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Using animal manure to grow lettuce (*Lactuca sativa* L.) in a Homemade Hydroponics System

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Abstract

A Homemade Hydroponics System (HHS) using a continuous solution and air flow system is easy to build, cost saving and eco-friendly when using animal manure as a source of hormones and nutrients in agricultural production. Lettuce (*Lactuca sativa* L.) was set as a plant model and suspended in a manure solution with a foam platform in a reused foam box, and an air pump was used to provide aeration. Five liquid treatments were investigated on the yield of lettuce: three manures (bat, cattle, pig), commercial chemical fertilizer and groundwater in HHS for 49 days. The pH and temperature did not differ between treatments, but the EC was highest in chemical fertilizer followed by bat manure. Yield was highest (125 gram per plant) with chemical fertilizer closely followed by bat (119 gram per plant), cattle (44 gram per plant) and pig (40 gram per plant) manure. The results confirm that bat liquid manure can use in place of chemical fertilizer for lettuce production in HHS. Moreover, bat manure also has the lowest cost production (0.4 Baht per litre) due to a bat cave being near the experimental area. The usefulness of other animal local manures should be investigated further.

Keywards: animal manure, Homemade Hydroponics System, lettuce, plant growth

1. Introduction

Plants in soil have to rely on many factors such as the physical climate, availability of water, presence of pests and disease organisms, weeds, and soil structure and chemistry for their growth and crop yield. Hence, hydroponics is widely used to produce many vegetables (tomato, lettuce, cucumber and pepper) and ornamental crops (herbs, rose, freesia and foliage plants) (1). However, a hydroponic system uses a chemical solution as a fertilizer. Where the nutrients are not captured or recycled, the unused nutrients can contribute to environmental pollution, destroying the balance of the ecosystem (2). Nowadays people are much more concerned for their health to consume good and clean plants which are free from chemical residues. Organic foods have become popular because they are perceived to be environmentally friendly, and the cost of production can be low if there is a good local source of nutrients, especially animal manures (2, 3, 4).

Sukhothai province, Thailand has plenty of animal manure such as bat, cattle and pig. Presently, tilization of these manures is limited in farming in this region. The objective of this study is to add value to local manures by evaluating their effectiveness on growth of lettuce (*Lactuca sativa* L.) as a plant model.

2. Materials and Methods

This research was conducted as an experimental study to test the effect of several manures of local animal in Phitsanulok and Sukhothai province on growth of lettuce in Homemade Hydroponics System (HHS).

2.1 Experimental design

Homemade Hydroponics System using a continuous solution and air flow system was set for planting lettuce seedlings to be suspended in a manure solution by a foam platform in a reused foam box and used air pump to provide oxygen. Completely Randomized Design for 5 treatments including groundwater (negative control), chemical fertilizer (www.hydroponics.in.th), bat liquid manure (from Chao Ram cave, Sukhothai province), cattle liquid manure and pig liquid manure (from organic farm feeding at Thung Saliam, Sukhothai province) were tested under the plastic roof greenhouse for 49 days. Each treatment had 8 replications (Figure 1).

2.2 Preparation of manures and HHS setting

Animal manures were air dried and ground in a chamber. Each manure was mixed and fermented in groundwater for 24 hours in ratios of 1:50. After that, filtered though a thin white cloth and diluted a solution with groundwater in ratios of 1:3. Then, put the diluted solution into a hydroponic Foam tank (45x60x30 cm) using HHS. Lettuce seedlings were grew in sterilized sand and only uniform growth in height of lettuce seedlings (2 cm) were selected to the experiment.

2.3 Yield quality analyses

Quality form (colour and lettuce components), electrical conductivity, pH and solution temperature of each treatment were recorded every 7 days using a handheld EC probe (WP-84, TPS Pty Ltd, Australia) and a volumetric cylinder (5). The fresh weight was measured in the end. Furthermore, cost of each animal manure was calculated on gram per litre and compared with chemical fertilizer and groundwater.

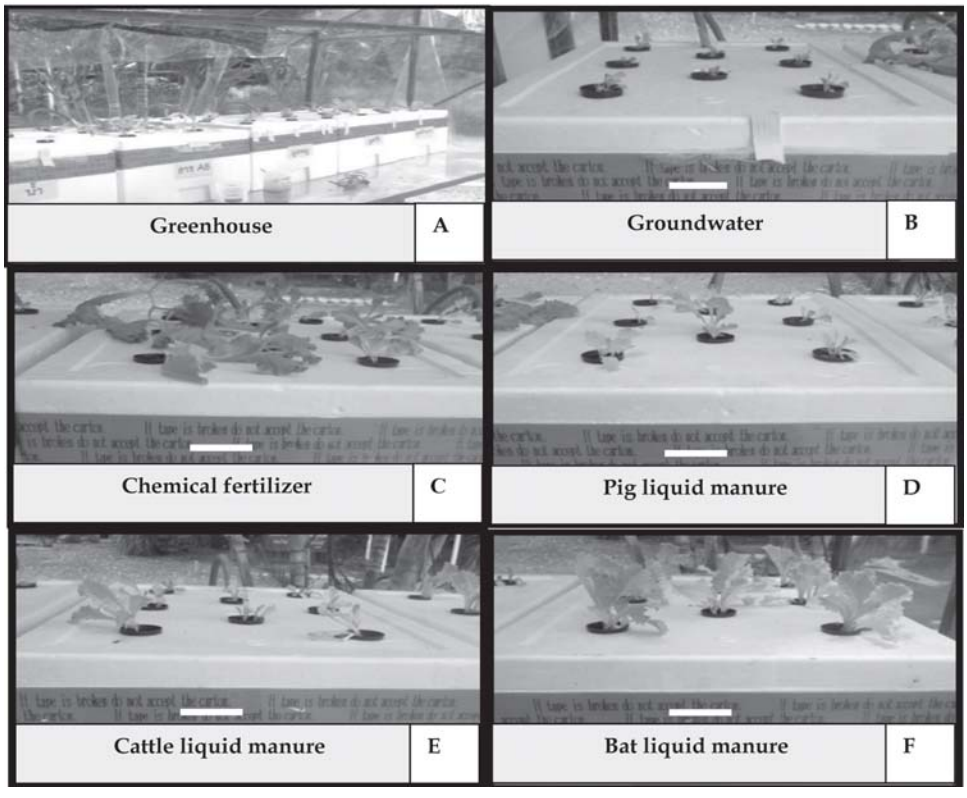

Figure 1. Lettuce growth in different nutrient solutions (B-F) within a greenhouse for 49 days (A), white bar = 10 cm.

2.4 Data Analysis

Statistic analysis used SPSS version 11.5 (SPSS Inc., Chicago, USA) to calculate mean ± standard deviation of fresh weight and compared homogeneity of variance using Tukey test of each treatment.

3. Results and Discussion

The cost of each treatment was calculated and compared. Bat manure is lowest cost (0.4 baht/litre) following by cattle (0.5 baht/litre) and pig manure (0.6 baht/litre). The commercial chemical fertilizer has highest price (3 baht/litre) (Table 1). All manure has a lower cost production than chemical fertilizer especially local animal manure. It is cheaper and easier to get in a production area because it has huge quantities in their area. Then, it may have a small demand to use for other objectives. Normally, local manures are given free or sold in a low price while commercial chemical fertilizer need to be bought or ordered from the merchant. Using local manure as a hydroponic solution for growing plant is an added value on farm residues.

Table 1. Cost of nutrient solutions

Nutrient solution	Cost (Baht/litre)
Groundwater (- control)	0a*
Chemical fertilizer (+ control)	3c
Bat	0.4b
Cattle	0.5b
Pig	0.6b

*The same letter in each column means that there were no significant differences at Pd"0.05 using Tukey's test.

Manure needs to ferment for 24 hours before use due to it can get rid of some toxins and release nutrients in manure especially nitrogen which is important on plant growth (6) needs to go through mineralization before it becomes available for plants, the remaining 25 to 50% is ammonium (NH_4^+), which is highly susceptible to volatilization (6, 7). Every week, nutrient solution properties were observed. pH 8.0 and temperature 25°C were found in every nutrient treatment solution. pH was not different between treatments. Because in the same temperature could release the same nutrients to solute in all liquid manures. As pH is a measure of the hydrogen ion concentration, a change in the temperature of a solution will be reflected by a subsequent change in pH (8).

Electrical conductivity (EC) is an indirect indication of the strength of nutrient solution. The higher EC hinders nutrient absorption due to increase the osmotic pressure whereas lower EC may strictly affects on plant health and yield (9). For example high EC values have the negative effects of salinity on reductions in fruit weights of tomato by 10% with 5.0 - 6.0 dS m^{-1}, by 30% with 8.0 dS m^{-1} and by 40% with over 10.0 dS m^{-1} were compared with the normal values 2.5-3.0 dS m^{-1} (10) and lettuces were found that fresh and dry weights decreased significantly after increasing EC of nutrient solution (11). In this study, EC was highest in chemical fertilizer (615.5 µS/cm) followed by cattle liquid manure (311.3 µS/cm), pig liquid manure (302.0 µS/cm), bat liquid manure (290.0 µS/cm) and groundwater (241.5µS/cm) respectively (Table 2). Different source of animal manure affected to EC level. It may come from the particular food and their metabolism of each animal. Bat eats insect and plant while cattle and pig eat only plant. Bat manure definitely has various nutrients more than cattle and pig manures. The high EC level shows a lot of available nutrient solute in their solution. For the manure solutions were very diverse. Even an EC value of bat, cattle and liquid solution have a small difference but bat liquid solution gave a higher fresh weight more than others. Concern with the fresh weight may predict that plant cannot use all solute nutrients for their growth, although bat manure can give a good one for them. However, the stage of alternation of generations of plant needs a difference EC level such as in tomato (*Solanum lycopersicum*). During the vegetative growth stage, high

EC level (8.4/14.3 dS m^{-1} inflow/efflux solution) reduced leaf conductance and transpiration rate by 28% and 29%, respectively, compared with low EC treatment (2.3/5.9 dS m^{-1}), regardless of cultivar. Then, during reproductive growth stage, EC level is not significantly affect the transpiration rate (9). So, the optimum EC level need to concern and specific on plant type.

Table 2. Electrical conductivity in nutrient solutions after 49 days

Nutrient solution	EC (μS/cm)
Groundwater	241.5±1.3a*
Chemical fertilizer	615.5±2.1e
Bat	290.0±1.8b
Cattle	311.3±1.3d
Pig	302.0±2.2c

*The same letter in each column means that there were no significant differences at ≤0.05 using Tukey's test. Values are mean ± standard deviation (n=8)

Table 3. Fresh weight of lettuce grown in five nutrient solutions for 49 days

Nutrient solution	Leaf number	Fresh weight (gram)
Groundwater	5.6±1.8a	12.5±0.6a*
Chemical fertilizer	8.0±3.3b	125.0±6.1e
Bat	8.2±3.7b	118.8±0.4d
Cattle	7.8±3.2ab	43.8±0.7c
Pig	7.6±3.3ab	40.0±4.8b

*The same letter in each column means that there were no significant differences at ≤0.05 using Tukey's test. Values are mean ฑ standard deviation (n=8)

Form quality of lettuce in bat liquid manure and chemical fertilizer are healthy with good shape, bright green colour and high leaf number more than others. Bat liquid manure shows high fresh weight (mean 119 gram per plant) more than cattle liquid manure (mean 44 gram per plant) and pig liquid manure (mean 40 gram per plant) but less than chemical fertilizer (mean 125 gram per plant) significantly (≤ 0.05) (Table 3). All lettuces in bat liquid manure have a good shape and normal colour. It may have adequate nutrient levels in manure solution such as nitrogen, phosphorus, potassium and Zinc (10, 12).

Poultry manures have higher levels of plant nutrient concentrations (nitrogen, phosphorus and potassium) than other types of livestock and also have higher calcium, magnesium and sulfur than other manures (13). In this study bat liquid manure gave the good result for plant promotion more than pig and cattle manure. The plant nutrient content of animal manures varies with animal species and among animals of the same species. The chemical analyses can use to predict accurately the plant nutrient input from a given application of animal manures to the solution or land. The several factors may affect the mineral composition of animal manure and influence its efficiency of use as a fertilizer including 1) animal size and species; 2) housing and rearing management; 3) ration fed; 4) storage, hauling, and spreading methods; 5) rate of manure applied and 6) climate (13). The multiplicity of factors and their possible interactions make the prediction of fertilizer value of animal manures are uncertain but it has essential nutrients (ammonium-NH_4^+, phosphorus (P_2O_5), and potassium (K_2O) etc.) and micronutrients for crop production. Using animal manures is about the environmental care, safe and low cost production more than chemical fertilizers (14).

4. Conclusion

A Homemade Hydroponics System (HHS) was developed and used for nutrient recovery from liquid manures and for producing value added products. Fresh weight of lettuce produced with bat liquid manure was 94% that obtained with chemical fertilizer showing that this natural nutrient source can be used in place of chemical fertilizer for lettuce production in HHS. However, the supply of bat manure is limited so other local manures,

such as bird, chicken, horse etc., should be evaluated to determine whether they can provide a balanced nutrient supply for production of hydroponic vegetables.

Suggestions

1) The concentration of bat liquid manure should be investigated further in order to define the optimum conditions for lettuce growth.

2) The nutrient supply characteristics of other animal manures in local areas should be determined in order to identify suitable new biofertilizers for HHS.

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