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Growth and yield of different leaf-type lettuce (*Lactuca sativa* L.) cultivars grown in protected and open field cultivation

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ABSTRACT

Leafy vegetable production in the Philippines is less diversified than many other countries, especially those used in salads. As a result, Filipino farmers are less familiar with production of leaf-type lettuce that is increasing in popularity with consumers. Therefore, two separate experiments were conducted simultaneously in open field and under bamboo house-type protective structures roofed with plastic to evaluate the performance and profitability of different leaf-type lettuce cultivars. Each study was carried out in randomized complete block design with five treatment cultivars and three replications. Most cultivars grown under protective structures had higher marketable yields than those grown in the open field. Despite plants grown under protective structures incurring higher production costs compared to the open field, higher marketable yields under protective structures resulted in higher net returns. Among the five cultivars, Green Span gave the highest return in the open field and Green Tower under the protective structure. Smaller lettuce cultivars produced lower yields than bigger cultivars.

Keywords: asteraceae, food safety, rain shelter, conventional, soil splash

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an annual plant which belongs to the Asteraceae family. Lettuce is noted for its edible green and sometimes red leaves (Poincelot 2004). Leaves are normally eaten raw as a key component of salads, though it can also be used in soups, sandwiches, wraps and can also be grilled. It is an important component for human diet because it is rich in vitamins, minerals, fiber, few

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and large amount of water. In addition to its main use as a leafy green, it has also gathered religious and medicinal significance over centuries of human consumption.

Lettuce is usually grown in areas with a daily mean temperature range of 10-20ºC (50-60ºF) (Siemonsma & Kasem 1994). Cool nights are essential for quality lettuce production as high temperature tend to produce strong flavor (Jones 1983). Lettuce like many other crops has different cultivars, each with different characteristics (Bullard & Mortensen 1964). Likewise, each cultivar will perform differently depending on many factors such as soil-type, climate, and pest and disease pressures. Hence, evaluating their performance to determine which is suitable to a given place is necessary.

Conventional open field cultivation faces a number of problems such as plants being subjected to heavy rain, wind, and diseases. Protected cultivation in the form of low-cost protective structures offers the possibility of solving some of these problems in lettuce production. Trialling this method of cultivation in tropical climates can create awareness among growers and policy makers of the potential for this technology to increase yield and quality of vegetables grown in difficult environments like type IV (characterized by frequent & heavy rainfall throughout the year) rainfall pattern in the humid tropics. At present, there is limited information about the growth and yield of different cultivars of leaf-type lettuce grown under protective structures and open-field especially in Leyte, Philippines, hence this study was conducted.

MATERIALS AND METHODS

Site Description

This study was conducted in the Australian Centre for International Agricultural Research-Integrated Crop Management (ACIAR-ICM) project site of the Department of Horticulture, Visayas State University (VSU) from August to September 2014. It was located at 10°44'45.6"N 124°47'30.7"E and an elevation of 10m above sea level. The area was dry lowland with continuous and intensive vegetable production since the vegetable project started.

Protective Structure

A house-type protective structure with curved roofing made of bamboo was used in this study. The structure had open sides for good ventilation, and an inner area of 200m^2 ie, 5mx40m. The roof was covered with 0.002mm UV-treated plastic, standing 4m high.

Experimental Design and Treatments

A simple randomized complete block design (RCBD) with three replications was set up on each type of cultivation. The types of cultivation were conventional (Open field) and protected cultivation (Bamboo house-type structure). Cultivars grown with both cultivation methods were Black rose, Grand rapid, Green span, Green tower, and Sunny red. Each treatment plot had an area of 1mx4m with a planting distance of 25cmx25cm and accommodated 62 plants.

Fertilization and Irrigation

Basal and drench application of 90-60-60kg N, P_2O_5, K_2O per hectare using complete (16-16-16NPK) and calcium nitrate (19% Ca & 15.5% NO_3) respectively, were applied. Drenching of calcium nitrate was at the rate of 250g per 50L of water. The basal fertilizer was applied at transplanting, while drenching commenced one week after basal application, continuing at weekly intervals.

Immediate watering after transplanting was done to minimize transplanting stress and hasten recovery. Irrigation was using J-turbo slim drip lines with drippers every 25cm, dispensing approximately 1.2L per hour. Watering was done daily, or as required based on soil moisture levels.

Data Gathered

The horticultural characteristics comprised the weekly plant height and number of leaves; root length, fresh weight and volume. Root volume was measured using water displacement method. Yield included the marketable and non-marketable in actual area computation, and total yield per hectare basis. The marketable plants were those free from pest damage. Expenses in all activities and inputs, and gross income were recorded for economic analysis. The gross income was computed by multiplying the marketed plants and current market price. Net return was then computed by subtracting expenses to gross income. The data on total weekly rainfall and temperature were obtained from Philippine Atmospheric Geophysical Astronomical Services Administration (PAG-ASA), VSU meteorological station near the experimental site.

Data Analysis

Data were analyzed using ANOVA by Statistical Tool for Agricultural Research (STAR) version 2.0.1 and means were compared using least significant difference (LSD) at 5% level of significance. Bartlett's test was used to combine analysis for two different cultivation systems. The statistical analysis was supervised by the Department of Statistics of VSU.

RESULTS AND DISCUSSION

Horticultural Characteristics

The type of cultivation significantly affected plant height of leaf-type lettuce (Table 1). Taller plants were consistently observed in all cultivars grown under the protective structure. Faster growth of plants under the structure was likely due to the protection provided by the structure against adverse environmental conditions such as heavy rainfall and high light intensity (Mabesa 2010). There was very high rain (Figure 1A) in first week after transplanting that provided stress to the seedlings and temporary suppress growth but survival was affected as drainage in the area was improved. However, the fluctuation of heat (Figure 1B) especially in protected cropping resulted in variable performance of each cultivars which implies their level of tolerance to temperature increase.

Table 1. Plant height (cm) and number of leaves of different leaf-type lettuce cultivars grown in the open field and protective structure conducted at ACIAR-ICM project in Visayas State University (VSU) from August to September 2014

Treatment	weekly plant height (cm)			weekly number of leaves		
	1	2	3	1	2	3
TYPE OF CULTIVATION SYSTEM						
Open Field	9.88	14.33b	20.11b	5.86	10.93	17.71
Protected	12.68	19.23a	26.47a	6.80	11.32	17.85
VARIETY						
Open field						
Black Rose	6.51	10.21d	14.04d	4.47c	6.53d	7.97c
Grand rapid	11.54	17.32a	26.24a	5.20bc	9.20c	15.03b
Green Span	11.99	15.31b	20.92b	7.07a	14.10a	25.33a
Green Tower	11.34	16.09b	22.44b	7.00a	14.30a	23.90a
Sunny Red	8.01	12.71c	16.89c	5.57b	10.53b	16.30b
Protected						
Black Rose	8.34c	12.42d	16.69d	5.30d	7.10c	9.33c
Grand rapid	14.23b	24.72a	36.03a	5.67cd	10.00a	15.83b
Green Span	13.90b	21.44b	27.77c	7.70b	14.30a	24.63a
Green Tower	16.85a	23.08ab	32.11b	8.77a	14.30a	23.63a
Sunny Red	10.07c	14.46c	19.76d	6.57c	9.97b	10.53b

Means within the same column in a block followed by a common letter and/or no letter designation are not significantly different from each other using Least Significant Difference at 5% level of significance.

Among all cultivars tested, "Grand rapid" was the tallest regardless of type of cultivation used. Conversely, "Black rose" and "Sunny red" were found to be the shortest growing lettuce plants. The cultivars with the greatest leaf number were "Green span" and "Green tower", and "Back rose" had the least number of leaves. The "Green span" had consistently more roots than other cultivars in terms of length, weight and volume (Table 2). These superior characteristics of roots contributed to better performance of "Green span" in most parameters including yield.

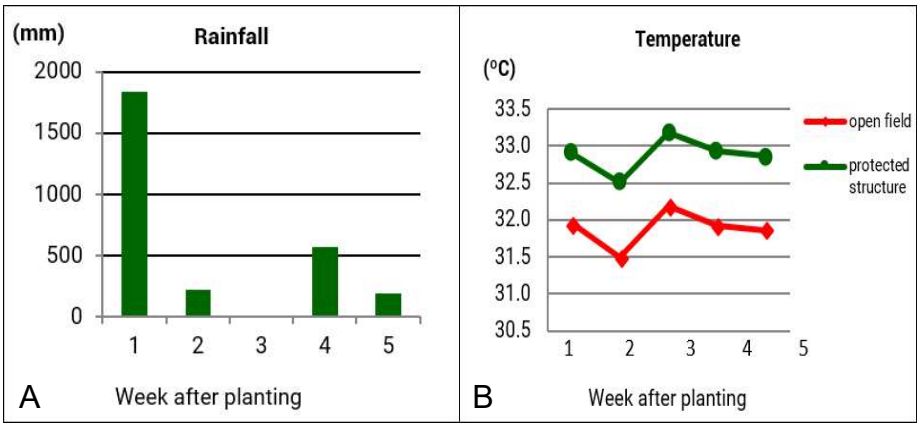

Figure 1.Total weekly rainfall (A) and average weekly temperature (B) gathered from thermometers suspended inside the structure and in open field throughout the experiment (August 12 to September 12, 2014) taken from Agromet Station, VSU, Visca, Baybay City, Leyte

Table 2. Root characteristics of different leaf-type lettuce cultivars grown in the open field and protective structure conducted at ACIAR-ICM project in Visayas State University (VSU) from August to September 2014

Treatment	Roots		
	Length (cm)	fresh weight (g)	volume (cm^3)
TYPES OF CULTIVATION SYSTEM			
Open Field	18.90	19.05	12.53
Protected	18.32	21.69	14.71
VARIETY			
Open field			
Black Rose	16.33c	6.05e	4.53d
Grand rapid	19.90b	18.75c	11.60c
Green Span	22.10a	31.78a	20.60a
Green Tower	18.45bc	25.43b	16.47b
Sunny Red	17.74bc	13.23d	9.47c
Protected			
Black Rose	16.32d	7.62c	6.20b
Grand rapid	19.28b	19.95b	10.93b
Green Span	20.63a	33.09a	22.73a
Green Tower	17.65c	32.40a	23.60a
Sunny Red	17.74c	15.40b	10.07b

Means within the same column in a block followed by a common letter and/or no letter designation are not significantly different from each other using Least Significant Difference at 5% level of significance.

Yield and Yield Components

The protected cultivation grown lettuce had slightly higher marketable and total yield in numerical value than open field cultivation but statistically insignificant. Lower yield of lettuce in the open field was attributed to direct exposure of lettuce to rain (Figure 1) and showed slower growth in size (Figure 2). According to Gonzaga et al (2013):

Growing vegetable crops under protective structures is not new, and the explanations for yield increase are well documented. They include reduced periods of leaf wetness creating less favourable conditions for diseases to infect, protected from soil splash, reduced weed growth, moderate soil and air temperatures, and reduced leaching of nutrients.

The yield of black rose and sunny red cultivars were significantly lower in both types of cultivation. The difference in yields of these two cultivars compared to others were mainly due to sizes which are smaller, hence resulted to lighter weight of produce per unit area. This was attributed to its varietal characteristics where it can only grow up to 20-23cm as described in seed packaging label. These two cultivars must be planted closer compared to other cultivars to meet similar yields than the others.

Growth and yield of different leaf-type lettuce

Figure 2. Leaf-type lettuce grown in open field (A) were smaller in size than protected cultivation (B) at the experimental station of the Department of horticulture, Visayas State University, Visca, Baybay City, Leyte

Table 3. Yield parameters of different leaf-type lettuce cultivars grown in open field and under protective structure conducted at ACIAR-ICM project in Visayas State University (VSU) from August to September 2014

Treatment	Yield (kg per $4m^2$)		Total yield ($t\ ha^{-1}$)
	Marketable	Non-marketable	
TYPES OF CULTIVATION SYSTEMS			
Open Field	2.06	0.86	13.96
Protected	2.53	0.60	17.88
VARIETY			
Open field			
Black Rose	1.14d	0.06	6.54c
Grand rapid	1.94bc	1.02	14.85ab
Green Span	2.83a	1.51	18.93a
Green Tower	2.62ab	1.33	18.05a
Sunny Red	1.78cd	0.36	11.43bc

Table 3 continued

Treatment	Yield (kg per 4m^2)		Total yield (t ha^{-1})
	Marketable	Non-marketable	
VARIETY			
Protected			
Black Rose	1.06d	0.09	6.59c
Grand rapid	2.75bc	1.30	23.18a
Green Span	3.09ab	0.87	22.61a
Green Tower	3.45a	0.59	23.08a
Sunny Red	2.31c	0.13	13.94b

Means within the same column in a block followed by a common letter and/or no letter designation are not significantly different from each other using Least Significant Difference at 5% level of significance.

Table 4. Estimates of the cost and return analysis per 100m^2 of different cultivars of leaf-type lettuce grown in open field and under protected cultivation

Treatment	Yield (kg)	Gross Income (PhP)	Total Expenses (PhP)	Net Return (PhP)
Open Field				
Black Rose	49.88	3,241.88	2,470.84	771.04
Grand Rapid	84.88	5,516.88	2,470.84	3,046.04
Green Span	123.81	8,047.81	2,470.84	5,576.97
Green Tower	114.63	7,450.63	2,470.84	4,979.79
Sunny Red	77.88	5,061.88	2,470.84	2,591.04
Protected Cropping				
Black Rose	46.38	3,014.38	3,004.64	9.74
Grand Rapid	120.31	7,820.31	3,004.64	4,815.67
Green Span	135.19	8,787.19	3,004.64	5,782.55
Green Tower	150.94	9,810.94	3,004.64	6,806.30
Sunny Red	101.06	6,569.06	3,004.64	3,564.42

Current market price = P65.00

Cost and Return Analysis

Lettuces grown under protective structures incurred higher production costs although the yield was much greater compared to those grown in the open field. Highest net income was obtained by Green span in the open field cultivation of PHP5,576.973 per 100m^2 area at PHP65 per kg market price. On the other hand, Green Tower had the highest net return of PHP6,806.298 in protected cultivation. Lower net incomes were obtained in open field cultivation compared to the protected as manifested by yield produced. The Black Rose had the lowest net return due to the small plant size, which resulted in a low yield.

CONCLUSION

Production of leaf-type lettuces in Leyte, Philippines was possible despite warm tropical weather and type IV rainfall pattern. Different cultivars of lettuce produced economically viable yields. The Green span, Green tower and Grand rapid were larger plants compared to other cultivars which resulted in higher yields and returns. The net return from Black rose was lowest due to the small size of the plant which therefore requires higher plant density per unit area than other cultivars to meet similar yield and return. Protected cropping of lettuce produced higher yields and better quality than open field. Despite higher production costs under protected cropping, it still gave a higher net return. The results suggested production of leaf lettuce in the region regardless of cultivar were applicable and economically viable in protected cropping as rain slightly affected performance. On the other hand, open field cultivation needs further testing on their response to variability of weather especially on different months of the year.

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