INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 18, No. 1, p. 93-101, 2021

RESEARCH PAPER OPEN ACCESS

Evaluation of Different Growing Substrates on Lettuce (*Lactuca sativa*) under Non - Circulating Hydroponic System

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Key words: Lettuce, Rock wool, Coco coir, Sawdust, substrates.

http://dx.doi.org/10.12692/ijb/18.1.93-101 Article published on January 20, 2021

Abstract

Hydroponic technology has many benefits that it is highly productive and conserves water and land most especially if natural resources are scarce. Normally, plants grow inside a greenhouse that controls temperature, light, water and nutrition. The study was conducted to evaluate the performance of different growing substrates on lettuce under a non-circulating hydroponics system. It was conducted at Cagayan State University – Piat Campus from September to October 2019. The Completely Randomized Design (CRD) with four replications was used to test the following treatments: T_1 – Rockwool, T_2- Coco peat, T_3 – Carbonized Rice Hull (CRH) and T_4 – Sawdust. Results show that plants under coco coir (T_2)–obtained the tallest and longest roots while the most number of leaves and heaviest fresh biomass was registered in rock wool (T_1). In terms of water pH, the result revealed no significant differences among treatment means. In the absence of rock wool, the coco coir can be used as an alternative as growing substrates for a non-circulating hydroponics system since they did not differ significantly.

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Introduction

The world's population increased greatly in the last few decades. The improvement of living standards in many countries increased with the great demand for high-value crops, off-season supply, and high-quality products. Therefore, the quality of life (QOL) of people increased considerably. In this regard, protected agriculture which is a labor-intensive industry can produce a higher amount of food for the increased population of the world. The efficiency and quality of the agricultural products can be increased through the modifications of the environmental controls, management of culture systems, and the use of technological innovations.

One of the technological innovations is the hydroponics system, which is a modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. Possibly it is the most intensive culture system utilizing all the resources efficiently for maximizing the yield of crops and the most intense form of agricultural enterprises for commercial production of greenhouse vegetables (Jensen, 1997; Dorais *et al.*, 2001, Grillas *et al.*, 2001).

Lettuce is an important vegetable commodity and in demand by the local markets throughout the year. This popularity has led to an increase in lettuce production and consumption in urban areas since it has become popular as a vegetable salad (Maboko and Du Plooy, 2008). Lettuce is normally consumed raw and has a high nutrient value, being rich in calcium, iron, and vitamin A. It is a good source of vitamins and popular food for weight-conscious consumers because of its low kilojoule content (Niederwieser, 2001; Maboko, 2007). Lettuce is easily adapted to the hydroponics culture system.

Moreover, the suitability of different substrates in the successful vegetable establishment and their effect on growth, yield, and product quality has been extensively investigated by many researchers around the world. However, only a few pieces of research have been conducted for the improvement of horticultural crop quality in different substrates. Recent reviews suggested that changes in quality parameters of horticultural crops are influenced by the use of growing substrate (Gruda, 2009).

With this information, therefore, growing media or substrates is an available strategy for advocating judicious for sustainable lettuce production. This study was conducted to assess the performance of hydroponically grown lettuce using different growing media. The positive result of this study will benefit lettuce growers and will be introduced also to areas with limited space. Hence, this study.

Generally, the study aimed to evaluate the performance of growing lettuce under different growing substrates under a non-circulating hydroponics system. Specifically, the study aimed to: (1) determine the nutrient composition and concentration of the nutrient solution; and (2) evaluate the agronomic and yield components of lettuce applied with different substrates.

Materials and methods

The following materials were used in the study: lettuce seeds, SNAP solution, fruit styro box, plastic styro cup, measuring device (graduated cylinder and ruler) cutter, water, coco peat, sawdust, rockwool and carbonized rice hull.

Experimental Design and Treatments

The Completely Randomized Design (CRD) was used and it was replicated 28 times using the 28 boxes with 8 plants in each planting box to test the following treatments:

T_1 – Rockwool

T_2- Coco peat

T_3 – Carbonized Rice Hull (CRH)

T_4 – Sawdust.

Preparation of seedlings and growing boxes

Establishing the Seedlings

Fill the sowing tray with a layer of the growing media at 1 inch thick and level the media. Scatter the small seeds of lettuce uniformly and thinly and water liberally every day until the seeds will germinate at 3-5 days. Grow the seedlings under the sun for 7 to 14 days before transferring them to individual growing cups (seedling plugs).

Preparing the Growing Boxes

Make 8 holes on the lid or cover of the box using the tin can borer (Fig. 1). Use the plastic bag as the liner of the bottom half of the box to make it fit to hold the nutrient solution (Fig. 2). Use packaging tape to close all the open slits of the lid/cover to prevent the entry of mosquitoes (Fig. 3).

Preparing the Seedling Plugs

Prepare the Styrofoam, use the serrated knife or saw to make 4 – 6 slits (about 2 inches long on the side and including about ½ inch at the bottom). Fill in the holding cups with the growing media (about 1 inch thick). Transplant a seedling from the sowing tray. "Dig" a hole in the middle of the growing media in the cup (Fig. 4). Use the bamboo stick to uproot the seedlings from the sowing tray with care.

Transfer only one (1) seedling per cup. Lightly press the media around the base of the transplanted seedling. Water carefully the seedling plugs.

Methods of analyzing the nutrient composition

The samples of extracts were collected and submitted to the Cagayan Valley Integrated Agricultural Laboratory at Tuguegarao City as the basis for nutrient formulation. Table 1 shows the mineral composition and concentration of the nutrient solution and they were analyzed using the different methods: Nitrogen – *Kjeldahl Jauber - Gunning*, Phosphorus - *Vanadomolybdate*, Potassium – *Flame Atomic Emission* while micronutrients were analyzed using *Atomic Absorption Spectrophotometric*.

Care and management of the crop

The nutrient solution to water ratio remained consistent at 25ml in every 10 liters of water. The pH was monitored for every replacement of the solution. Daily monitoring of the occurrence of insect pests was strictly monitored.

Harvesting

Harvesting was done at 30 days after transplanting. Plant samples were tag just at harvest to avoid intermixing of samples.

Data gathered

Plant Height (cm). Ten representative sample plants were used to measure the height of the plants at weekly intervals. The total plant height was divided by ten to get the average height per plant.

Number of Leaves. The leaves of the plants were counted at harvest. The total number of leaves of the sample plants was divided by ten to get the average number of leaves per plant.

Root Length (cm). The length of roots of the sample plants was measured using the foot rule. Fresh Weight per Plant (g). The weight of the sample plants was weighed using the digital weighing balance.

Water pH. The pH of every treatment was observed at a weekly interval using the pH meter.

Statistical analysis

The data were analyzed using STAR, version 2.0.1 2014. Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna following procedures for analysis of variance (ANOVA) for Complete Randomized Design (CRD) to test the significant differences among treatments. The Least Significance Difference (LSD) test was also used to analyze mean comparisons.

Results and discussion

Plant height at maturity

The plant height as affected by different growing substrates is presented in Fig. 5. The plants are grown in coco coir (T_2) produced the tallest plants with a mean of 27.91 centimeters, closely followed by the plants grown in rock wool (T_1) with a mean value of 19.60 centimeters. The plants cultured in carbonized rice hull (T_3) produced a mean of 23.23 centimeters and the shortest plants were produced from the sawdust (T_4) with a mean of 22.45 centimeters.

Table 1. Mineral composition and concentration of the nutrient solution.

	Nutrient Content						
Materials	N (%)	P (%)	K (%)	Zinc (ppm)	Copper (ppm)	Manganese (ppm)	Iron (ppm)
SNAP Solution A	0.07	0.64	3.84	1	2.5	17.5	1
SNAP Solution B	0.04	1.89	0.01	12.5	10	3225	160

Analysis of variance reveals a significant difference among treatments tested. The significant result among treatments may be due to the reason that the substrates possess less water retention capacity (Tian *et al.*, 2012). Jayasinghe (2012) mentioned that when there are a lot of larger particles, it results in excessive aeration and inadequate water to be retained, whereas when the fine particles are excess, the pores can be clogged which reduces the porosity aeration.

Further, a substrate's particle size distribution is important as it determines the pore space, gas exchange and water retention capacity (Abad *et al.*, 2001) which improves the plant's growth.

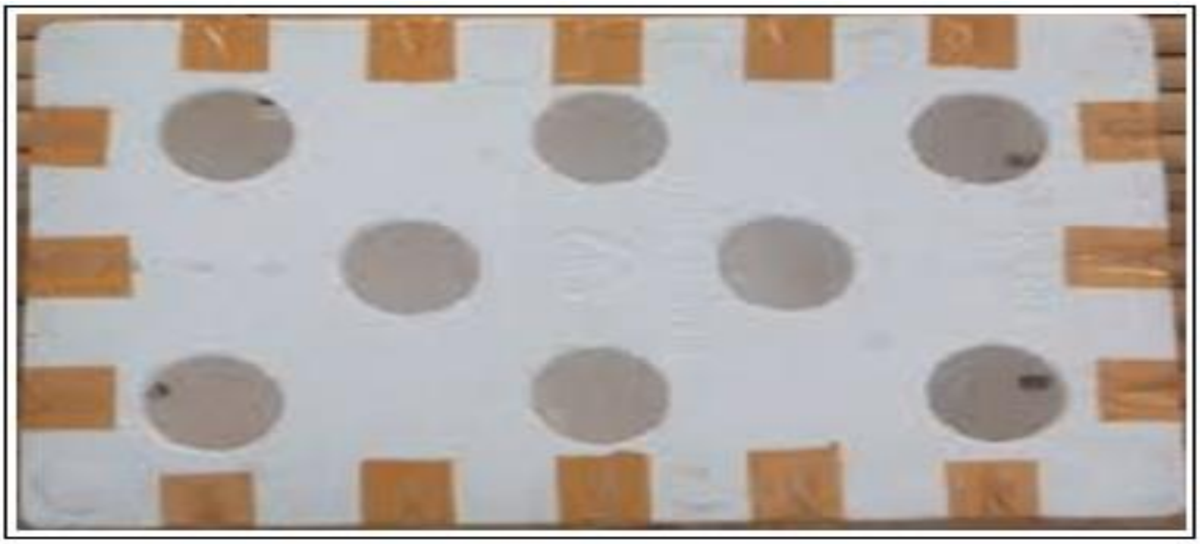

Fig. 1. Eight (8) holes on the lid or cover of the box.

Fig. 2. Plastic bag as the liner of the bottom half on the box.

Number of leaves

The average number of leaves as affected by different growing substrates is presented in Fig. 6. The plants are grown in rock wool (T_1) produced the most number of leaves with a mean of 17.25. It was followed by the plants grown in coco coir (T_2) with a mean value of 16.25. The plants are grown in carbonized rice hull (T_3) produced a mean of 14.25.

Fig. 3. Use packaging tape to close all the open slits of the lid/cover.

Fig. 4. Transfer only one (1) seedling per cup.

The least number of leaves was produced from the sawdust (T_4) with a mean of 13.25 centimeters. Results showed significant variation among treatment means. This result confirms the study of Shinohara (1999), who reported that growth, yield and fruit quality of tomato grown in coconut fiber were not different from those grown in rock wool. At maturity, the average number of leaves is within the range of 10-12 fully developed true leaves for lettuce as described by Kristkova *et al.* (2008) which suggests a normal growth of the plants. The average width of leaves at harvest (4 weeks after planting) which is <25 cm can be classified as small based on the morphological descriptors of lettuce as described by Kristkova *et al.* (2008).

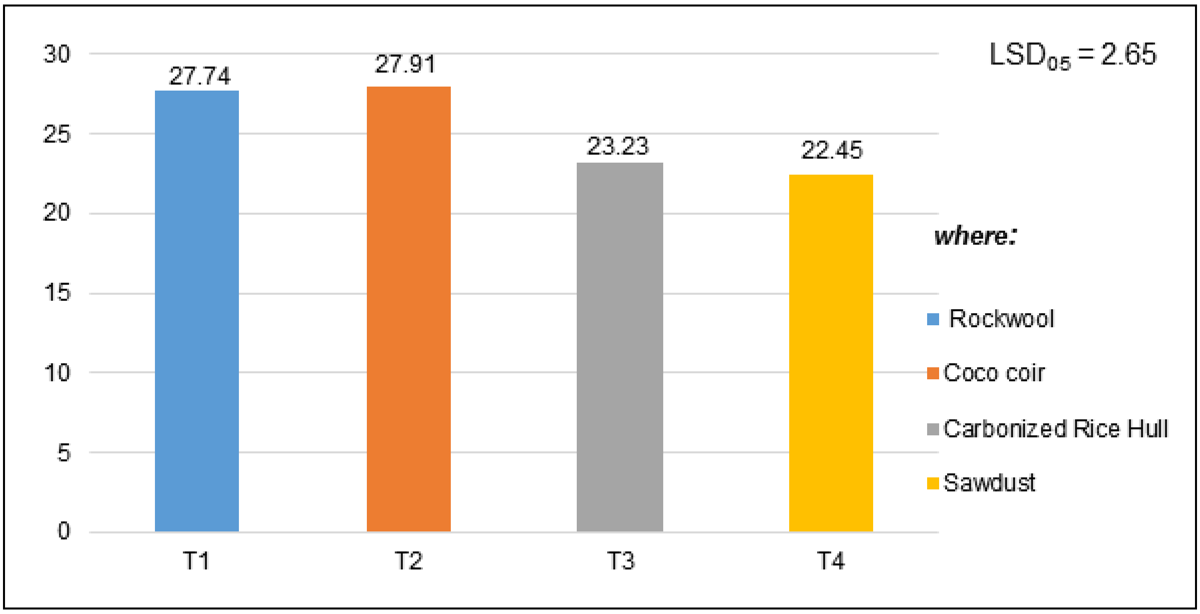

Fig. 5. Plant height (cm) of lettuce as affected by different growing substrates under non-circulating hydroponics system.

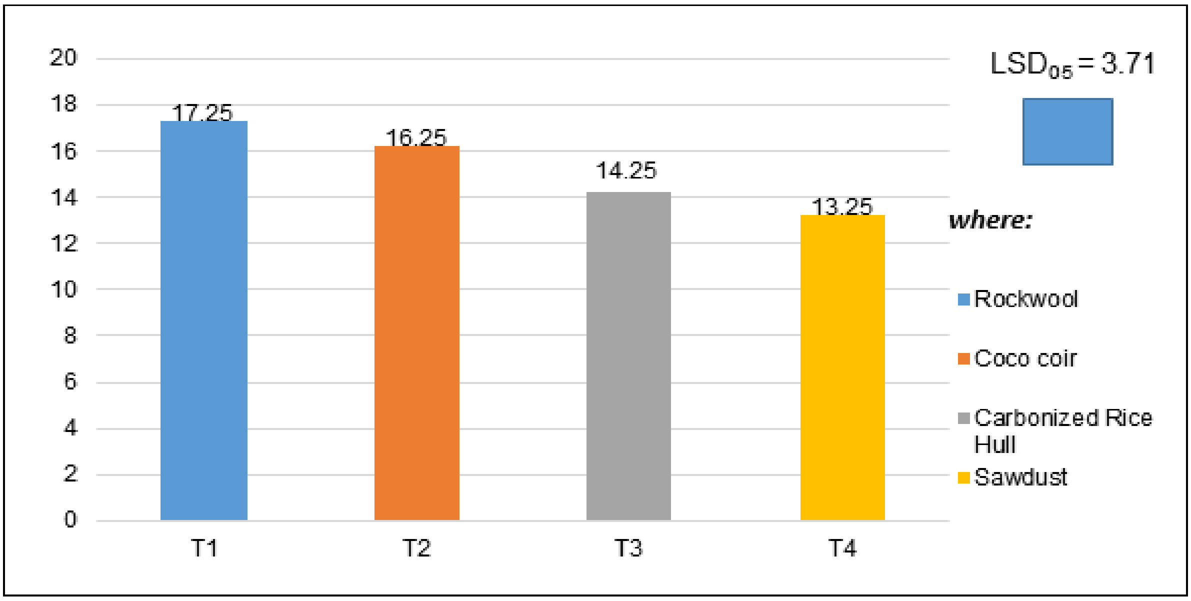

Fig. 6. Number of leaves of lettuce as affected by different growing substrates under non-circulating hydroponics system.

Root length (cm)

Fig. 7 shows the average length of roots as affected by different growing substrates Results revealed significant differences among treatment means. The plants are grown in coco coir (T_2) and rock wool (T_1) produced the longest roots with a comparable mean value of 33.03 and 32.4 centimeters. It was followed by the plants cultured in sawdust (T_4) and carbonized rice hull (T_3) solution with a comparable mean value of 26.44 and 25.33 centimeters. Analysis of variance reveals significant differences among treatments. These results may be attributed to coco coir as organic plant material, it breaks down and decomposes very slowly, so it won't provide any nutrients to the plants growing in it, making it perfect for hydroponics. Coco coir is also pH neutral, holds moisture very well, yet still allows for good aeration for the roots. Ma and Nichols (2004) also demonstrated that the phytotoxicity was attributed to the phenolic compounds in the coconut-coir substrates and was severely inhibited root growth of lettuce.

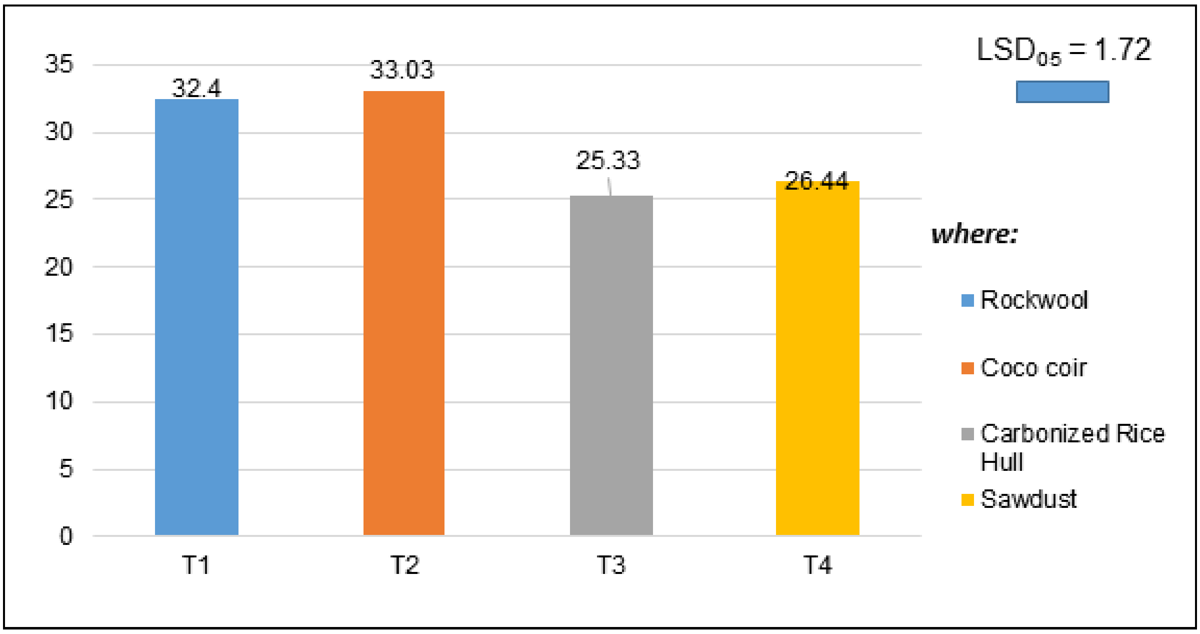

Fig. 7. Root length (cm) of lettuce as affected by different growing substrates under non-circulating hydroponics system.

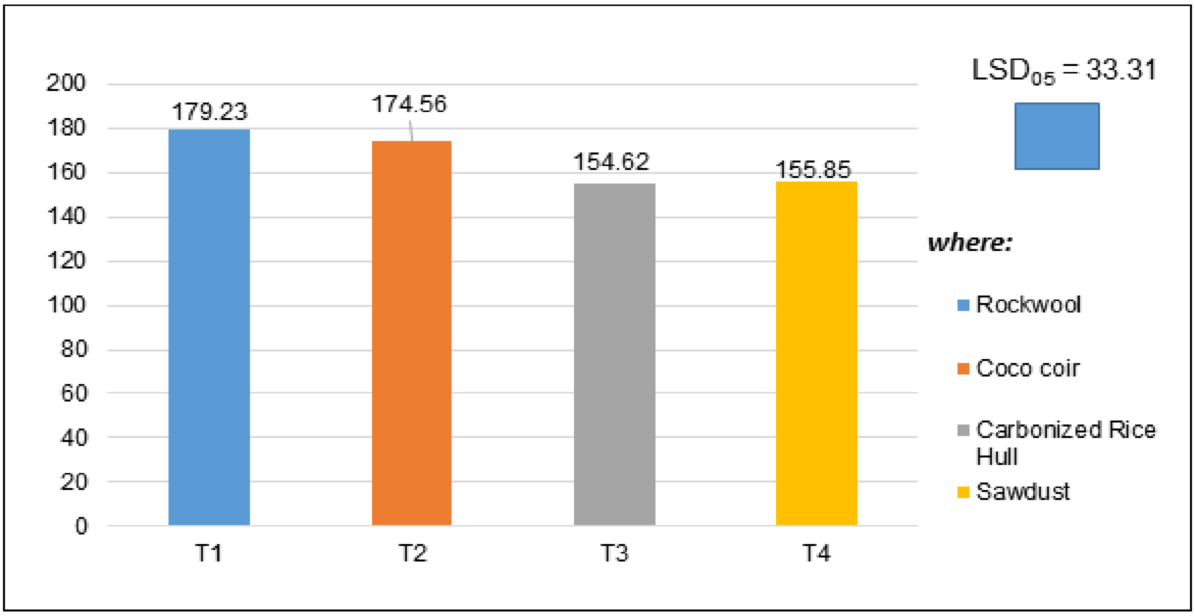

Fig. 8. Fresh weight (g) of lettuce as affected by different growing substrates under non-circulating hydroponics system.

Fresh weight (g)

The fresh weight per plant as affected by the different growing substrate is shown in Fig. 8. Results revealed significant differences among treatment means in the fresh weight per plant. The plants are grown in the rock wool (T_1) produced the heaviest plant with a mean value of 179.23 grams followed by the coco coir (T_2) with 174.56 grams and the least in fresh weight was produced from the sawdust (T_4) and carbonized rice hull (T_3) with a comparable mean value of 155.85 and 154.62 grams, respectively. The variation among treatments is the same with the number of leaves wherein the more number of leaves produced the heavier in fresh biomass. Ghehsared (2012) results of last investigations showed that coconut fiber was sufficient substrates for the growth of some plants especially for vegetables and growers use these materials as growing media in greenhouse cultures that possibly produce the most number of leaves and fresh biomass.

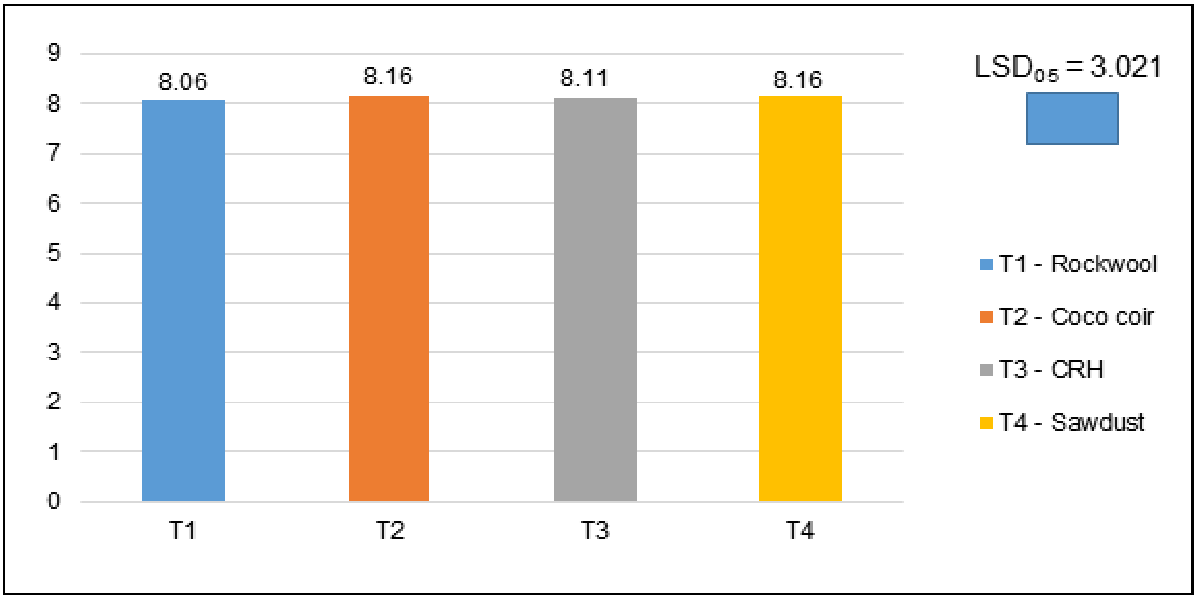

Fig. 9. Water pH as affected by different growing substrates on lettuce under non - circulatinghydroponics system.

pH of the growing substrates

The average weekly pH under different growing substrates is shown in Fig. 9. No variations were noted on the different growing substrates wherein all treatments will range from 8.06 to 8.16. All the growing medium obtained pH values of alkaline which means that the availability of nutrients from the growing solution is dependent on the pH of the solution. The alkalinity is an important water quality parameter that needs to be closely monitored in hydroponic systems (Timmons & Ebeling, 2013; Reed, 2006).

Conclusion

Based on the result of the study, coco coir obtained the tallest and longest roots per plant while the most number of leaves and heaviest fresh biomass was registered in rock wool that gives a significant difference among treatments. In terms of water pH, the result revealed no significant differences among treatment means. In the absence of rock wool, the coco coir can be used as an alternative as growing substrates for a non-circulating hydroponics system since they did not differ significantly.

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