [2]. One of the hydroponic systems that is easy to apply is the hydroponic wick system. The use of this system is considered because it uses minimal resources, is the simplest, the cheapest, so it is suitable for beginners [3,4].

The growth rate of hydroponic lettuce is influenced by the presence, availability of nutrients in the medium and the amount of nutrients that can be absorbed by plants [5]. Several alternatives can be used as an option to provide nutrients for lettuce grown hydronically. Efforts to supply these nutrients are considered in various ways, including considering the cost of cultivation to make it cheaper and relatively easy to provide in various places and locations. Options that can be made include the use of NPK fertilizers and a complete mixture of macro-micro-solid fertilizers. The NPK Mutiara and Growmore hydroponic media tests have been carried out in the research of [6], the results obtained have not been able to keep up with the growth of the liquid synthetic fertilizers tested, so it is necessary to search for further compositions to further maximize the growth of hydroponic lettuce with the wick system. Another alternative that can also be done is to use the waste from the slaughterhouse of poultry in the form of feathers, which is a problem for the environment because of its contamination.

The need to increase the product per unit area has become a need that must be met. Increased agricultural products tend to use more inorganic fertilizers per unit area, causing excessive application of inorganic fertilizers [7]. Such conditions can also affect natural resources such as soil and water to become polluted so that it can become a health problem [8]. In addition, environmental pollution due to agricultural products is also a contributor to other environmental pollution. The use of agricultural [9] and livestock waste as alternative nutrient resources for hydroponics has also been tested [10].

The poultry industry is one of the largest industries and contributes to most of the generation of solid waste which includes the slow breakdown of keratin in chicken feather waste. Each bird is estimated to have about 125 g of feathers so feather waste production can reach 3000 tonnes per week. Poultry feathers can contain keratin around 90% [11]. This condition makes its breakdown by microbes difficult [12]. So that the next effort made is to make it into liquid organic fertilizer. The use of liquid organic fertilizer from chicken feather waste deserves further investigation. So, it is necessary to do research to find out how the Growth Rate of Hydroponic Lettuce on various synthetic nutrient compositions and nutrients sourced from liquid organic fertilizers from chicken feather waste.

2. Materials and Methods

The preparation of growing space and hydroponic installations was carried out in February to September 2020 in the experimental garden of the Faculty of Agriculture, Fisheries and Biology, University of Bangka Belitung with controlled environmental conditions. Hydroponic nutrient preparation was made according to the type of treatment and there was no replacement of the nutrient solution during observation (Table 1). Liquid synthetic nutrients are obtained in a complete package of macro and micronutrients that are ready for application. Solid synthetic nutrients are obtained by mixing NPK fertilizer and liquid complementary fertilizers containing macro and micronutrients. Liquid organic fertilizer (LOF) from chicken feathers comes from composting chicken feathers with chicken manure and after 8 weeks of solid compost is produced, then solid compost is dissolved in water for 4 weeks then applied as liquid organic fertilizer. The nutrient placement medium used was a 12 liters Styrofoam box and filled with nutrient solution up to a volume of 10 liters. A hole was made for the placement of 5 plants per box.

The nursery is done by planting the seeds on rockwool media measuring 2 cm × 2 cm × 2 cm with sufficient water flowing in the seed tub. Planting is carried out when the sown seeds are 14 days old characterized by an average plant height of 5 cm and a number of leaves 4. Selected seeds are transferred to a netpot that has been worn with a flannel wick. Transfer of seeds is done by inserting 1 seed per 1 planting hole in the rockwool medium which has been drained with nutrient solution.

Table 1. Types of fertilizer treatments and dosages used

Type of Treatment	Source of nutrient solution and dosage	Explanation
P1	AB-mix (control) 50 ml in 10 liters of water	Liquid synthetic
P2	NPK 10 g + Gandasil 5 g in 10 liter of water	Solid synthetic
P3	AB-mix 25 ml + 5 g NPK + 2.5 g Gandasil in 10 liters of water	Liquid synthetic + solid synthetic
P4	AB-mix 25 ml + 400 ml chicken feathers LOF in 10 liters of water	Liquid synthetic + liquid organic
P5	5 g NPK + 2.5 g Gandasil + 400 ml liquid organic chicken feather fertilizer in 10 liters of water	Synthetic solid + organic liquid

2.1. Data Collection

Measurement of growth and production data was carried out at the end of the experiment, the lettuce plants were separated into leaves and roots, the fresh weight (FW) of the leaves, the fresh weight of the roots, was weighed with an electronic analytical balance with an accuracy of 0.1 mg. Leaf and root dry weight was obtained by drying in an oven at 80 °C and drying for 72 hours and recording the dry weight (DW) of leaves and roots [13]. The ratio of shoot wet weight and root wet weight ratio was calculated by comparing the wet weight of the fresh shoot with the wet weight of the fresh roots. The net assimilation rate (NAR) (mg.cm^{-1}.hour^{-1}) is calculated using the equation [14]:

$$\mathbf{NAR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e A_2 - \log_e A_1}{A_2 - A} \mathbf{g\,m^{-2}day^{-1}} \tag{1}$$

Where W_2 and W_1 are the dry weight of plants at times t_1 and t_2, $\log_e A_2$ and $\log_e A_1$ are leaf areas A_1 and A_2 at times t_1 and t_2.

Relative plant height growth rate (cm.day^{-1}), relative leaf number growth rate (strands.day^{-1}) and relative growth rate (RGR) were calculated using the formula RGR = ($\ln W_2 - \ln W_1$) / ($t_2 - t_1$), where W_1 and W_2 are plant dry weights at times t_1 and t_2 [15]). The dry weight is used to calculate the relative growth rate (RGR), then for the calculation of the relative plant height (RPH) and the relative leaf number growth rate (RLN), the plant height data and the number of leaves data are used.

2.2. Statistics and Data Analysis

The study was conducted using a single completely randomized design (CRD) consisting of 5 (five) treatment levels, namely P1, P2, P3, P4, and P5 (Table 1). Each treatment was repeated 6 times so that there were 24 experimental units. Each experimental box had 5 planting holes and 5 sample plants. Data were analyzed using the SPSS (Statistical Package for Social Sciences) program through the F test (Fisher's Test) with a confidence level of 95%. If it shows that there is a significant effect, then proceed with the Duncan's Multiple Range Test at the 95% confidence level. To assess the relationship between growth, the coefficient of determination (R2) was carried out [16].

3. Results and Discussion

The treatment of various types of nutrient composition derived from solid synthetic fertilizers, liquid synthetic fertilizers and solid organic fertilizers had a significant effect on the total wet biomass production of the plant, the ratio of shoot wet weight: root wet weight, net assimilation rate (NAR), plant height growth rate, The growth in the number of leaves and the relative growth rate of the hydroponic system wick lettuce plant (Table 2).

Tabel 2. The results of the variety of growth rates and production of hydroponic lettuce at various nutrient compositions are sourced from liquid synthetic fertilizers, solid synthetic fertilizers and liquid organic fertilizers

Variable	Pr>F	C.V. (%)
1. Total wet biomass production per plant (g.plant^{-1})	5.52619E-05*	23.59
2. Ratio of shoot wet weight; the wet weight of the roots	0.001631914*	26.57
3. Net assimilation rate (NAR) ((g.cm^{-2}.day^{-1})	2.86531E-08*	25.10
4. Relative plant height growth rate (cm.day^{-1})	0.000382555*	23.99
5. Relative leaf number growth rate (leaf.day^{-1})	7.49881E-06*	28.36
6. Relative crop growth rate (g.day^{-1})	0.000962589*	18.73

*Significant effect at the 95% level, Pr>F: probability value and, C.V.: Coefficient of Variance

Hydroponic cultivation of vegetables is used to use formulated fertilizers complete with standardized applications. Liquid synthetic nutrient mixtures contain compounds that are almost the same as nutrients needed by plants and are easily absorbed by plants [17]. Net assimilation rate (NAR) (g.cm^{-2}.day^{-1}) is the main determinant of RGR variation. The results showed that the highest NAR was still found in P1, which was significantly different from other nutrient types (Table 3). NAR has a strong and positive relationship with the rate of photosynthesis because it is based on leaf area and leaf nitrogen content. This condition is thought to be caused in addition to P1 containing sufficient nutrients, it is also due to the relatively better nutrient uptake in this condition compared to other treatments. Where nutrient uptake and good translocation rates cause the relative growth rate to be good for the whole plant as well as for other plant parts.

The best total wet biomass production was obtained in treatment P4, treatment P4 gave the best results of 84.27 g per plant. This result was not significantly different from P3 treatment and significantly different from other treatments (Table 3). This condition indicates that the results achieved by P4 can exceed the formulated liquid synthetic nutrients (P1). As well as relatively complete, P4 nutrient media has better absorption, because it is a nutrient formulated in half the recommended liquid synthetic dosage and 400 ml of liquid organic nutrients are added per 10 liters of water. This condition has been able to make the media nutrient equivalent to synthetic media with a full dose (P1). Nutrients derived from liquid organic fertilizers are able to show better growth than synthetic nutrients. Similar results were also conveyed in Zandvakili et al. [7] research, where in general the results showed higher growth of lettuce with liquid synthetic solutions compared to organic fertilizers or without fertilization.

Table 3. Results of further tests of total wet biomass production per plant, ratio of shoot wet weight: root wet weight and net assimilation rate (NAR) using Duncan's Multiple Range Test (DMRT) with a 95% significance level.

Treatment	Net assimilation rate (NAR) ($g.cm^{-2}.day^{-1}$)	Total wet biomass production per plant	Ratio of shoot wet weight: root wet weight
P1	0.0142 c	50.55 ab	7.08 a
P2	0.0007 a	35.47 a	13.88 bc
P3	0.0075 b	72.05 c	10.27 ab
P4	0.0031 a	84.27 c	13.64 bc
P5	0.0026 a	52.75 b	15.28 c

Note: The number followed by the same letter in the same column shows insignificant differences in the advanced test of Duncan's Multiple Range Test (DMRT) α = 5%

Ratios of shoot wet weight and root wet weight were made to predict the dominance of shoot or root development. Table 3 shows the highest shoot root ratio was found on P5 media and it was not significantly different from P4. Increasing the ratio indicates more development of shoots than roots. In general, synthetic nutrient replacement treatment with organic stimulated shoot development of P4 (half the liquid synthetic dose added 400 ml of liquid organic per 10 liters of water) and P5 (half the dose of solid synthetic fertilizer added 400 ml of liquid organic per 10 liters of water). This condition also reflects that the addition of liquid organic matter causes better shoot growth than roots. Organic fertilizers promote upper growth because liquid synthetic solutions provide the highest concentrations of nitrogen, potassium, magnesium, and iron in lettuce whereas lettuce grown with organic fertilizers has the highest phosphorus. The accumulation of plant nutrients is different for each type of nutrient used [7].

3.1. Growth Rate of Hydroponic Lettuce on various Nutrient compositions of Liquid Organic Fertilizers and Synthetic Fertilizers

Plant height is an indicator for evaluating plant growth, reflecting the ability to synthesize and accumulate organic matter. Lettuce will grow well if it is at an appropriate height and is balanced for each period [5]. Plant height growth rates were obtained in treatment P3 and P4 (table 4). P3 and P4 are able to exceed P1 for the plant height growth rate. In P3, half of the liquid synthetic was replaced by solid synthetics and in P4, half of the liquid synthetic was replaced by LOF. This replacement shows that the performance of synthetic solids and liquid organic is almost equal to replace half the dose of LOF. This is because the high growth rate of lettuce is caused more by age than by nutrient intake.

Table 4. Post-hoc test results plant height growth rate, leaf number growth rate and relative growth rate using Duncan's Multiple Range Test (DMRT) with a real level of 95%

Treatment	Plant height growth rate	The rate of growth in the number of leaves	Relative growth rate
P1	0.058 bc	0.044 c	0.321 c
P2	0.031 a	0.012 a	0.210 a
P3	0.059 c	0.046 c	0.273 bc
P4	0.068 c	0.028 b	0.245 ab
P5	0.044 ab	0.027 b	0.194 a

Note: The number followed by the same letter in the same column shows insignificant differences in the advanced test of Duncan's Multiple Range Test (DMRT) α = 5%.

The effect of nutrient solutions on the growth and composition of lettuce (*Lactuca sativa* L.) using liquid synthetic solutions, synthetic in and organic hydroponic solutions resulted in higher growth of lettuce with liquid synthetic solutions compared to organic fertilizers [7]. This is also in line with what happened to the growth rate variable in the number of leaves, which appeared to be equivalent to the relative growth rate, the best treatment was obtained at P3 which was able to match P1 and was not significantly different from P4. Treatment P3 replaced half liquid synthetic nutrients with solid synthetics and P4 treatment half the liquid synthetic nutrient dose was replaced by LOF as much as 400 ml per 10 liters of water. This replacement leaves more nutrients available for leaf growth. The leaves of vegetable plants play a role in the growth and development of vegetable plants. It participates in photosynthesis and synthesizes organic matter. Furthermore, the leaves are responsible for transpiration. Especially for leafy vegetables such as lettuce, leaves play a role in determining the productivity and quality of vegetables [5].

The trend of plant height growth and number of leaves also caused an increase in the rate of dry weight accumulation, which was reflected in the relative growth rate variables. The relative growth rate calculated is the increase in dry weight per time. Table 4 shows that P1 treatment still shows a higher relative growth rate, but P3 treatment is almost able to match P1. This is due to the presence of different water content in the plant tissue so that although in terms of total biomass, P3 and P4 plants have been able to compensate and even exceed P1 but the dry weight gain is not the case. This trend indicates that liquid synthetic nutrients (P1) have not been fully replaced by solid synthetic (P4) and LOF (P3) at relative growth rate variables (Table 4). The growth of lettuce for each plant and the yield of plant dry matter was determined by increasing the application of organic matter, but the effect of the application of organic matter on some plant macro constituents (N, P, K, Ca and Mg) was not found to be statistically significant [8].

3.2. *The relationship between net assimilation rate and plant growth rate*

To see the tendency of the relationship between the two variables, a graph with the coefficient of determination is used (Figure 1). The increase in net assimilation rate (NAR) ($g.cm^{-2}.day^{-1}$) tends to increase plant growth (Figure 1a) with R2 = 0.310. This value indicates that the rate of plant assimilation will affect the growth of plant height by 31 percent, while the remaining 69.0 percent of plant height will be influenced by other factors. The increase in the rate of assimilation will tend to increase the relative leaf growth rate (Figure 1b) with a value of R2 = 0.712, this value indicates that the plant assimilation rate will affect the relative leaf growth rate by 71 percent, while the remaining 29.0 percent will be influenced by relative leaf growth. by factors other than the net assimilation rate (NAR) ($g.cm^{-2}.day^{-1}$).

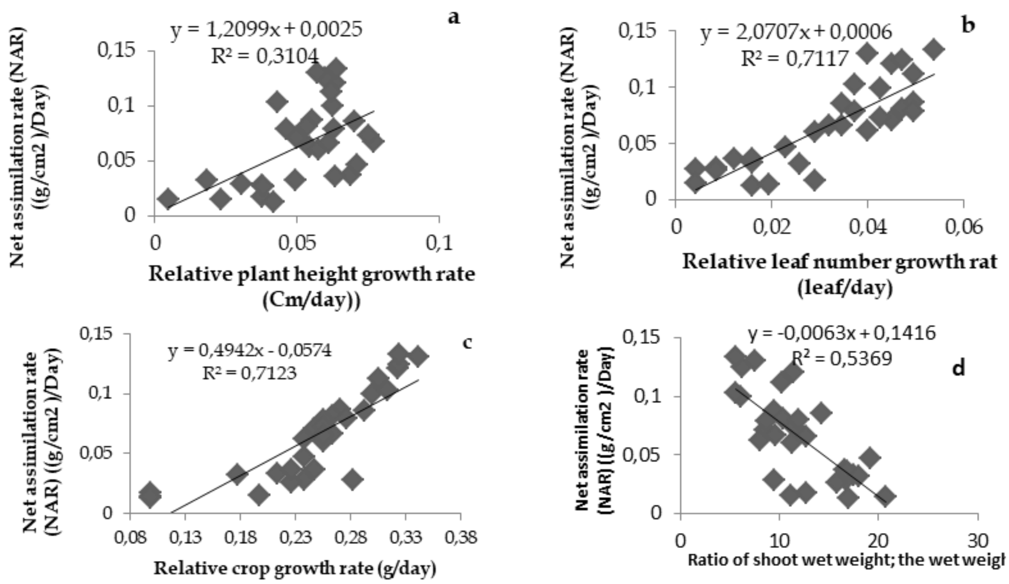

Figure 1. Graph of the relationship between various growth variables due to the treatment of various nutrient compositions for liquid organic and synthetic fertilizers. (a) NAR with plant height growth rate, (b) NAR with leaf number growth rate, c) NAR with relative leaf growth rate, d) NAR with ratio wet weight of shoots; wet weight of roots

The application of organic fertilizers combined with inorganic fertilizers is a solution to overcome the decrease in lettuce production [18]. The increase in net assimilation rate (NAR) ($g.cm^{-2}.day^{-1}$) tended to increase plant growth under dry weight accumulation (Figure 1c) with a value of R2 = 0.712. This value indicates that the plant assimilation rate affects the relative growth rate of 71 percent, while the remaining 29.0 percent of the relative growth rate is influenced by other factors. The net assimilation rate (NAR) can determine the relative growth rate (RGR) but in some variables this relationship is not strong and even vice versa (Sutoro et al. 2008). This condition occurs in the ratio of shoot wet weight: root wet weight (Figure 1d) with a value of R2 = 0.537, this value indicates that the rate of plant assimilation reduces the ratio of shoot wet weight: root wet weight by 53.7 percent, while the rest is 46.3 percent. Ratio of shoot wet weight: root wet weight will be influenced by other factors beyond the net assimilation rate. So that in line with Frasetya et al. [18], the application of organic fertilizers combined with inorganic is a solution to overcome the decrease in lettuce production, with several nutrient enrichment treatments.

4. **Conclusion**

The type of nutrient treatment had a significant effect on all variables of lettuce growth. The best treatment for Net assimilation rate (NAR), total wet biomass production per plant, wet weight ratio of shoots: root wet weight, relative plant height growth rate, relative leaf number growth rate, and relative plant growth rate obtained at synthetic nutrient composition of 25 ml.10 L^{-1} + 400 ml.10 L^{-1} chicken feathers LOF (P4). The increase in net assimilation rate tended to increase the height increase rate, number of leaves and weight of fresh biomass, but the net assimilation rate tended to decrease the ratio of shoot wet weight: root wet weight.

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