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Head Lettuce *(Lactuca sativa* L., Asteraceae) Production in a Non-Circulating Hydroponic System Under the Climatic Condition of Biliran, Philippines: A Preliminary Investigation

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Abstract

This study explored head lettuce *(Lactuca sativa* L., Asteraceae) production in a non-circulating hydroponic system under the climatic conditions of Biliran, Philippines. One-sample t-test was used to compare the experimental yield of head lettuce with the reported average yield of 3 kg/m^2 in lettuce growing areas of the Philippines under the conventional production system. Result revealed that the experimental marketable yield of 2.92 kg/m^2 is comparable to the reported average yield of lettuce. Preliminary result indicates the possibility of head lettuce production in a non-circulating hydroponic system under the outdoor environment of Biliran, Philippines.

Keywords: head lettuce, SNAP hydroponics system, Biliran, vegetable production, warm climate

Introduction

Head lettuce *(Lactuca sativa* L., Asteraceae) is a high-value vegetable known to thrive well only in cool, high-altitude areas (PCARRD, 1999). Maynard and Hochmuth (2007) reported that head lettuce grow best between 15^{0}C and 18^{0}C. Biliran province with most arable land situated in lowland areas with relatively warm climate (temperature range of 23^{0}C to 32^{0}C [World Weather Online, 2014]), and Eastern Visayas in general is a nontraditional lettuce producing region. As of 2008, the area devoted to lettuce production in Eastern Visayas is only 2 hectares with an average production from 2003 to 2008 of only 1.13 metric tons per hectare (Bureau of Agricultural Statistics, 2009). The region having the highest production per hectare (from year 2003- 2008) is Northern Mindanao which averaged to 9.77 metric tons per hectare.

The need to enhance food production prompted the agricultural sector to explore different ways to maximize crop production. One of the studies undertaken by researchers is the conduct of adaptability trials to evaluate the performance and viability of producing a nontraditional crop in a certain area using some technology interventions. Nowadays, technologies have been developed to make crop production possible in areas which are not suitable to traditional farming system due to different factors such as undesirable climatic conditions, fresh water scarcity, and problematic soil condition. Hydroponics is one of the technologies utilized in areas not suitable to traditional farming system. Hydroponics is a system of growing plants in a soilless nutrient solution. Usually done under a protective structure (e.g. plastic houses and greenhouses), it allows for uninterrupted vegetable production even during off-season (Santos & Ocampo, 2009). This study attempted to establish the possibility of raising head lettuce in a non-circulating hydroponics under the outdoor environmental condition of Biliran.

Raising lettuce in a floating hydroponic system, Thompson et al. (1998) revealed that the plant could be grown in warmer geographic areas by optimizing root zone

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temperature and did found out that quality lettuce growth could be attained even at elevated temperatures when the optimal pond or root temperature is 24^0C. Senillo (2004), using a non-circulating hydroponic system successfully raised head lettuce inside the screen house of the Visayas State University in Baybay, Leyte, Eastern Visayas.

As a cool-season crop, most studies have been conducted on head lettuce in warm regions under controlled greenhouse conditions. Not much published information is available on the performance of head lettuce in hydroponics under a warm climate such as in Biliran. In this study, a field experiment was conducted to assess the growth and yield of head lettuce under Biliran condition. The yield of head type lettuce in hydroponics under Biliran outdoor condition was compared to the established yield in traditional head lettuce-growing areas in the Philippines.

Materials and Methods

Study Site and Climatic Condition

The study was conducted inside the campus of Naval State University-Biliran, Biliran Province ($11^0$28'30"N, $124^0$28'08 "E) from February 1 to 28, 2013. The site was free from any obstructions and was open to sunlight anytime of the day. During the period of experiment, the climatic condition of Biliran is relatively dry with daytime temperature that ranges from 24^0C in early morning to 32^0C in the middle part of the day.

The hydroponics System

The study used the SNAP hydroponics system, a non-circulating hydroponics system developed by the Physiology Laboratory of the Institute of Plant Breeding in the University of the Philippines Los Baños College, Laguna and the Bureau of Agricultural Research of the Department of Agriculture (Santos and Ocampo, 2002). SNAP hydroponics system was chosen because of its simplicity and applicability in isolated areas such as island villages without any conventional power source. SNAP hydroponics utilizes passive aeration system and does not need any pump to circulate the nutrient solution on the roots of the plants.

Used Styrofoam boxes of imported grapes having an inside dimension of 56.0 cm length by 35.5 cm width by 9.0 cm deep were utilized as the hydroponics growing boxes. Transparent plastic bags measuring 20 inches x 30 inches were used as liners of the growing boxes to hold the nutrient solution.

The seedling plug which was used to hold the aggregate material and to serve as plant anchorage was an 8-ounce styrofoam cup with 8 equally spaced holes in the corner of the bottom. The top cover of the growing box was provided with 8 holes enough to fit and hold the top of the seedling plug. In this study, sterilized coco coir dust was used as the aggregate material. Figure 1 shows the schematic detail of the growing box. At 8 plants per growing box, the system has a planting density of about 40 plants/m^2.

A transparent UV-stabilized plastic roofing was provided primarily to shield the hydroponic system from rain. The support structure is made of bamboo and has a floor area of 30 sq. meters (10 m length x 3m width). The structure is open at the sides to allow free circulation of air towards the plants (Figure 2).

Planting and Harvesting Procedures

Iceberg variety of head lettuce was used as planting material in this study. Lettuce seeds were sown on a styropor seedbed containing 1-inch thick coco coir dust. The seedbed was kept moist by watering it with tap water. The seedlings were allowed to grow for 12 days inside the protective structure before transplanting to individual growing cups or seedling plugs. Twelve days after sowing, the emerged seedlings have already developed 3 leaves.

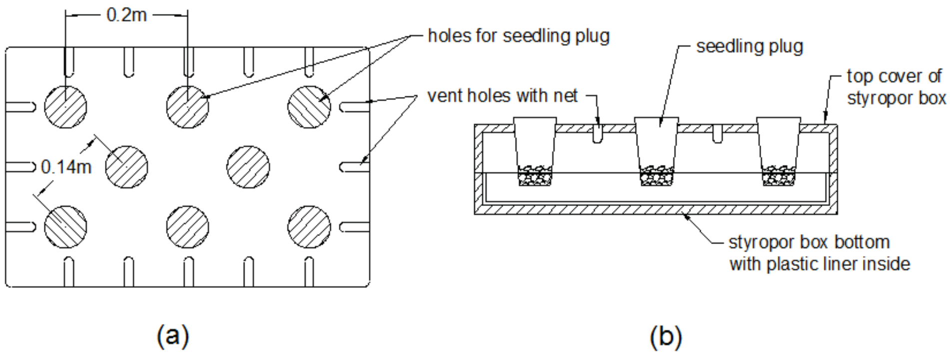

Figure 1: Detail of growing box (a – top view; b – side cross-section).

Figure 2: Lay-out of the protective structure.

Figure 3: Lay-out of the protective structure.

Figure 4: Lay-out of the protective structure.

Table 1: *Mineral composition and concentration of the nutrient solution*

Nutrients	**milligram of material/100 liters of water**
Fertilizer Ingredient 1	
Nitrate Nitrogen (N)	4,800.00
Available Phosphate (P_2O_5)	10,560.00
Soluble Potash (K_2O)	24,960.00
Water soluble Magnesium (Mg)	2,976.00
Combined Sulfur (S)	3,840.00
Boron (B)	48
Chelated Copper (Cu)	14.4
Chelated Iron (Fe)	288
Chelated Manganese (Mn)	48
Molybdenum (Mo)	9.6
Chelated Zinc (Zn)	14.4
Fertilizer Ingredient 2	
Magnesium Sulfate ($MgSO_4$)	10,000.00
Fertilizer Ingredient 2	
Ferrous Sulfate ($FeSO_4$)	2,000.00
Fertilizer Ingredient 3	
Calcium Nitrate [$Ca(NO_3)_2$]	96,000.00

Transplanting of seedlings was done by digging a hole in the middle of the sterilized coco coir growing media which is $\frac{1}{2}$ inch depth in the seedling plugs, transferring only one seedling per cup. The transferred seedlings were made to stand firmly by replacing the dug media to the base of the seedling. Figure 3 shows the seedlings established inside the experimental area, while Figure 4 shows the transplanting of individual seedlings to the seedling plugs.

The plants were harvested 28 days after transplanting. The individual styrofoam seedling plugs were removed from each plant as well as the coco coir dust that cling on the roots at the base of the plant. Freshly harvested plants were weighed immediately.

Preparation of Nutrient Solution

The hydroponic fertilizer used in the study was acquired from a commercial supplier following the recommended nutrient formulation for lettuce in a SNAP hydroponic system. Three separate fertilizer ingredients in powdered form were dissolved in tap water to produce the recommended hydroponic solution to be applied to the growing boxes. The composition of each fertilizer ingredient and the concentration of minerals in nutrient solution is listed in Table 1. Each growing box comprising of 8 lettuce plants was applied with 12 liters of nutrient solution. This amount is enough to supply the needed requirement of the plants from transplanting until harvest.

Experiment and Statistical Analysis

The experiment was replicated 20 times using 20 planting boxes with 8 plants in each planting box. The study compared the yield of head lettuce grown in the SNAP hydroponics system with the reported 3kg/m^2 general average yield lettuce regardless of variety (Abaygar, 2009) in lettuce-growing areas in the Philippines. One-sample t-test was used to determine significant difference between the experimental yield and the reported average yield of lettuce.

Table 2: *Vegetative characteristics of head lettuce in SNAP Hydroponics system*

Parameters	**Weeks After Transplanting**			
	1	**2**	**3**	**4**
Ave. number of leaves	4.66	7.72	8.53	10.5
Ave. plant height (cm)	4.34	10.48	18.79	23.37
Ave. width of leaves (cm)	2.97	5.44	11.5	17.14
Ave. length of leaves (cm)	4.03	9.74	17.2	22.47

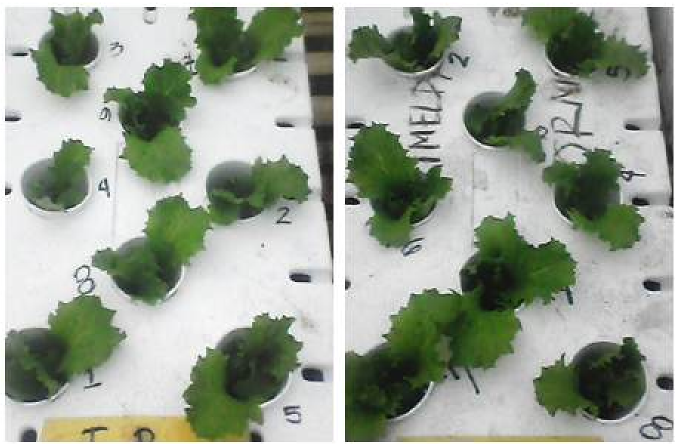

Figure 5: Lettuce plants 2 weeks after transplanting.

Table 3: *Yield of head-type lettuce in SNAP Hydroponics system*

Parameters	**Value, grams**	**Equivalent yield in kg/sq.m.**
Ave. weight of biomass per plant	90.32	3.6128
Ave. weight of roots per plant	8.56	0.3424
Ave. marketable weight per plant	73.08	2.9232
Ave. non-marketable weight per plant	8.69	0.3476

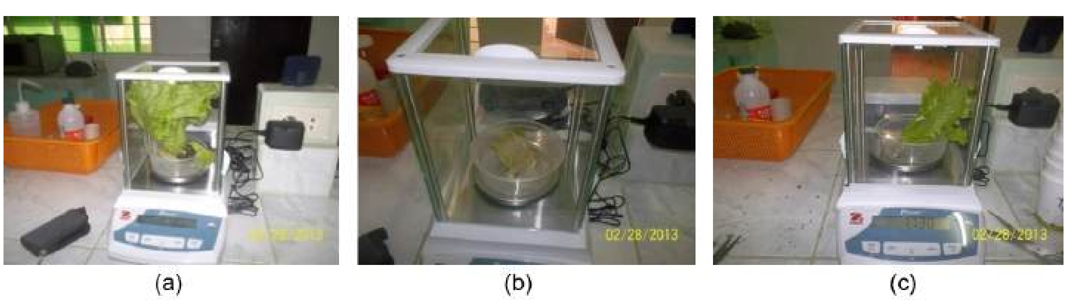

Figure 6: Freshly harvested lettuce in the electronic platform balance [(a) total biomass, (b) roots, (c) marketable part]

Data Gathering and Instrumentation

The weekly horticultural data includes the following: number of leaves per plant, plant height, leaf width, and leaf length. In each growing box, the number of leaves of every plant was counted. The plant height was measured as the distance from the base of the plant to the tip of the tallest leaf. The fully developed leaf in the sample plant was chosen for measurements of the leaf width and length.

The yield parameters that were measured after harvest were the total fresh biomass weight per plant, fresh weight of roots per plant, and the fresh marketable weight per plant. Weight measurement was made inside the tissue culture laboratory using the electronic platform balance. Feedbacks from the consumers of the freshly harvested lettuce who were mainly the faculty members of Naval State University-Biliran were also solicited to assess the eating quality of the fresh vegetable.

Results and Discussion

The horticultural characteristics of lettuce plant are presented in Table 2. The average number of leaves increased approximately 2-3 cm every week while the height of the plant increased approximately 3-8 cm every week. Rapid growth of the plants was observed 2 weeks after transplanting as shown in the increase of the plants' height, leaf width and length (Figure 5). 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 suggest 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).

Generally, the plants were observed to be healthy and the growth is typical to the plants grown in lettuce growing areas under the conventional production system. However, all the plants were observed to form only loose heads during maturity. This observation is supported by PCARRD (1999) that the iceberg varieties of lettuce will not form heads in hotter areas.

The fresh biomass (Figure 6) yield of lettuce plants is presented in Table 3. The average weight of roots is about 9.48% of the total biomass weight per plant, while the average marketable yield is about 80.91% of the total fresh biomass weight per plant. On the other hand the non-marketable weight is about 9.62% of the total fresh biomass weight per plant.

T-test reveals that the experimental marketable yield of 2.92 kg/m^2 is not significantly different *(t-value = 1.579, p-value = 0.124)* to the reported average yield of lettuce which is 3 kg/m^2 which suggest that the yield of head lettuce in a hydroponics system under the outdoor environment of Biliran is comparable to the average yield in lettuce producing areas under the conventional production system. Despite the climatic condition of Biliran which might not be ideal for lettuce production, the result could be attributed to the higher planting density in the hydroponics system compared to the lettuce planted in the soil or in the field. In addition, the nutrients supplied in a hydroponic system are formulated to provide complete nutrition of the plants until maturity. This is supported by Roberto (2003) who cited the benefits of hydroponics over the conventional field production as follows: 1) elimination of soil borne pests, fungi and diseases, 2) elimination of troublesome weeds and stray seedlings which eliminates the need for herbicides and reduces labor, and 3) significantly increased yields because of higher planting density and shorter crop maturation cycle.

Feedbacks from the consumers of the produced lettuce revealed a comparable taste of the experimental lettuce with the one commercially sold in the market. Though, sensory evaluation of the fresh lettuce was not covered in the experiment.

Conclusion

The result indicates that head lettuce production in a non-circulating hydroponic system under the outdoor environment of Biliran, Philippines is possible. Under the Biliran climatic condition, the yield of head lettuce in a non-circulating hydroponic production system is comparable to the yield in traditional lettuce growing areas using the conventional production system. However, it should be noted that the result represent only one cropping season and one cultivar of head lettuce. Future studies should include other head lettuce cultivars, different planting seasons as well as other hydroponic production system.

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