

Effects of goat manure liquid fertilizer combined with AB-MIX on foliage vegetables growth in hydroponic

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Abstract. Hydroponic as one of the protected cultivation practices is very important to be developed in Indonesia due to not only the reduction of arable agricultural lands in lines with increasing of residential demand and other public facilities but also due to the negative influences of climate change as well global warming to plant growth. The effects of liquid fertilizer made from goat manure (LFGM) in combination with AB-Mix on three kinds of foliage vegetable growth was examined in hydroponics. The research was conducted by 3 x 4 factorial experiment and arranged in Completely Randomized Design with 3 replications. The first factor was foliage vegetable consisting of 3 levels: Mustard Green, Lettuce, and Red Spinach. The second factor was the mixture composition of nutrient solution consisting of 4 levels: LFGM + AB-Mix (v/v: 1:1), LFGM + AB-Mix (v/v: 1:3), LFGM + AB-Mix (v/v: 3:1), and A/B mix as control. Results indicated that the application of LFGM + AB-Mix (v/v: 1:3) resulted in similar plant growth as control (AB-Mix application), and also resulted in the highest chlorophyll content of Mustard green.

1. Introduction

The reduction of arable agricultural lands in lines with increasing of residential demand and other public facilities, and also the negative influences of climate change as well global warming to plant growth can be serious obstruct for food production in the future all over the world. It has been projected that 50% of the world's fertile land may be unfeasible in near future [1]. In several countries, population growth is increasing rapidly and therefore there is an increase in food consumption, but the areas for agricultural crops do not increase at the same proportion [2].

In recent years, hydroponic crop cultivation significantly increased and allows a more efficient use of water and fertilizers, as well as control the climate and pest factors [3]. The hydroponic system can induce highest vegetative growth, yield, and quality of plants [4]. The benefits of hydroponically agricultural practices are numerous [5,6] and it can be applied for soil conservation and preservation of water resources [2,7]. The practice of hydroponic in a controlled environment, resulting in higher yield and water efficiency, also support continuous production throughout the year [5]. Hydroponically plant cultivation has been found to be a good alternative and is commercially used in many western countries [8].

The production of organic liquid fertilizer is a very important strategy to support the development of hydroponic cultivation. The liquid organic fertilizer can substitute inorganic chemical substances which is more expensive and difficult to obtain in several countries such as Indonesia. Fertilizers as a

source of nutrients are very important for plant growth, and the quality of liquid fertilizer is determined by pH and the content of nutrient elements. The quality of organic liquid fertilizer is also determined by the content of another chemical substance such as growth regulator and organic acid [9,10]. The use of electrical conductivity (EC)-based nutrient control in hydroponic can afford excessive or inadequate nutrients for plant growth [11]. An equilibrium nutrient supply is vital for better plant growth in the hydroponic system.

The quality of liquid fertilizer is determined by not only the pH but also the nutrient elements content. The use of effectiveness microorganisms (EM) during incubation of raw materials is suggested to obtain the high quality of liquid organic fertilizer. In order to give energy and nutrients to accelerate the development of EM during incubation, it can be added molasses, NPK, and urea in the production of liquid organic fertilizer [12]. EM is the probiotic microorganisms used to ferment organic materials and applied to produce better plant growth [13]. This research was objected to determine the appropriate combination of liquid fertilizer made from goat manure and AB-mix to can accelerate plant growth and yield. AB-Mix is well known as a commercial nutrient solution for hydroponic with macro-elements (N, P, K, S, Ca, and Mg) and micro-elements (Fe, B, Mn, Zn, Cu, and Mo) nutrients composition.

2. Materials and Methods

2.1. Research Site and Period

Fermentation of liquid fertilizers made from goat manure (LFGM) was carried out from the first week until the fourth week of February 2017. The application of liquid fertilizer was conducted from March until August 2017 in Wonosari, Yogyakarta, Indonesia.

2.2. Fermentation of the materials

Fermentation of the materials consisted of the following steps: (1) 0.5 kg Sugar + 1 kg ZA were diluted by 20 liters water in the 25-liter volume plastic bucket, then added with 20 ml of EM and 2 kg of air-dried goat manure; (2) The mixed materials were stirred manually around 5 minutes and then the plastic bucket was capped properly; (3) The plastic was placed in the room temperature condition; (4) The mixed fermented materials were stirred manually around 2 minutes, every day in the morning and afternoon; (5) After three weeks of fermentation, the pH, EC, and TDS of the solution was observed using portable pH/EC/TDS/Temperature meter Hanna Instruments H19811-5.

The experiment of the application of liquid fertilizer on foliage vegetables (mustard green, lettuce, and spinach) was carried out by 3 x 4 experimental factorial arranged in Completely Randomized Design (CRD) using three replications. The first factor was foliage vegetables consisted of 3 levels: P1: Mustard green, P2: Lettuce, and P3: Red spinach. The second factor was the combination of nutrient solution consisted of 4 levels: A: LFGM + AB-Mix (v/v: 1:1), B: LFGM + AB-Mix (v/v: 1:3), C: LFGM + AB-Mix (v/v: 3:1), and D: A/B mix as control.

Seeds of mustard green (*Brassica rapa* L), lettuce (*Lactuca sativa* L), and red spinach (*Alternanthera amoena* Voss) were cultivated in the compost media during for two weeks until seedlings, then selected to get the homogenous seedlings. The seedlings then planted in the hydroponic connected pipes installation constructed to appropriately shallow flow technique (SFT). The plants were irrigated and fertilized by the combination of nutrient solution in an appropriate treatment. The EC of the nutrient solution was consistently set in the range of 1600-1650 μSCm^{-1} , whereas the pH of the nutrient solution was in the range of 5.5-6.5.

Four weeks after planting, leaf number, shoot fresh and dry weight, root dry weight, chlorophyll content, and root/shoot ratio from 5 plant samples at each treatment were observed. Chlorophyll content was measured on the intact leaves of plants with no destructive assays taken from lower, middle, and upper leaves of the plants using digital chlorophyll meter called *CCM 200 plus Chlorophyll Content Meter*.

3. Results and Discussion

Table 1 indicated there was no significant effects of liquid fertilizers on leaf numbers, shoot fresh weight, and root dry weight of Lettuce, also on chlorophyll contents of lettuce and red spinach. The application of LFGM + AB-Mix (v/v: 1:3) resulted in the highest shoot fresh weight, dry weight, and chlorophyll content of Mustard green. In general, the application of goat manure liquid fertilizer combined with AB-Mix in ratio 1:1-3 (v/v) resulted in the similar plant growth compared to control (AB-Mix application) on foliage vegetables. These results indicated that the quality of goat manure liquid fertilizer is good. An experiment conducted by Sunaryo *et al.* [14] showed that the nutrient content of the goat manure was in the range of standard recommended by the Regulation Minister of Agriculture Republic Indonesia [15].

The application of LFGM + AB-Mix (v/v: 3:1) resulted in the lowest shoot fresh weight, shoot dry weight, and root dry weight of Mustard green as well as shoot dry weight of Lettuce. The application of LFGM + AB-Mix (v/v: 3:1) on Red spinach resulted in the lowest shoot fresh weight and shoot dry weight.

There was an interaction between the application of liquid fertilizers and kinds of foliage vegetables on R/S (root/shoot) ratio (Table 2). Red spinach had the lowest R/S ratio, whereas the highest R/S ratio was gained on lettuce with both applications of LFGM + AB-Mix (v/v: 3:1) and application of A/B mix. These results indicated that the application of LFGM + AB-Mix (v/v: 1:1, 1:3, and 3:1) and AB-Mix on Red spinach resulted in better assimilate partitioning to the shoot compare than that of Mustard green and Lettuce.

Table 1. Effects of liquid fertilizers on Mustard green, Lettuce, and Red spinach growth

Plants	Treatments	Leaf numbers	Shoot fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Chlorophyll content (%)
P1	A	16.44 ab	132.47 b	11.59 b	1.60 b	17.12 b
	B	18.44 a	155.23 a	14.63 a	2.08 a	20.00 a
	C	15.22 b	99.07 c	9.27 c	1.27 c	16.88 b
	D	17.67 a	125.20 b	11.13 b	1.56 b	16.69 b
$\rho > F$		0.0284	0.0031	0.0005	0.0006	0.0578
P2	A	13.44 a	79.03 a	3.30 ab	0.47 a	4.50 a
	B	12.77 a	81.66 a	3.80 a	0.58 a	6.11 a
	C	13.11 a	66.72 a	2.51 b	0.45 a	4.90 a
	D	13.32 a	75.33 a	3.17 ab	0.58 a	4.80 a
$\rho > F$		0.9809	0.8799	0.0626	0.3101	0.2794
P3	A	18.11 bc	108.61 a	16.44 a	2.01 a	15.39 a
	B	20.66 a	126.28 a	19.19 a	2.10 a	16.84 a
	C	16.78 c	83.31 b	12.69 b	1.56 b	15.27 a
	D	19.33 ab	106.51 a	16.23 a	1.86 ab	15.25 a
$\rho > F$		0.0011	0.0067	0.0064	0.0529	0.2935

Mean followed by the same letter in the same column is not significantly different at $\alpha=5\%$ level by DMRT

P1: Mustard green, P2: Lettuce, P3: Red spinach

A: LFGM + AB-Mix (v/v: 1:1)

B: LFGM + AB-Mix (v/v: 1:3)

C: LFGM + AB-Mix (v/v: 3:1)

D: A/B mix

Table 2. The interaction between the application of liquid fertilizers and kinds of foliage vegetables on R/S ratio

Treatment combination	P1 (Mustard green)				P2 (Lettuce)				P3 (Red spinach)				Interaction $\rho > F$
	A	B	C	D	A	B	C	D	A	B	C	D	
R/S ratio	0.138	0.142	0.137	0.139	0.139	0.152	0.181	0.182	0.122	0.109	0.123	0.114	0.0003
	bc	b	bcd	b	b	b	a	a	de	e	cde	e	

Mean followed by the same letter is not significantly different at $\alpha=5\%$ level by DMRT A: LFGM + AB-Mix (v/v: 1:1)

B: LFGM + AB-Mix (v/v: 1:3)

C: LFGM + AB-Mix (v/v: 3:1)

D: A/B mix

4. Conclusion

The combination of goat manure liquid fertilizer with AB-Mix in ratio 1:1-3 (v/v) resulted in similar plant growth as control (AB-Mix application) at all vegetables, and the highest chlorophyll content at Mustard green, while the combination with AB-Mix (v/v: 1:1, 1:3, and 3:1), and AB-Mix resulted in better assimilate partitioning to the shoot of red spinach.

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