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GROSS MARGIN ANALYSIS OF SELECTED VEGETABLES GROWN UNDER PROTECTED AND OPEN FIELD CULTIVATION IN LEYTE, PHILIPPINES

Glorybeth CASTILLO [*], Jessa H. RUALES[*], Moises Neil V. SERIÑO[**], Therese C. RATILLA[**]

Visayas State University, [*]Department of Economics, [**]Visayas Socio-Economic Research and Data Analytics Center, College of Management and Economics, Visca, Baybay City, Leyte, 6521 Philippines, Phone: +630535637751; Emails: glorybethcastillo@gmail.com, jessa.ruales@vsu.edu.ph, moisesneil.serino@vsu.edu.ph, therese.ratilla@vsu.edu.ph

Corresponding author: moisesneil.serino@vsu.edu.ph

Abstract

Growing vegetables has been a problem during the wet season in Leyte island, Philippines, because of intense rain affecting the growth and quality of produced vegetables. Using protected cultivation has been identified as one of the promising solutions in dealing with this problem. Several experimental trials under protected and open field cultivation have been conducted to evaluate the applicability and profitability of protected cultivation under Leyte island conditions. Gross margin analysis was used to measure and compare the profitability of selected high value vegetables like tomato, sweet pepper, and lettuce grown under protected cultivation compared to the conventional practice in open field cultivation. Results show that vegetables planted under protected cultivation employing different production practices are more profitable than vegetables grown under open field cultivation. This suggests that protected cultivation will help vegetable farmers increase their production and profitability, particularly during the wet season.

Key words**:** *profitability analysis, high-value vegetables, protected cropping, rural Philippines*

INTRODUCTION

The vegetable industry is a dynamic and sizeable agricultural subsector in the Philippine economy. In terms of production, Philippine Statistics Authority (PSA) (2016) reported that 5.1 million tons of vegetables are produced in 544,000 hectares of land in the country in 2015 [13]. The annual average growth rate of vegetable production only constitutes 3% from 2010-2015. In 2014-2015, net returns and net profit-cost ratio per hectare from the production decreased from 2.22 million pesos to 2.08 million pesos and 18.01 to 17.75, respectively, which are still generally lower than the net returns of other crops such as rice and corn [13].

Vegetables play an essential role in the Philippine economy. However, growing vegetables has been a problem during the wet season due to heavy winds and rain, leading to the inability of the farmers to satisfy demand for vegetables [1, 3, 6]. Vegetable production in the country can be enhanced by exploring new farm technologies and improving farm skills [4]. One of the feasible approaches to address this problem is through the use of a protected cropping system and integrated cropping management system [12]. Using a protected production system, previous study found that the average yields of selected vegetables grown under protected structure were relatively higher than vegetables planted in the conventional method [6, 12].

Growth in agricultural can be sustained not just by input growth but with technological development [21]. Protected cultivation is the most contemporary approach to produce horticultural crops in a modified and controlled environment. It manipulates production factors such as light, soil, water, temperature, humidity, etc., to attain maximum productivity and even allows a regular supply of vegetables during off-season [18]. This is also used to protect the plants from adverse climatic conditions, including protecting insect pests and diseases. This technology can further help farmers produce

safe and high-quality vegetables as well as gain higher income. Protected cultivation has spread worldwide for the last decades [18, 22, 23, 24].

Previous research results showed that crops under protective structures have higher yields on average than those grown in the open field [6, 16]. This study will add further evidence of the profitability of protected vegetable cultivation under Leyte conditions. Leyte island is vulnerable to extreme weather events [11, 17, 19]; hence, finding practical approaches to continue production is vital in keeping the vegetable supply chain. This study aims to compare the production of selected vegetables grown under protected cultivation and in the open field using gross margin analysis. The results of this study would be beneficial to improve the year-round production system of vegetables in Leyte. Vegetable farmers will be able to improve their yields with protected cultivation by producing during off-season and capture higher prices, thus enhancing their profitability. This study will be helpful to policymakers for the formulation of projects, programs, or policies necessary for the development of the vegetable sector.

MATERIALS AND METHODS

Study Sites

The selected study sites were the experimental area of the Department of Horticulture in Visayas State University (VSU) for the comparison of protected and open field setup. This located in 10 kilometers north of Baybay City, Leyte. Map 1 shows the location of the study. The Visayas State University has an experimental area devoted to field trials of agricultural technologies [20].

Data Collection

Data on production receipts and total variable costs were gathered through face-to-face interviews using a prepared and pre-tested questionnaire. Information about production inputs like direct inputs, labor and overhead costs; and revenues were collected in the experimental site. In addition, an interview with one (1) on-field horticulturist and one (1) focus group discussion with farm workers were done to obtain information about the potential yield changes from protected and open field cultivation. This method of obtaining information is called Delphi technique. This technique is widely accepted as a means for consensus-building method to gather data or information from persons in their domain of expertise especially in case of limited data [10].

Map 1. Location of vegetable experimental site
Source: [8].

Gross Margin Analysis

Gross margin analysis has been used in previous studies to initially assess the potential of intervention before a full economic analysis is done [1, 15]. Gross margin is the firm's total revenue minus the cost of goods sold or the variable inputs used to produce the outputs sold. The total revenue comprises the sales from the marketable and non-marketable yield of crops. The variable cost includes direct inputs such as seeds, fertilizers, pesticides, material cost; labor cost; and overhead cost such as rent of machines. The gross margin per enterprise for each type of cultivation was compared. Values were converted to per m^2 to compare both cultivations systematically. The gross margin is derived using the following calculations:

Gross margin = Gross returns – Total variable cost

where gross returns is computed by multiplying the total production by prevailing farm gate prices [14].

RESULTS AND DISCUSSIONS

Gross margin analysis of tomatoes grown under protective structure and open-field with different organic amendments

Tomato is highly sensitive to pest and disease attacks which can reduce productivity to a considerable extent, particularly bacterial wilt caused by *Ralstonia solanacearum* [2]. Photo 1 shows the field trial to evaluate the effects of waste cabbage residues, *Chromola enaodorataa* (a weed species) and forest leaf litter as soil organic amendments on disease occurrence and yield performance of tomato grown under protective and open-field cultivation. The total area planted for all four treatments is 200 m^2. These organic amendments were added to the soil at the rate of 15 kg/10 m^2 plot area with 3 replications. Figure 2 shows the experimental setup of tomatoes grown under protected and open field cultivation. Gorme et al. (2017) discussed in details about the experimental of these organic amendments [9].

Photo 1. Tomato plants grown under protective structure (A) and in open field (B)
Source: [9].

To determine the profitability of these organic amendments, the gross margin analysis was conducted. The variable costs include all material and labor inputs incurred in carrying out the different trials planted in a total area of 200m^2 area. Each treatment has a total plot size of 30m^2. Table 1 shows the gross margin analysis of protected cultivation and open field disaggregated by treatments.

The total revenue was computed by multiplying the total quantity of harvested tomato fruits by the average farm gate of tomato in Leyte.

Results show that tomatoes planted under protected structure yields eight times higher gross margin than those planted in the open field. Between treatments, tomatoes planted in soil with cabbage waste have the highest gross margin in both types of cultivation. This result coheres with previous study findings that cabbage farm residues can generally minimize bacterial wilt disease and increase yield in tomato [2].

Table 1. Gross margins of tomato production with different organic soil amendments

Items	Organic Amendments			
	Forest Leaf Litters	Cabbage Waste	*Chromolaena odorata*	Control
PROTECTED CULTIVATION				
Yield (kg/30m^2)	79.88	102.00	76.85	73.90
Price/kg (PHP)	34.02	34.02	34.02	34.02
A. Gross Returns (PHP)	2,717.52	3,470.04	2,614.44	2,514.08
Materials	686.04	956.04	606.04	556.04
Labor	890.28	841.85	938.68	648.28
B. Variable Cost (PHP)	1,576.32	1,797.89	1,544.72	1,204.32
C. Gross Margin (A-B) per 30m^2 (PHP)	**1,141.20**	**1,672.15**	**1.069.72**	**1,309.76**
Gross margin per hectare (PHP)	**313,830.57**	**459,842.48**	**294,173.40**	**360,184.68**
OPEN FIELD				
Yield (kg/30m^2)	47.95	58.50	46.63	43.80
Price/kg (PHP)	34.02	34.02	34.02	34.02
A. Gross Returns (PHP)	1,631.26	1,990.17	1,586.35	1,490.08
Materials	686.04	956.04	606.04	556.04
Labor	867.59	819.16	915.99	625.59
B. Variable Cost (PHP)	1,553.63	1,775.20	1,522.03	1,181.63
C. Gross Margin (A-B) per 30m^2 (PHP)	**77.63**	**214.97**	**64.32**	**308.44**
Gross Margin per hectare (PHP)	**21,347.55**	**59,116.33**	**17,688.29**	**84,822.23**

Note: PHP = Philippine peso (currency)
Source: Authors calculation based on the experimental data and survey data, 2017.

Tomatoes grown in the soil medium without organic amendments have a higher gross margin than those with forest leaf litters and *Chromolaena odorata.* This is because adding organic amendments requires additional labor and materials compared to the traditional way of growing tomatoes. On a per hectare analysis, the cabbage waste amendments under protected structure yield a gross margin of PHP 459,842 per hectare compared to open

field cultivation with an estimated gross margin of only PHP 59,116 per hectare (Table 1).

Gross margin analysis of sweet pepper grown under protective structure and open-field

Sweet pepper production has been limited due to pest infestation throughout the country [5]. These pests reduced the yield and quality of the fruits. Sweet pepper pests include insects, mites, pathogens, and nematodes. Among these, mites, specifically broad mites and insects like the fruit worm, fruit fly, and sucking species, are common [5]. The high cost of chemicals (insecticides) to be used as a repellant for insect infestation led to the development of organic concoctions like the vermitea. The use of vermitea as fertilizer and repellant against insect pests is one of the organic options that small farmers can easily adopt [5].

In this study, vermitea was tested to know if it can minimize insect infestation on sweet pepper. Photo 2 shows the experimental setup of pepper grown under protected and open field cultivation. The treatment application was done by spraying the test plants early in the morning or late in the afternoon using the recommended rates of application of each treatment.

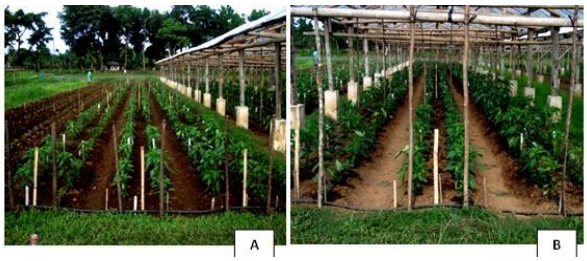

Photo 2. Comparison of sweet pepper grown in open field (A) and in protective structure (B)
Source: [5].

The gross return of sweet pepper was calculated by multiplying the total yield of sweet pepper with the selling price of PHP 100.00 per kilogram (Table 2). The material cost includes all necessary inputs in growing sweet pepper. For the treatments, all the necessary ingredients in preparing the brewed and ordinary vermitea including water were quantified and given monetary value. The labor input includes all the activities from sowing seeds, harrowing bed preparation, transplanting, weeding, harvesting, and all other activities with a given rate of PHP 150.00 per man-day. The revenue and variable cost was computed from planting sweet pepper in a 200 m^2 with 4 treatments and three replications. The average plot size for every treatment application is about 30m^2. Results show that a positive gross margin can be observed in all the treatments under the protected cultivation (Table 2).

Table 2. Gross margins of sweet pepper production with different kinds of insecticides.

Items	Insecticides			
	Tap Water	Ordinary Vermitea	Brewed Vermitea	Insecticide (Oschin)
PROTECTED CULTIVATION				
Yield (kg/30m^2)	19.70	24.10	19.70	37.50
Price/kg (PHP)	100	100	100	100
A. Gross Returns (PHP)	1,970	2,410	1,970	3,750
Materials	382.55	727.55	432.15	627.55
Labor	638.25	638.25	638.25	638.25
B. Variable Cost (PHP)	1,020.80	1,365.80	1,070.40	1,265.80
C. Gross Margin (A-B) per 30m^2 (PHP)	**949.20**	**1,044.20**	**899.60**	**2,484.20**
Gross Margin per hectare (PHP)	**261,029.31**	**287,154.31**	**247,389.31**	**638,154.31**
OPEN FIELD				
Yield (kg/30m^2)	12.00	11.60	13.40	12.20
Price/kg (PHP)	100	100	100	100
A. Gross Returns (PHP)	1,200	1,160	1,340	1,220
Materials	380.55	727.55	432.15	627.55
Labor	525.76	525.76	525.76	525.76
B. Variable Cost (PHP)	906.31	1,253.51	957.91	1,153.31
C. Gross Margin (A-B) per 30m^2 (PHP)	**293.69**	**-93.31**	**382.09**	**66.69**
Gross Margin per hectare (PHP)	**80,765.44**	**-25,659.56**	**105,075.44**	**18,340.44**

Source: Authors calculation based on the experimental data and survey data, 2017.

In the open field, a negative gross margin can be observed in the sweet pepper treated with ordinary vermicast (PHP -93.31) as a control to pest infestation. The treatment sprayed with insecticide has the highest gross margin of PHP 2,484.20 in the protected structure and the brewed vermitea (PHP 382.09) in the open field. However, the treatment with insecticide (PHP 66.69) yields the least positive gross margin in the open field and the brewed

vermitea has the lowest amount of gross margin in the protected structure (PHP 899.60).

It was observed that plants grown under the protective structure were generally more vigorous, have darker and broader leaves, and w2ere mostly taller than sweet pepper grown in open field cultivation [5]. In addition, the fruiting period of sweet pepper grown under protected structure lasted for fourteen weeks, and those planted in the open-field lasted only for ten weeks. This contributed to the relatively enormous difference in gross margin between protected cultivation and open field cultivation.

Gross margin analysis of lettuce grown under protective structure and open-field

Growing leafy vegetables like lettuce (*Lactuca sativa* L.*)* requires intensive care and management practices. One such practice is the method of raising vegetable seedlings. Seedling production is a vital farm operation to consider since it is the critical stage that highly affects the yield of the crops [7]. An experiment exploring different methods of raising seedlings is specified in the following treatments and disaggregated between the types of cultivation. Photo 3 shows the growth performance of lettuce grown in the open field and under protected structure.

Photo 3. Performance of lettuce in the open field (A) and under protective structure (tunnel type).
Source: [7].

The gross return for lettuce was computed based on the farm gate selling price of PHP 80.00 per kilogram. It can be noticed in Table 3 that the lettuce grown under the protected structure yields better than those grown in the open field regardless of the methods of raising seedlings. In terms of the management practice in raising seedlings, T_3 or the seeds sown in seedling trays then transplanted to the field results in a higher gross margin in the open field (PHP 12,683.50) and under the net-tunnel structure (PHP 9,808.10).

Table 3. Gross margin analysis of lettuce production with different methods of raising seedlings

Items	Raising Seedlings			
	T_1	T_2	T_3	T_4
PROTECTED CULTIVATION				
Yield (kg/30m^2)	108.96	122.88	165.12	104.64
Price/kg (PHP)	80	80	80	80
A. Gross Returns (PHP)	8,716.80	9,830.40	13,209.60	8,371.20
Materials	1,861.50	1,501.50	1,561.50	1,201.5
Labor	1,960.00	1,870.00	1,840.00	1,900.00
B. Variable Cost (PHP)	3,821.50	3,371.50	3,401.50	3,101.50
C. Gross Margin (A-B) per 30m^2 (PHP)	**4,895.30**	**6,458.90**	**9,808.10**	**5,269.70**
Gross Margin per hectare (PHP)	**636,389.0**	**839,657.0**	**1,275,053.0**	**685,061.0**
OPEN FIELD				
Yield (kg/30m^2)	98.40	104.64	202.56	91.20
Price/kg (PHP)	80	80	80	80
A. Gross Returns (PHP)	7,872.00	8,371.20	16,204.80	7,296.00
Materials	1,861.50	1,501.50	1,561.50	1,201.50
Labor	2,080.00	2,020.00	1,960.00	2,080.00
B. Variable Cost (PHP)	3,941.50	3,521.50	3,521.50	3,281.50
C. Gross Margin (A-B) per 30m^2 (PHP)	**3,930.50**	**4,849.70**	**12,683.30**	**4,014.50**
Gross Margin per hectare (PHP)	**510,965.0**	**630,461.0**	**1,648,829.0**	**521,885.0**

Note: T_1- Seed sown in seedbox, then pricked to seedling trays then transplant, T_2- Seeds sown in seedbox, then transplant to the field, T_3- Seeds sown in seedling trays, then transplanted, T_4- Seeds sown directly to the field.
Source: Authors calculation based on the experimental data and survey data, 2017.

Comparing the gross margins under the two types of cultivations shows that T_1, T_2, and T_4 yield higher profit under protected cultivation and only T_3 yield a bigger profit in the open field. This implies that lettuce with seeds sown in seedling trays before transplanted to the field performs better in the open field than in the protected structure. Further experiments from horticulture experts will be needed to confirm this result.

CONCLUSIONS

Gross margin analysis has been conducted to investigate whether it is profitable to grow vegetable crops under protected structure as compared to the conventional method of growing vegetables. Gross margin analysis of selected vegetable crops experimented under different cropping practices were conducted. With gross margin as a measure of profitability, we only consider the variable costs incurred in the production. This analysis excludes the cost of the structure. Results show that vegetables grown under protected cultivation yield higher production, translating to higher profit than open field cultivation. This suggests that cultivation under protected structure will enhance the production and as well profitability of vegetable farmers. Tomato, sweet pepper, and lettuce cultivated under protected structures have higher gross margins as compared to open field cultivation.

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